ESSAYS

ON THE

MICROSCOPE.

T. S. Duché pinxit

Truth discovering to Time, Science instructing her Children in the Improvements on the Microscope.

London, Published July 1st 1787, by Geo. Adams, No. 60 Fleet Street. —

ESSAYS

ON THE

MICROSCOPE;

CONTAINING

A PRACTICAL DESCRIPTION OF THE MOST IMPROVED
MICROSCOPES;
A GENERAL HISTORY OF INSECTS,
THEIR TRANSFORMATIONS, PECULIAR HABITS, AND ŒCONOMY:
AN ACCOUNT OF THE VARIOUS SPECIES, AND SINGULAR PROPERTIES, OF THE HYDRÆ
AND VORTICELLÆ: A DESCRIPTION OF THREE HUNDRED
AND EIGHTY-THREE ANIMALCULA:
WITH
A CONCISE CATALOGUE OF INTERESTING OBJECTS: A VIEW OF THE ORGANIZATION
OF TIMBER, AND THE CONFIGURATION OF SALTS, WHEN
UNDER THE MICROSCOPE.

ILLUSTRATED WITH THIRTY-TWO FOLIO PLATES.

BY THE LATE
GEORGE ADAMS,
MATHEMATICAL INSTRUMENT MAKER TO HIS MAJESTY, &c.

THE SECOND EDITION,
WITH CONSIDERABLE ADDITIONS AND IMPROVEMENTS, BY
FREDERICK KANMACHER, F. L. S.

LONDON:
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MDCCXCVIII.

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Crawford

TO

THE KING.

SIR,

Every work that tends to enlarge the boundaries of science has a peculiar claim to the protection of Kings. He that diffuses science, civilizes man, opens the inlets to his happiness, and co-operates with the Fountain and Source of all knowledge. By science truth is advanced; and of DIVINE TRUTH Kings are the representatives.

The work which I have now the honour to present to YOUR MAJESTY, calls the attention of the reader to those laws of Divine order by which the universe is governed and supported; in it we find that the minutest beings share in the protection, and triumph in the bounty of the Sovereign of all things: that the infinitely small manifest to the astonished eye the same proportion, regularity and design, which are conspicuous to the unassisted sight in the larger parts of creation. By finding all things formed in beauty, and produced for use, the mind is raised from the fleeting and evanescent appearances of matter, to contemplate the permanent principles of truth, and acknowledge that the whole proceeds from the wisdom that originates in love.

It was by YOUR MAJESTY's goodness and gracious patronage that I was first induced to undertake a description of mathematical and philosophical instruments, that I might thereby facilitate the attainment of those sciences that are connected with them, and by shewing what was already obtained, excite emulation, and quicken invention.

It is to the same goodness that I am indebted for this opportunity of subscribing myself,

SIR,

YOUR MAJESTY's

Most humble,

Most obedient,

and most dutiful

Subject and Servant,

GEORGE ADAMS.

PREFACE.

IN the preface to my ESSAYS ON ELECTRICITY AND MAGNETISM, I informed the public that it was my intention to publish, from time to time, essays describing the construction and explaining the use of mathematical and philosophical instruments, in their present state of improvement. This work will, I hope, be considered as a performance of my promise, as far as relates to the subject here treated of.*

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* Towards the completion of this design, our author afterwards published, 1. Astronomical and Geographical Essays; 2. Geometrical and Graphical Essays; 3. An Essay on Vision; 4. Lectures on Natural and Experimental Philosophy. He had projected other compilations, and was preparing a new edition of this work; but, alas! how uncertain are all human projects! constant attention to an extensive business and to literature, preyed on a constitution far from robust, and at length rapidly accelerated his dissolution, which happened at Southampton, on the 14th of August, 1795; aged 45. By this event, the world was prematurely deprived of the beneficial effects of his farther labours, and his friends of the conversation of a man, whose amiable and communicative disposition endeared him to all those who had the pleasure of knowing him. His life had been devoted to religious and moral duties, to the acquisition of science, and its diffusion for the benefit of mankind. To those who had no personal knowledge of Mr. ADAMS, his works will continue to display his merits as an author, and his virtues as a valuable member of society. EDIT.

The first chapter contains a short history of the invention and improvements that have been made on the microscope, and Father Di Torre's method of making his celebrated glass globules. The second treats of vision, in which I have endeavoured to explain in a familiar manner the reason of those advantages which are obtained by the use of magnifying lenses; but as the reader is supposed to be unacquainted with the elements of this science, so many intermediate ideas have been necessarily omitted, as must in some degree lessen the force, and weaken the perception of the truths intended to be inculcated: to have given these, would have required a treatise on optics.

In the third chapter, the most improved microscopes, and some others which are in general use, are particularly described; no pains have been spared to lessen the difficulty of observation, and remove obscurity from description; the relative advantages of each instrument are briefly pointed out, to enable the reader to select that which is best adapted to his pursuits. The method of preparing different objects for observation, and the cautions necessary to be observed in the use of the microscope, are the subjects of the fourth chapter.

When I first undertook the present essays, I had confined myself to a re-publication of my father's work, entitled, Micrographia Illustrata; but I soon found that both his and Mr. Baker's tracts on the microscope were very imperfect. Natural history had not been so much cultivated at the period when they wrote, as it is in the present day. To the want of that information which is now easily obtained, we may with propriety impute their errors and imperfections. I have, therefore, in the fifth chapter, after some general observations on the utility of natural history, endeavoured to remedy their defects, by arranging the subject in systematic order, and by introducing the microscopic reader to the system of Linnæus, as far as relates to insects: by this he will learn to discriminate one insect from another, to characterize their different parts, and thus be better enabled to avoid error himself, and to convey instruction to others.

As the transformations which insects undergo, constitute a principal branch of their history, and furnish many objects for the microscope, I have given a very ample description of them; the more so, as many microscopic writers, by not considering these changes with attention, have fallen into a variety of mistakes. Here I intended to stop; but the charms of natural history are so seducing, that I was led on to describe the peculiar and striking marks in the œconomy of these little creatures. And should the purchaser of these essays receive as much pleasure in reading this part as I did in compiling it; should it induce him to study this part of natural history; nay, should it only lead him to read the stupendous work of the most excellent Swammerdam, he will have no reason to regret his purchase, and one of my warmest wishes will be gratified.

In the next chapter I have endeavoured to give the reader some idea of the internal parts of insects, principally from M. Lyonet's Anatomical and Microscopical Description of the Caterpillar of the Cossus or Goat-moth. As this book is but little known in our country, I concluded that a specimen of the indefatigable labour of this patient and humane anatomist would be acceptable to all lovers of the microscope; and I have, therefore, appropriated a plate, which, whilst it shews what may be effected when microscopic observation is accompanied by patience and industry, displays also the wonderful organization of this insect. This is followed by a description of several miscellaneous objects, of which no proper idea could be formed without the assistance of glasses.

To describe the fresh-water polype or hydra; to give a short history of the discovery of these curious animals, and some account of their singular properties, is the business of the succeeding chapter. The properties of these animals are so extraordinary, that they were considered at first to be as contrary to the common course of nature, as they really were to the received opinions of animal life. Indeed, who can even now contemplate without astonishment animals that multiply by slips and shoots like a plant? that may be grafted together as one tree to another, that may be turned inside out like a glove, and yet live, act, and perform all the various functions of their contracted spheres? As nearly allied to these, the chapter finishes with an account of those vorticellæ which have been enumerated by Linnæus. It has been my endeavour to dissipate confusion by the introduction of order, to dispose into method, and select under proper heads the substance of all that is known relative to these little creatures, and in the compass of a few pages to give the reader the information that is dispersed through volumes.

From the hydræ and vorticellæ, it was natural to proceed to the animalcula which are to be found in vegetable infusions; microscopic beings, that seem as it were to border on the infinitely small, that leave no space destitute of inhabitants, and are of greater importance in the immense scale of beings than our contracted imagination can conceive; yet, small as they are, each of them possesses all that beauty and proportion of organized texture which is necessary to its well-being, and suited to the happiness it is called forth to enjoy. A short account of three hundred and seventy-seven* of these minute beings is then given, agreeable to the system of the laborious Müller, enlarging considerably his description of those animalcula that are most easily

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* To these, six more are now added, making the whole three hundred and eighty three. Edit.

met with, better known, and consequently more interesting to the generality of readers.

The construction of timber, and the disposition of its component parts, as seen by the microscope, is the subject of the next chapter; a subject confessedly obscure. With what degree of success this attempt has been prosecuted, must be left to the judgment of the reader. The best treatise on this part of vegetation is that of M. Du Hamel du Monceau sur la Physique des Arbres. If either my time or situation in life would have permitted it, I should have followed his plan; but being confined to business and to London, I can only recommend it to those lovers of the works of the Almighty, who live in the country, to pursue this important branch of natural history. There is no doubt but that new views of the operations in nature, and of the wisdom with which all things are contrived, would amply repay the labour of investigation. Every part of the vegetable kingdom is rich in microscopic beauties, from the stateliest tree of the forest, from the cedar of Lebanon, to the lowliest moss and the hyssop that springeth out of the wall; all conspiring to say how much is hid from the natural sight of man, how little can be known till it receives assistance, and is benefited by adventitious aid.

From the wonderful organization of animals, and the curious texture of vegetables, we proceed to the mineral kingdom, and take a cursory view of the configuration of salts and saline substances, exhibiting a few specimens of the beautiful order in which they arrange themselves under the eye, after having been separated by dissolution; every species working as it were upon a different plan, and producing cubes, pyramids, hexagons, or some other figure peculiar to itself, with a constant regularity amidst boundless variety.

Though all nature teems with objects for the microscopic observer, yet such is the indolence of the human mind, or such its inattention to what is obvious, that among the purchasers of microscopes many have complained that they knew not what subjects to apply to their instrument, or where to find objects for examination. To obviate this complaint, a catalogue is here given, which is interspersed with the description of a few insects, and other objects, which could not be conveniently introduced in the foregoing chapters. By this catalogue it is hoped that the use of the microscope will be extended, and the path of observation facilitated.

To avoid the formal parade of quotation, and the fastidious charge of plagiarism, I have subjoined to this preface a list of the authors which have been consulted. As my extracts were made at very distant periods, it would have been impossible for me to recollect to whom I was indebted for every new fact or ingenious observation.

The plates were drawn and engraved with a view to be folded up with the work; but as it is the opinion of many of my friends that they would, by this mean, be materially injured, I have been advised to have them stitched in strong blue paper, and leave it to the purchaser to dispose of them to his own mind.

A LIST OF THE AUTHORS

WHICH HAVE BEEN CONSULTED IN THE COMPILATION OF THE FORMER AND PRESENT EDITION OF THESE ESSAYS.

ADAMS.	Micrographia Illustrata, or the Microscope Explained.	London, 1746 and 1781.
ADDISON.	Spectator.	
BAKER.	An Attempt towards the Natural History of the Polype.	London, 1743.
———	The Microscope made Easy.	London, 1744.
———	Employment for the Microscope.	London, 1753.
BARBUT.	Genera Insectorum of Linnæus. 4to.	London, 1781.
BERKENHOUT.	Botanical Lexicon. 8vo.	London, 1764.
———	Synopsis of Natural History. 2 vols. 8vo.	London, 1789.
BIRCH.	History of the Royal Society. 4to. 4 vols.	London, 1756.
BLAIR.	Sermons.	London, 1792.
BONNANI.	Observationes circa Viventia, quæ in Rebus non Viventibus reperiuntur, &c. 4to.	1691.
BONNET.	Oeuvres d'Histoire Naturelle et de Philosophie. 9 tom. 4to.	Neufchatel, 1779.
BORELLUS.	De vero Telescopii Inventore.	
BRAND.	Select Dissertations from the Amœnitates Academicæ, &c. 8vo.	London, 1781.
CURTIS.	Instructions for Collecting and Preserving Insects. 8vo.	London, 1771.
———	Translation of the Fundamenta Entomologiæ. 8vo.	London, 1772.
———	Flora Londinensis. Folio.	London, 1777, &c.
———	Botanical Magazine. 8vo.	London, 1787, &c.
CYCLOPÆDIA.	By Dr. Rees. 4 vols. Folio.	London, 1786.
DE GEER.	Memoires pour servir a l'Histoire des Insectes. 4to. 7 tom.	1752.
DELLEBARRE.	Memoires sur les Differences de la Construction et des Effects du Microscope.	1777.
DERHAM.	Physico-Theology. 8vo.	London, 1732.
DONOVAN.	History of British Insects. 8vo.	London, 1792, &c.
———	Treatise on the Management of Insects. 8vo.	London, 1794.
DU HAMEL DU MONCEAU.	La Physique des Arbres.	Paris, 1757.
ELLIS.	Essay towards a Natural History of Corallines. 4to.	1755.
———	Zoophytes, by Dr. Solander. 4to.	London, 1786.
ENCYCLOPÆDIA BRITANNICA.	4to. 18 vols.	Edinburgh, 1797.
EPINUS.	Description des Nouveaux Microscopes.	
FABRICIUS.	Philosophia Entomologica. 8vo.	1778.
GEOFFROY.	Histoire Abregee des Insectes. 2 tom. 4to.	Paris, 1764.
GLEICHEN.	Les plus Nouvelles Deucouverts dans le Regne Vegetal, &c. Folio.	1770.

Goldsmith.	History of the Earth and Animated Nature. 8vo.	London, 1774.
Grew.	Anatomy of Plants. Folio.	London, 1682.
Haller.	Physiologia.	
Hedwig.	Theoria Generationis et Fructificationis de Plantarum Cryptogamicarum.	Petersb. 1784.
Hill.	Review of the Royal Society. 4to.	London, 1751.
——	History of Animals. Folio.	London, 1752.
——	Essays in Natural History. 8vo.	London, 1752.
——	The Construction of Timber explained by the Microscope. 8vo.	London, 1770.
——	Inspector.	
Home.	Treatise on Ulcers, &c. 8vo.	London, 1797.
Hooke.	Micrographia. Folio.	London, 1665.
——	Lectures and Collections. 4to.	London, 1678.
Hooper.	Economy of Plants. 8vo.	Oxford, 1797.
Joblot.	Observations d'Histoire Naturelle faites avec le Microscope. 4to. 2 tom.	Paris.
Journal de Physique, par Rozier, &c.		
Jones.	A Course of Lectures on the Figurative Language of the Holy Scriptures. 8vo.	1787.
Kippis.	Biographia Britannica. Folio.	1778, &c.
Ledermuller.	Microscopische Ergötzungen. 4 theile. 4to.	
Leeuwenhoek.	Arcana Naturæ. 4to.	Lugd. Bat. 1722.
——	Opera Omnia. 4to.	Ibid. 1722.
Lettsom.	Naturalist's Companion. 8vo.	London, 1774.
Linnean Society.	Transactions. 3 vols. 4to.	London, 1791, &c.
Linnæus.	Systema Naturæ. 8vo. edit. 12mo.	Holmiæ, 1766.
Lyonet.	Theologie des Insectes de Lesser. 2 tom. 8vo.	La Haye, 1742.
——	Traite Anatomique de la Chenille qui ronge le Bois de Saule. 4to.	
Macquer.	Dictionary of Chemistry.	London, 1777.
Magny.	Journal d'Economie.	1753.
Malpighi.	Opera. 4to.	Lugduni Bat. 1687.
Martin.	Micrographia Nova. 4to.	Reading, 1742.
——	Optical Essays. 8vo.	London.
Muller.	Animalcula Infusoria Fluviatilia et Marina. 4to.	Hauniæ, 1786.
Nicholson.	Introduction to Natural Philosophy. 2 vols. 8vo.	1787.
——	Journal of Natural Philosophy, &c.	1797.
Needham.	New Microscopical Discoveries. 8vo.	London, 1745.
Neuere Geschichte der Missions Anstalten.	4to.	Halle, 1796.
Pallas.	Elenchus Zoophytorum. 8vo.	Hagæ Comit. 1766.
Parsons.	Microscopic Theatre of Seeds. 4to.	London, 1745.
Power.	Microscopical Observations. 4to.	1664.
Priestley.	On Light, Vision, and Colours. 4to.	1772.
Reaumur.	Memoires pour servir a l'Histoire des Insectes. 8vo.	Amsterdam, 1737.
Redi.	De Insectis.	1671.

Reid.	On the Intellectual Powers of Man.	Nurnberg, 1746, &c.
Rosel.	Insecten Belustigung. 4 theile. 4to.	
Royal Society.	Philosophical Transactions.	
Rutherforth.	Natural Philosophy. 2 vols. 4to.	Cambridge, 1748.
Schirach.	Histoire Naturelle de la Reine des Abeilles.	A la Haye, 1771.
Shaw.	Naturalist's Miscellany. 8vo.	London, 1790, &c.
Smith, R.	Optics. 2 vols. 4to.	Cambridge, 1738.
Smith, I. E.	English Botany. 8vo.	London, 1790, &c.
Spalanzani.	Opuscules de Physiques Animale et Vegetale.	Geneva, 1777.
Stillingfleet.	Miscellaneous Tracts. 8vo.	London, 1762.
Swammerdam.	The Book of Nature, revised by Hill. Folio.	London, 1758.
Swedenborg.	Œconomia Regni Animalis, cui accedit Introductio ad Psychologiam Rationalem. 4to.	Amsterdam, 1743.
————	Regnum Animale, Anatomice, Physice et Philosophice Perlustratum. 4to.	Hagæ Comit. 1744.
Tremeley.	Memoires pour servir a l'Histoire des Polypes deau douce.	Paris, 1744.
Valmont de Bomare.	Dictionnaire Raisonne universal d'Histoire Naturelle.	Lyon, 1776.
Walker.	A Collection of Minute and Rare Shells. 4to.	London, 1784
Yeats.	Institutions of Entomology. 8vo.	Ibid. 1773.

London, *Dec.* 12, 1797.

The Public are hereby respectfully informed, that the Stock and Copyright of the following Works by the same Author, lately deceased, have been purchased by W. and S. Jones, Opticians, &c. and that they are now to be had at their Shop in Holborn.

I. GEOMETRICAL AND GRAPHICAL ESSAYS. This Work contains, 1, A select Set of Geometrical Problems, many of which are new, and not contained in any other Work. 2. The Description and Use of those Mathematical Instruments that are usually put into a Case of Drawing Instruments. Besides these, there are also described several New and Useful Instruments for Geometrical Purposes. 3. A complete and concise System of Surveying, with an Account of some very essential Improvements in that useful Art. To which is added, a Description of the most improved Theodolites, Plane Tables, and other Instruments used in Surveying; and most accurate Methods of adjusting them. 4. The Methods of Levelling, for the Purpose of conveying Water from one Place to another; with a Description of the most improved Spirit Level. 5. A Course of Practical Military Geometry, as taught at Woolwich. 6. A short Essay on Perspective. The Second Edition, corrected, and enlarged with the Descriptions of several Instruments unnoticed in the former Edition, by W. Jones, Math. Inst. Maker; illustrated by 35 Copper-plates, in 2 vols. 8vo. Price 14s. in Boards.

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ADVERTISEMENT.

THE editor esteems it his indispensable duty, to point out the several improvements which have been made in this work, in order to render it still more acceptable to the public.

The whole has been carefully revised—many typographical errors corrected—numerous additions and emendations from the author's own copy incorporated, and some superfluities rejected. Wherever any ambiguity occurred, the editor has endeavoured to elucidate the passage, observing due caution not to misconceive the idea which the author meant to inculcate. A more regular arrangement has been attempted, and occasional notes subjoined: in these, and in other parts of the work, it has been the editor's primary object to ascertain facts, not to decide peremptorily. Should he in any instance have erred, he can assure the candid critic, that he shall experience a most sensible pleasure in conviction.

The principal additions are,

Accounts of the latest improvements which have been made in the construction of microscopes, particularly the lucernal.

A description of the glass, pearl, &c. micrometers, as made by Mr. Coventry, and others.

An arrangement and description of minute and rare shells.

A descriptive list of a variety of vegetable seeds.

Instructions for collecting and preserving insects, together with directions for forming a cabinet.

A copious list of objects for the microscope.

A list of Mr. Custance's fine vegetable cuttings.

With respect to the plates, three new engravings are introduced, viz.

PLATE IV. Exhibiting the most improved compound microscopes, with their apparatus.
PLATE XIV. Microscopical figures of minute and rare shells.
PLATE XV. ——————— ——— — a variety of vegetable seeds.

Many additional figures have been inserted in other plates, and a number of errors in the references corrected.

A complete list of the plates and a more extensive index are also added.

It has been generally understood, that the author intended to have published this edition in octavo; but, the impropriety of adopting that mode must appear evident, for the very reason assigned by the author himself, in the concluding part of his preface. If the plates are liable to sustain damage by folding them into a quarto, they would have been subjected to far greater injury by being doubled into an octavo size, besides, being extremely incommodious for reference. As the work now appears, the purchaser may either retain the plates in the separate volume, or, without much inconvenience, if properly guarded, have them bound with the letter press.

It affords the editor a pleasing satisfaction to mention, that notwithstanding the additional heavy expense incurred in the article of paper, &c. yet, by somewhat enlarging the page, and other œconomical regulations in the mode of printing, this edition is offered to the public at a trifling advance on the original price, though the improvements now made occupy considerably more than one-hundred pages.

Anxious, lest the reputation which the work has already acquired, should be diminished by any deficiency on his part, the editor has sedulously applied himself to render it extensively useful to the serious admirer of the wonders of the creation; whether he has succeeded, is now submitted to the decision of the intelligent part of the public. He shall only add, that conscious of the purity of his intentions, and convinced of the instability of all terrestrial attainments, he trusts that he is equally secured from the weakness of being elevated by success, or depressed by disappointment.

Apothecaries Hall, London,
Jan. 1, 1798.

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—— 145, line 17, *for* cast of *read* cast-off
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A
LIST OF THE PLATES,

WITH REFERENCES TO THE PAGES WHERE THE SEVERAL FIGURES ARE DESCRIBED.

N. B. The reader will find no references to the several letters which appear in the bodies of these figures, for reasons assigned by the author as above; in order not to deface the plate, they were suffered to remain.

LIST OF PLATES.

ESSAYS

ON THE

MICROSCOPE:

CHAP. I.

A CONCISE HISTORY OF THE INVENTION AND IMPROVEMENTS WHICH HAVE BEEN MADE UPON THE INSTRUMENT CALLED A MICROSCOPE.

IT is generally supposed that microscopes* were invented about the year 1580, a period fruitful in discoveries; a time when the mind began to emancipate itself from those errors and prejudices by which it had been too long enslaved, to assert its rights, extend its powers, and follow the paths which lead to truth. The honor of the invention is claimed by the Italians and the Dutch; the name of the inventor, however, is lost; probably the discovery did not at first appear sufficiently important, to engage the attention of those men, who, by their reputation in science, were able

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* The term microscope is derived from the Greek μικρος little, and σκοπεω to view; it is a dioptric instrument, by means of which objects invisible to the naked eye, or very minute, are by the assistance of lenses, or mirrors, represented exceeding large and very distinct. EDIT.

to establish an opinion of its merit with the rest of the world, and hand down the name of the inventor to succeeding ages. Men of great literary abilities are too apt to despise the first dawnings of invention, not considering that all real knowledge is progressive, and that what they deem trifling, may be the first and necessary link to a new branch of science.

The microscope extends the boundaries of the organs of vision; enables us to examine the structure of plants and animals; presents to the eye myriads of beings, of whose existence we had before formed no idea; opens to the curious an exhaustless source of information and pleasure; and furnishes the philosopher with an unlimited field of investigation. "It leads," to use the words of an ingenious writer, "to the discovery of a thousand wonders in the works of his hand, who created ourselves, as well as the objects of our admiration; it improves the faculties, exalts the comprehension, and multiplies the inlets to happiness; is a new source of praise to him, to whom all we pay is nothing of what we owe; and, while it pleases the imagination with the unbounded treasures it offers to the view, it tends to make the whole life one continued act of admiration."

It is not difficult to fix the period when the microscope first began to be generally known, and was used for the purpose of examining minute objects; for, though we are ignorant of the name of the first inventor, we are acquainted with the names of those who introduced it to the public, and engaged their attention to it, by exhibiting some of its wonderful effects. Zacharias Jansens and his son had made microscopes before the year 1619, for in that year the ingenious Cornelius Drebell brought one, which was made by them, with him into England, and shewed it to William Borel, and others. It is possible, this instrument of Drebell's was not strictly what is now meant by a microscope, but was rather a kind of microscopic telescope,* something similar in principle to that lately described by Mr. Æpinus, in a letter to the Academy of Sciences at Petersburgh. It was formed of a copper tube six feet long and one inch diameter, supported by three brass pillars in the shape of dolphins; these were fixed to a base of ebony, on which the objects to be viewed by the microscope were also placed. In contradiction to this, Fontana, in a work which he published in 1646, says, that he had made microscopes in the year 1618: this may be also very true, without derogating from the merit of the Jansens, for we have many instances in our own times of more than one person having executed the same contrivance, nearly at the same time, without any communication from one to the other.† In 1685, Stelluti published a description of the parts of a bee, which he had examined with a microscope.

If we consider the microscope as an instrument consisting of one lens only, it is not at all improbable that it was known to the ancients much sooner than the last century; nay, even in a degree to the Greeks and Romans: for it is certain, that spectacles were in use long before the above-mentioned period: now, as the glasses of these were made of different convexities, and consequently of different magnifying powers, it is natural to suppose, that smaller and more convex lenses were made, and applied to the examination of minute objects. In this sense, there is also some ground for thinking the ancients were not ignorant of the use of lenses, or at least of what approached nearly to, and might in some instances be substituted for them. The two principal reasons which support this opinion are, first, the minuteness of some

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* Vide Borellum de vero Telescopii Inventore.

† In 1664 Dr. Power published his "Experimental Philosophy," the first part of which consists of a variety of microscopical observations; and in the following year Dr. Hooke produced his "Micrographia," illustrated with a number of elegant figures of the different objects. Edit.

ancient pieces of workmanship, which are to be met with in the cabinets of the curious: the parts of some of these are so small, that it does not appear at present how they could have been executed without the use of magnifying glasses, or of what use they could have been when executed, unless they were in possession of glasses to examine them with. A remarkable piece of this kind, a seal with very minute work, and which to the naked eye appears very confused and indistinct, but beautiful when examined with a proper lense, is described "Dans l'Histoire de l'Academie des Inscriptions," tom. 1, p. 333. The second argument is founded on a great variety of passages, that are to be seen in the works of Jamblichus, Pliny, Plutarch, Seneca, Agellius, Pisidias, &c. From these passages it is evident that they were enabled by some instrument, or other means, not only to view distant objects, but also to magnify small ones; for, if this is not admitted, the passages appear absurd, and not capable of having a rational meaning applied to them. I shall only adduce a short passage from Pisidias, a christian writer of the seventh century, Τα μελλοντα ως δια διοπτρȣ σύ βλεπεις· "You see things future by a *dioptrum:*" now we know of nothing but a perspective glass or small telescope, whereby things at a distance may be seen as if they were near at hand, the circumstance on which the simile was founded. It is also clear, that they were acquainted with, and did make use of that kind of microscope, which is even at this day commonly sold in our streets by the Italian pedlars, namely, a glass bubble filled with water. Seneca plainly affirms it, *Literæ, quamvis minutæ et obscuræ, per vitream pilam aqua plenam majores clarioresque cernuntur.* Nat. Quæst. lib. 1, cap. 7. "Letters, though minute and obscure, appear larger and clearer through a glass bubble filled with water." Those who wish to see further evidence concerning the knowledge of the ancients in optics, may consult Smith's Optics, Dr. Priestley's History of Light and Colours, the Appendix to an Essay on the first Principles of Natural Philosophy by the Rev. Mr. Jones, Dr. Rogers's Dissertation on the Knowledge of the Ancients, and the Rev. Mr. Dutens's Enquiry into the Origin of the Discoveries attributed to the Moderns.*

The history of the microscope, like that of nations and arts, has had its brilliant periods, in which it has shone with uncommon splendor, and been cultivated with extraordinary ardour; these have been succeeded by intervals marked with no discovery, and in which the science seemed to fade away, or at least lie dormant, till some favourable circumstance, the discovery of a new object, or some new improvement in the instruments of observation, awakened the attention of the curious, and animated their researches. Thus, soon after the invention of the microscope, the field it presented to observation was cultivated by men of the first rank in science, who enriched almost every branch of natural history by the discoveries they made with this instrument: there is indeed scarce any object so inconsiderable, that has not something to invite the curious eye to examine it; nor is there any, which, when properly examined, will not amply repay the trouble of investigation.

I shall first speak of the SINGLE MICROSCOPE, not only as it is the most simple, but because, as we have already observed, it was invented and used long before the double or compound microscope. When the lenses of the single microscope are very convex, and consequently the magnifying power very great, the field of view is so small, and it is so difficult to adjust with accuracy their focal distance, that it requires some practice to render the use thereof familiar; at the same time, the smallness of the aperture to these lenses has been found injurious to the eyes of some observers:

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* A new edition in French of this learned and valuable work, with many and useful notes, is just published. EDIT.

notwithstanding, however, these defects, the great magnifying power, as well as the distinct vision which is obtained by the use of a deep single lens, more than counterbalances every difficulty and disadvantage. It was with this instrument that Leeuwenhoek and Swammerdam, Lyonet and Ellis examined the minima of nature, laid open some of her hidden recesses, and by their example stimulated others to the same pursuit.

The construction of the single microscope is so simple, that it is susceptible of but little improvement, and has therefore undergone but few alterations; and these have been chiefly confined to the mode of mounting it, or the additions to its apparatus. The greatest improvement this instrument has received, was made by Dr. Lieberkühn, about the year 1740; it consisted in placing the small lens in the center of a highly polished concave speculum of silver, by which means he was enabled to reflect a strong light upon the upper surface of an object, and thus examine it with great ease and pleasure. Before this contrivance, it was almost impossible to examine small opake objects with any degree of exactness and satisfaction; for the dark side of the object being next the eye, and also overshadowed by the proximity of the instrument, its appearance was necessarily obscure and indistinct.

Dr. Lieberkühn adapted a microscope to every object; it consisted of a short brass tube, at the eye end of which a concave silver speculum was fixed, and in the center of the speculum a magnifying lens: the object was placed in the middle of the tube, and had a small adjustment to regulate it to the focus; at the other end of the tube there was a plano convex lens, to condense and render more uniform the light which was reflected from the mirror. But all these pains were not bestowed upon trifling objects; his were generally the most curious anatomical preparations, a few of which, with their microscopes, are, I believe, deposited in the British Museum. It will be proper, in this place, to give some account of Mr. Leeuwenhoek's microscopes, which were rendered famous throughout all Europe, on account of the numerous discoveries he had made with them, as well as from his afterwards bequeathing a part of them to the Royal Society. The microscopes he used were all single, and fitted up in a convenient simple manner; each of them consisted of a very small double convex lens, let into a socket between two plates rivetted together, and pierced with a small hole; the object was placed on a silver point or needle, which, by means of screws adapted for that purpose, might be turned about, raised or depressed at pleasure, and thus be brought nearer to, or be removed farther from the glass, as the eye of the observer, the nature of the object, and the convenient examination of its parts required. Mr. Leeuwenhoek fixed his objects, if they were solid, to the foregoing point with glue; if they were fluid, he fitted them on a little plate of talc, or exceeding thin blown glass, which he afterwards glued to the needle, in the same manner as his other objects. The glasses were all exceeding clear, and of different magnifying powers, which were proportioned to the nature of the object, and the parts designed to be examined. But none of those, which were presented to the Royal Society, magnify so much as the glass globules, which have been used in other microscopes. He had observed, in a letter of his to the Royal Society, that from upwards of forty years experience, he found that the most considerable discoveries were to be made with such glasses, as magnifying but moderately, exhibited the object with the most perfect brightness and distinctness. Each instrument was devoted to one or two objects: hence he had always some hundreds by him.* There is some reason for supposing, that Leeuwenhoek was acquainted

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* Philosophical Transactions, No. 380, No. 458.

with a mode of viewing opake objects, similar to that invented by Dr. Lieberkühn.*

About the year 1665, small glass globules began to be occasionally applied to the single microscope, instead of convex lenses. By these globules, an immense magnifying power is obtained. The invention of them has been generally attributed to M. Hartsoeker; it appears, however, to me, that we are indebted to the celebrated Dr. Hooke for this discovery; for he described the manner of making them in the preface to his "Micrographia," which was published in the year 1665. Now the first account we have of any microscopical discovery by M. Hartsoeker, was that of the spermatic animalculæ, made by him when he was eighteen years old; which brings us down to the year 1674, long after Dr. Hooke's publication.

As these glass globules have been very useful in the hands of experienced observers, I shall lay before my readers the different modes which have been described for making them, that the reader may be enabled thereby to ascertain the reality of the discoveries that have been said to be made with them.

Take a small rod† of the clearest and cleanest glass you can procure, free, if possible from blebs, veins, or sandy particles; then by melting it in a lamp with spirit of wine, or the purest and clearest sallad oil, draw it out into exceeding fine and small threads; take a small piece of these threads, and melt the end thereof in the same flame, till you perceive it run into a small drop, or globule, of the desired size; let this globule cool, then

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* Priestley's History of Optics, p. 220.

† Lectures and Collections by Dr. Hooke.

fix it upon a thin plate of brass or silver, so that the middle of it may be directly over the center of a very small hole made in this plate, turning it till it is fixed by the before-mentioned thread of glass. When the plate is properly fixed to your microscope, and the object adjusted to the focal distance of the globule, you will perceive the object distinctly and immensely magnified. "By these means," says Dr. Hooke, "I have been able to distinguish the particles of bodies not only a million times smaller than a visible point, but even to make those visible whereof a million of millions would hardly make up the bulk of the smallest visible grain of sand; so prodigiously do these exceeding small globules enlarge our prospect into the more hidden recesses of nature."

Mr. Butterfield, in making of the globules, used a lamp with spirit of wine; but instead of a cotton wick, he used fine silver wire, doubled up and down like a skain of thread.* He prepared his glass by beating it to powder, and washing it very clean; he then took a little of this glass upon the sharp point of a silver needle, wetted with spittle, and held it in the flame, turning it about till a glass ball was formed; then taking it from the flame, he afterwards cleaned it with soft leather, and set it in a brass cell.

No person has carried the use of these globules so far as Father Di Torre, of Naples, nor been so dexterous in the execution of them; and if others have not been able to follow him in the same line, it may be fairly attributed to a want of that delicacy of touch for adjusting the objects to their focus, and that acuteness of vision which can only be acquired by long practice. Di Torre has also described, more minutely than any other author, the

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* Philos. Trans. No. 141.

mode of executing these globules, which, as it throws much light upon the preceding description by Dr. Hooke, will not, it is presumed, be unacceptable to the reader.

Three things are necessary for forming of these globules: 1. A lamp and bellows, such as are used by the glass-blowers. 2. A piece of perfect tripoli. 3. A variety of small glass rods. When the flame of the lamp is blown in an horizontal direction, it will be found to consist of two parts; from the base to about two thirds of its length, it is of a white colour; beyond this, it is transparent and colourless. It is this transparent part which is to be used for melting the glass, because by this it will not be in the least sullied; but it will be immediately soiled, if it touch the white part of the flame. The part of the glass which is presented to the flame, ought to be exceeding clean, and great care should be taken that it be not touched by the fingers. If the glass rod has contracted any spots, it must either be thrown away, or the parts that are spotted must be cut off.

The piece of tripoli which is to be used in forming the globules, should be flat on one side, and so large that it may be handled conveniently, and protect the fingers from the flame. A piece four or five inches long, and three or four inches thick, will answer very well. The best tripoli for this purpose is of a white colour, with a fine grain, heavy and compact, and which, after it has been calcined, is of a red colour. This kind resists the fire best, is not apt to break when calcined, and the melted glass does not adhere to it. To calcine this tripoli, cover it well all round with charcoal nearly red hot, leaving it thus till the charcoal is quite cold; it may then be taken out. Let several hemispherical cavities be made on the flat side of the tripoli; they should be of different sizes, nicely polished, and neatly rounded at the edges, in order to facilitate the entrance of the flame. The large globules are to be placed in the large cavities, and the minuter ones, in the small cavities. The holes in the tripoli must never be touched with the finger. If it be necessary to clean them, it should be done with white paper; the larger globules may be cleaned with wash leather. The glass rods should be of various sizes, as of 1-10th, 1-20th, 1-30th of an inch in diameter, as clean and free from specks and bubbles as possible.

TO MAKE SMALL GLASS MICROSCOPIC GLOBULES.

Take two rods of glass, one in each hand, place their extremities close to each other, and in the purest part of the flame; when you perceive the ends to be fused, separate them from each other; the heated glass following each rod, will be finer, in proportion to the length it is drawn to, and the smallness of the rod; in this manner you may procure threads of glass of any degree of fineness. Direct the flame to the middle of the thread, and it will be instantly divided into two parts. When one of the threads is perfectly cool, place it at the extremity of the flame, by which it will be rendered round; and, if the thread of glass be very fine, an exceeding small globule will be formed. This thread may now be broke off from the rod, and a new one may be again drawn out as before, by the assistance of the other glass rod.

The small ball is now to be separated from the thread of glass; this is easily effected by the sharp edge of a piece of flint. The ball should be placed in a groove of paper, and another piece of paper be held over it, to prevent the ball from flying about and being lost. A quantity of globules ought to be prepared in this manner; they are then to be cleaned, and afterwards placed in the cavities of the tripoli, by means of a delicate pair of nippers. The globules are now to be melted a second time, in order to render them completely spherical; for this purpose, bring one of the cavities near the extremity of the flame, directing this towards the tripoli, which must be first heated; the cavity is then to be lowered, so that the flame may touch the glass, which, when it is red hot, will assume a perfect globular form; it must then be removed from the flame, and laid by; when cold, it should be cleaned, by rubbing between two pieces of white paper. Let it now be set in a brass cap, to try whether the figure be perfect. If the object be not well defined, the globule must be thrown away. Though, if it be large, it may be exposed two or three times to the flame. When a large globule is forming, it should be gently agitated by shaking the tripoli, which will prevent its becoming flat on one side. By attending to these directions, the greater part of the globules will be round and fit for use. In damp weather, notwithstanding every precaution, it will often happen, that out of forty globules, four or five only will be fit for use.

Mr. Stephen Gray, of the Charter-House, having observed some irregular particles within a glass globule, and finding that they appeared distinct and prodigiously magnified when held close to his eye, concluded, that if he placed a globule of water, in which there were any particles more opake than the water, near his eye, he should see those particles distinctly and highly magnified. This idea, when realized, far exceeded his expectation. His method was, to take on a pin a small portion of water which he knew had in it some minute animalculæ; this he laid on the end of a small piece of brass wire, till there was formed somewhat more than an hemisphere of water; on applying it then to the eye, he found the animalculæ most enormously magnified; for those which were scarce discernible with his glass globules, with this appeared as large as ordinary sized peas. They cannot be seen in day-time, except the room be darkened, but are seen to the greatest advantage by candle-light. Montucla observes, that when any objects are inclosed within this transparent globule, the hinder part of it acts like a concave mirror, provided they be situated between that surface and the focus; and that by these means they are magnified three times and an half more than they would be in the usual way. An extempore microscope may be formed, by taking up a small drop of water on the point of a pin, and placing it over a fine hole made in a piece of metal; but as the refractive power of water is less than that of glass, these globules do not magnify so much as those of the same size which are made of glass: this was also contrived by Mr. Gray. The same ingenious author invented another water microscope, consisting of two drops of water, separated in part by a thin brass plate, but touching near the center; which were thus rendered equivalent to a double convex lens of unequal convexities.

Dr. Hooke describes a method of using the single microscope, which seems to have a great analogy to the foregoing methods of Mr. Gray. "If you are desirous," says he, "of obtaining a microscope with one single refraction, and consequently capable of procuring the greatest clearness and brightness any one kind of microscope is susceptible of; spread a little of the fluid you intend to examine, on a glass plate, bring this under one of your microscopic globules, then move it gently upwards, till the fluid touch the globule, to which it will soon adhere, and that so firmly, as to bear being moved a little backwards or forwards. By looking through the globule, you will then have a perfect view of the animalculæ in the drop."*

Having laid before the reader the principal improvements that have been suggested, or made in the single microscope, it remains only to point out those instruments of this kind, which, from the

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* Hooke's Lectures and Conjectures, p. 98.

mode in which they are fitted up, seem best adapted for general use; the peculiar advantages of which, as well as the manner of using them, will be described in the third chapter of this work.

Fig. 1. Plate VI. A botanical microscope, contrived by Dr. Withering.

Fig. 2. Plate VI. A botanical microscope, by Mr. B. Martin, being the most universal pocket microscope.

Fig. 3. Plate VI, represents that which was used by M. Lyonnet for dissecting the cossus.

Fig. 5. Plate VI. The tooth and pinion microscope, which is now generally substituted in the room of Wilson's. Fig. 1. Plate II. B.

Fig. 1. Plate VII. B. The aquatic microscope used by Mr. Ellis for investigating the nature of coralline, and recommended to botanists by Mr. Curtis, in his valuable publication, the "Flora Londinensis."

Fig. 7. Plate VIII. A botanical magnifier, or hand megalascope, which by the different combinations of its three lenses produces seven different magnifying powers; when the three are used together, they are turned in, and the object viewed through the apertures in the sides.

Fig. 8. Plate VIII. A botanical magnifier, having one large lens and two small ones, but not admitting of more than three powers.

A COMPOUND MICROSCOPE, as it consists of two, three, or more glasses, is more easily varied, and is susceptible of greater changes in its construction, than the single microscope. The number of the lenses, of which it is formed, may be increased or diminished, their respective positions may be varied, and the form in which they are mounted be altered almost ad infinitum. But among these varieties, some will be found more deserving of attention than others; we shall here treat of these only.

The three first compound microscopes deserving of notice, are those of Dr. Hooke, Eustachio Divinis, and Philip Bonnani. Dr. Hooke gives an account of his in the preface to his Micrographia, which has been already cited; it was about three inches in diameter, seven long, and furnished with four draw-out tubes, by which it might be lengthened as occasion required: it had three glasses---a small object glass, a middle glass, and a deep eye glass. Dr. Hooke used all the glasses when he wanted to take in a considerable part of an object at once, as by the middle glass a number of radiating pencils were conveyed to the eye, which would otherwise have been lost: but when he wanted to examine with accuracy the small parts of any substance, he took out the middle glass, and only made use of the eye and object lenses; for the fewer the refractions are, the clearer and more bright the object appears.

An account of Eustachio Divinis's microscope was read at the Royal Society, in 1668.* It consisted of an object lens, a middle glass, and two eye glasses, which were plano convex lenses, and were placed so that they touched each other in the center of their convex surfaces; by which means the glass takes in more of an object, the field is larger, the extremities of it less curved, and the magnifying power greater. The tube, in which the glasses were inclosed, was as large as a man's leg, and the eye glasses as

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* Philos. Trans. No. 42.

broad as the palm of the hand. It had four several lengths; when shut up, it was sixteen inches long, and magnified the diameter of an object forty-one times; at the second length, ninety times; at the third length, one hundred and eleven times; at the fourth length, one hundred and forty three times. It does not appear that E. Divinis varied the object lenses.

Philip Bonnani published an account of his two microscopes in 1698;* both were compound; the first was similar to that which Mr. Martin published as new, in his Micrographia Nova,† in 1742. His second was like the former, composed of three glasses, one for the eye, a middle glass, and an object lens; they were mounted in a cylindrical tube, which was placed in an horizontal position; behind the stage was a small tube, with a convex lens at each end; beyond this was a lamp; the whole capable of various adjustments, and regulated by a pinion and rack; the small tube was used to condense the light on the object, and spread it uniformly over it according to its nature, and the magnifying power that was used.

If the reader attentively consider the construction of the foregoing microscopes, and compare them with more modern ones, he will be lead to think with me, that the compound microscope has received very little improvement since the time of Bonnani. Taken separately, the foregoing constructions are equal to some of the most famed modern microscopes. If their advantages be combined, they are far superior to that of M. Dellebarre, notwithstanding the pompous eulogium affixed thereto by Mess. De L'Academie Royale des Sciences.‡

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* Bonnani Observationes circa Viventia.

† Micrographia Nova, by B. Martin, 4to.

‡ Memoires sur les Differences de la Construction et des Effets du Microscope, de M. L. F. Dellebarre, 1777.

From this period, to the year 1736, the microscope appears not to have received any considerable alteration, but the science itself to have been at a stand. The improvements which were making in the reflecting telescope, naturally led those who had considered the subject, to expect a similar advantage would accrue to microscopes on the same principles: accordingly we find two plans of this kind; the first was that of Dr. Robert Barker. This instrument is entirely the same as the reflecting telescope, excepting the distance of the two speculums, which is lengthened, in order to adapt it to those pencils of rays which enter the telescope diverging; whereas, from very distant objects, they come in a direction nearly parallel. But this was soon laid aside, not only as it was more difficult to manage, but also because it was unfit for any but very small or transparent objects: for the object being between the speculum and the image, would, if it were large and opake, prevent a due reflection of light on the object.

The second was contrived by Dr. Smith.* In this there were two reflecting mirrors, one concave and the other convex; the image was viewed by a lens. This microscope, though far from being executed in the best manner, performed, says Dr. Smith, very well, so that he did not doubt but that it would have excelled others, if it had been properly finished.

As some years are more favourable to the fruits of the earth, so also some periods are more favourable to particular sciences, being rich in discovery, and cultivated with ardor. Thus, in the year 1738, Dr. Lieberkühn's invention of the solar microscope was communicated to the public: the vast magnifying power which was obtained by this instrument, the colossal grandeur with which it exhibited the minima of nature, the pleasure which arose from

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* Dr. Smith's Optics, Remarks, p. 94.

being able to display the same object to a number of observers at the same time, by affording a new source of rational amusement, increased the number of microscopic observers, who were further stimulated to the same pursuits by Mr. Trembley's famous discovery of the polype: the wonderful properties of this little animal, together with the works of Mr. Trembley, Baker, and my father, revived the reputation of this instrument.*

Every optician now exercised his talents in improving, as he called it, the microscope; in other words, in varying its construction, and rendering it different from that sold by his neighbour. Their principal object seemed to be, only to subdivide the instrument, and make it lie in as small a compass as possible; by which means, they not only rendered it complex and troublesome in use, but lost sight also of the extensive field, great light, and other excellent properties of the more ancient instruments; and, in some measure, shut themselves out from further improvements on the microscope. Every mechanical instrument is susceptible of almost infinite combinations and changes, which are attended with their relative advantages and disadvantages: thus, what is gained in power, is lost in time; "he that loves to be confined to a small house, must lose the benefit of air and exercise."

The microscope, nearly at the same period, gave rise to M. Buffon's famous system of organic molecules, and M. Needham's incomprehensible ideas concerning a vegetable force and the vitality of matter. M. Buffon has dressed up his system with all the charms of eloquence, presenting it to the mind in the most agreeable and lively colours, exerting the depths of erudition in the most interesting and seducing manner to establish his hypo-

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* Trembley Memoires sur les Polypes. Baker's Microscope made Easy; Attempt towards an History of the Polype; Employment for the Microscope. Adams's Micrographia Illustrata. Joblot's Observations d'Histoire Naturelle.

thesis, making us almost ready to adopt it against the dictates of reason, and the evidence of facts. But whether this great man was misled by the warmth of his imagination, his attachment to a favourite system, or the use of imperfect instruments, it appears but too evident, that he was not acquainted with the objects whose nature he attempted to investigate; and it is probable, that he never saw* those which he supposed he was describing, continually confounding the animalculæ produced from the putrifying decomposition of animal substances, with the spermatic animalculæ, although they are two kinds of beings, differing in form and nature; so that the beautiful fabric attempted to be raised on his hypothesis, vanishes before the light of truth and well conducted experiments.

After this period, the mind, either satisfied with the discoveries already made, which will be particularly described hereafter, or tired by its own exertions, sought for repose in other pursuits; so that for several years this instrument was again, in some measure, laid aside. In 1770, Dr. Hill† published a treatise, in which he endeavoured to explain the construction of timber by the microscope, and shew the number, the nature, and office of its several parts, their various arrangements and proportions in the different kinds; and point out a way of judging, from the structure of trees, the uses they will best serve in the affairs of life. So important a subject soon revived the ardor for microscopic pursuits, which seems to have been increasing ever since. About the same time, my father contrived an instrument for cutting the transverse sections of wood, in order that the texture thereof might be

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* Porro Buffonius, ut cum illustris viri venia dicam, omnino non videtur vermiculos seminales vidisse. Diuturnitas enim vitæ quam suis corpusculis tribuit, ostendit non esse nostra animalcula (id est, spermatica) quibus brevis et paucarum horarum vita est. Haller Physiol. tom. 7.

† Dr. Hill on the Construction of Timber.

rendered more visible in the microscope, and consequently be better understood; this instrument was afterwards improved by Mr. Cumming. Another instrument for the same purpose, more certain in its effects, and more easily managed, is represented in Fig. T. Plate IX; and will be described in one of the following chapters. Dr. Hill and Mr. Custance now endeavoured to bring back the microscope nearer to the old standard, to increase the field by the multiplication of the eye glasses, and to augment the light on the object, by condensing lenses; and in this they happily succeeded: Mr. Custance was unrivalled in his dexterity in preparing, and accuracy in cutting thin transverse sections of wood.

In 1771, my father published a fourth edition of his Micrographia, in which he described the principal inventions then in use; particularly a contrivance of his own, for applying the solar microscope to the camera obscura, and illuminating it at night by a lamp, by which means a picture of microscopic objects might be exhibited in winter evenings.

It appears * from the testimony of M. Æpinus, that Dr. Lieberkühn had considerably improved the solar microscope, by adapting it to view opake objects. This contrivance was by some means lost. The knowledge, however, that such an effect had been produced, led Æpinus to attend to the subject himself, in which he in some measure succeeded, and would, no doubt, have brought it to perfection, if he had increased the size of his illuminating mirror. Some further improvements were made on this instrument by M. Ziehr; but the most perfect instrument of the kind, is that of Mr. B. Martin, who published an account of it in

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* Priestley's Hist. of Optics, p. 743.

the year 1774.* The common solar microscope does not shew the surface of any object, whereas the opake solar microscope not only magnifies the object, but exhibits on a screen an expanded picture of its surface, with all its colours, in a most beautiful manner.

About the year 1774, I invented the improved lucernal microscope; this instrument does not in the least fatigue the eye: it shews all opake objects in a most beautiful manner; and transparent objects may be examined by it in various ways, so that no part of an object is left unexplored; and the outlines of all may be taken with ease, even by those who are most unskilled in drawing.

M. L. F. Dellebarre published an account of his microscope in the year 1777. It does not appear from this, that it was superior in any respect to those that were made in England, but was inferior in others; for those published by my father in 1771 possessed all the advantages of Dellebarre's in a higher degree, except that of changing the eye glasses.

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* Martin's Description and Use of an Opake Solar Microscope. The merits and ingenuity in constructing and improving microscopes by this learned optician, seem to be unnoticed by our late author. The following pamphlets by Mr. B. Martin are, among others of his valuable publications, instances of his indefatigable industry. Description and Use of a Pocket Reflecting Microscope, with a Micrometer; 1739. Micrographia Nova, or a New Treatise on the Microscope; 1742. Description of a New Universal Microscope; a Postscript to his New Elements of Optics; 1759. Description of several Sorts of Microscopes, and the Use of the Reflecting Telescope, as an universal Perspective for viewing every Sort of Objects. Optical Essays; 1770. A Description and Use of a Proportional Camera Obscura, with a Solar Microscope adapted thereto, annexed to his Description of the Opake Solar Microscope above-mentioned. Description of a New Universal Microscope; 1776. Description and Use of a Graphical Perspective and Microscope; 1771. Microscopium Polydynamicum, or a New Construction of a Microscope; 1771. An Essay on the genuine Construction of a standard Microscope and Telescope; 1776. Microscopium Pantometricum, or a new Construction of a Micrometer adapted to the Microscope. The most essential articles in the above works will be hereafter described. EDIT.

In 1784, M. Æpinus published a description of what he termed new-invented microscopes, in a letter to the Academy of Sciences at Petersburgh;* they are nothing more than an application of the achromatic perspective to microscopic purposes. Now it has been long known to every one who is the least versed in optics, that any telescope is easily converted into a microscope, by removing the object glass to a greater distance from the eye glasses; and that the distance of the image varies with the distance of the object from the focus, and is magnified more as its distance from the object is greater: the same telescope may, therefore be successively turned into a microscope, with different magnifying powers. Mr. Martin had also shewn, in his description and use of a polydynamic microscope, how easily the small achromatic perspective may be applied to this purpose. Botanists might find some advantage in attending to this instrument; it would assist them in discovering small plants at a distance, and thus often save them from the thorns of the hedge, and the dirt of a ditch.

Fig. 1. Plate III, represents the improved lucernal microscope.

Fig. 1. Plate IV. The improved compound and single microscope.

Fig. 2. Plate IV. The best universal compound microscope.

Fig. 3. Plate IV, is what is usually called Culpeper's, or the common three pillared compound microscope.

Fig. 1. Plate V, represents Martin's solar opake microscope.

Fig. 4. Plate VI, is a picture of the common solar microscope.

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* Description des Nouveaux Microscopes inventes par M. Æpinus.

Fig. 1. Plate VII. A, is Cuff's common compound microscope.

Fig. 3. Plate VIII. Martin's new microscopic telescope, or convenient portable apparatus for a traveller.

We cannot conclude this chapter better than with the following observations on the microscope. We are indebted to it for many discoveries in natural history; but let us not suppose that the Creator intended to hide these objects from our observation. It is true, this instrument discovers to us as it were a new creation, new series of animals, new forests of vegetables; but he who gave being to these, gave us an understanding capable of inventing means to assist our organs in the discovery of their hidden beauties. He gave us eyes adapted to enlarge our ideas, and capable of comprehending a universe at one view, and consequently incapable of discerning those minute beings, with which he has peopled every atom of the universe. But then he gave properties and qualities to matter of a particular kind, by which it would procure us this advantage, and at the same time elevated the understanding from one degree of knowledge to another, till it was able to discover these assistances for our sight.

It is thus we should consider the discoveries made by those instruments, which have received their birth from an exertion of our faculties. It is to the same power, who created the objects of our admiration, that we are ultimately to refer the means of discovering them. Let no one, therefore, accuse us of prying deeper into the wonders of nature, than was intended by the great author of the universe. There is nothing we discover by their assistance, which is not a fresh source of praise; and it does not appear that our faculties can be better employed, than in finding means to investigate the works of God.

From a partial consideration of these things, we are very apt to criticise what we ought to admire; to look upon as useless what perhaps we should own to be of infinite advantage to us, did we see a little farther; to be peevish where we ought to give thanks; and at the same time to ridicule those who employ their time and thoughts in examining what we were, i. e. some of us most assuredly were created and appointed to study. In short, we are too apt to treat the Almighty worse than a rational man would treat a good mechanic, whose works he would either thoroughly examine, or be ashamed to find any fault with them. This is the effect of a partial consideration of nature; but he who has candor of mind, and leisure to look farther, will be inclined to cry out:

How wond'rous is this scene! where all is form'd
With number, weight, and measure! all design'd
For some great end! where not alone the plant
Of stately growth; the herb of glorious hue,
Or food-full substance! not the laboring steed,
The herd, and flock that feed us; not the mine
That yields us stores for elegance and use;
The sea that loads our table, and conveys
The wanderer man from clime to clime, with all
Those rolling spheres, that from on high shed down
Their kindly influence; not these alone,
Which strike ev'n eyes incurious, but each moss,
Each shell, each crawling insect, holds a rank
Important in the plan of Him, who fram'd
This scale of beings; holds a rank, which lost,
Would break the chain, and leave behind a gap
Which nature's self would rue. Almighty Being,
Cause and support of all things, can I view

These objects of my wonder; can I feel
These fine sensations, and not think of thee?
Thou who dost thro' th' eternal round of time,
Dost thro' th' immensity of space exist
Alone, shalt thou alone excluded be
From this thy universe? Shall feeble man
Think it beneath his proud philosophy
To call for thy assistance, and pretend
To frame a world, who cannot frame a clod?---
Not to know thee, is not to know ourselves---
Is to know nothing---nothing worth the care
Of man's exalted spirit:---all becomes,
Without thy ray divine, one dreary gloom,
Where lurk the monsters of phantastic brains,
Order bereft of thought, uncaus'd effects,
Fate freely acting, and unerring chance.
Where meanless matter to a chaos sinks,
Or something lower still, for without thee
It crumbles into atoms void of force,
Void of resistance---it eludes our thought.
Where laws eternal to the varying code
Of self-love dwindle. Interest, passion, whim,
Take place of right and wrong, the golden chain
Of beings melts away, and the mind's eye
Sees nothing but the present. All beyond
Is visionary guess---is dream--- is death.*

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* Stillingfleet's Miscellaneous Tracts.

CHAP. II.

OF VISION; OF THE OPTICAL EFFECT OF MICROSCOPES, AND OF THE MANNER OF ESTIMATING THEIR MAGNIFYING POWERS.

THE progress that has been made in the science of optics, in the last and present century, particularly by Sir Isaac Newton, may with propriety be ranked among the greatest acquisitions of human knowledge. And Mess. Delaval and Herschel have shewn by their discoveries, that the boundaries of this science may be considerably enlarged.

The rays of light, which minister to the sense of sight, are the most wonderful and astonishing part of the inanimate creation; of which we shall soon be convinced, if we consider their extreme minuteness, their inconceivable velocity, the regular variety of colours they exhibit, the invariable laws according to which they are acted upon by other substances, in their reflections, inflections, and refractions, without the least change of their original properties; and the facility with which they pervade bodies of the greatest density and closest texture, without resistance, without crouding or disturbing each other. These, I believe, will be deemed sufficient proofs of the wonderful nature of these rays; without adding, that it is by a peculiar modification of them, that we are indebted for the advantages obtained by the microscope.

The science of optics, which explains and treats of many of the properties of those rays of light, is deduced from experiments, on which all philosophers are agreed. It is impossible to give an adequate idea of the nature of vision, without a knowledge of these experiments, and the mathematical reasoning grounded upon them; but as to do this would alone fill a large volume, I shall only endeavour to render some of the more general principles clear, that the reader, who is unacquainted with the science of optics, may nevertheless be enabled to comprehend the nature of vision by the microscope. Some of the most important of these principles may be deduced from the following very interesting experiment.

Darken a room, and let the light be admitted therein only by a small hole; then, if the weather be fine, you will see on the wall, which is facing the hole, a picture of all those exterior objects which are opposite thereto, with all their colours, though these will be but faintly seen. The image of the objects that are stationary, as trees, houses, &c. will appear fixed; while the images of those that are in motion, will be seen to move. The image of every object will appear inverted, because the rays cross each other in passing through the small hole. If the sun shine on the hole, we shall see a luminous ray proceed in a strait line, and terminate on the wall. If the eye be placed in this ray, it will be in a right line with the hole and the sun: it is the same with every other object which is painted on the wall. The images of the objects exhibited on the same plane, are smaller in proportion as the objects are further from the hole.

Many and important are the inferences which may be deduced from the foregoing experiment, among which are the following:

1. That light flows in a right line.

2. That a luminous point may be seen from all those places to which a strait line can be drawn from the point, without meeting with any obstacle; and consequently,

3. That a luminous point, by some unknown power, sends forth rays of light in all directions, and is the center of a sphere of light, which extends indefinitely on all sides; and if we conceive some of these rays to be intercepted by a plane, then is the luminous point the summit of a pyramid, whose body is formed by the rays, and its base by the intercepting plane. The image of the surface of an object, which is painted on the wall, is also the base of a pyramid of light, the apex of which is the hole; the rays which form this pyramid, by crossing at the hole, form another, similar and opposite to this, of which the hole is also the summit, and the surface of the object the base.

4. That an object is visible, because all its points are radiant points.

5. That the particles of light are indefinitely small; for the rays, which proceed from the points of all the objects opposite to the hole, pass through it, though extremely small, without embarrassing or confounding each other.

6. That every ray of light carries with it the image of the object from which it was emitted.

The nature of vision in the eye may be imperfectly illustrated by the experiment of the darkened room; the pupil of the eye being considered as the hole through which the rays of light pass, and cross each other, to paint on the retina, at the bottom of the eye, the inverted images of all those objects which are exposed to the sight, so that the diameters of the images of the same object are greater, in proportion to the angles formed at the pupil, by the crossing rays which proceed from the extremities of the object; that is, the diameter of the image is greater, in proportion as the distance is less; or, in other words, the apparent magnitude of an object is in some degree measured by the angle under which it is seen, and this angle increases or diminishes, according as the object is nearer to, or farther from the eye; and consequently, the less the distance is between the eye and the object, the larger the latter will appear.

From hence it follows, that the apparent diameter of an object seen by the naked eye, may be magnified in any proportion we please; for, as the apparent diameter is increased, in proportion as the distance from the eye is lessenned, we have only to lessen the distance of the object from the eye, in order to increase the apparent diameter thereof.* Thus, suppose there is an object, A B, Plate I. Fig. 1, which to an eye at E subtends or appears under the angle A E B, we may magnify the apparent diameter in what proportion we please, by bringing our eye nearer to it. If, for instance, we would magnify it in the proportion of F G to A B; that is, if we would see the object under an angle as large as F E G, or would make it appear the same length that an object as long as F G would appear, it may be done by coming nearer to the object. For the apparent diameter is as the distance inversely; therefore, if C D is as much less than C E, as F G is greater than A B, by bringing the eye nearer to the object in the proportion of C D to E D, the apparent diameter will be magnified in the proportion of F G to A B; so that the object A B, to the eye at D, will appear as long as an object F G would appear to the eye at E. In the same manner we might shew, that the apparent diameter of an object, when seen by the naked

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* Rutherforth's System of Natural Philosophy, p. 330.

eye, may be infinite. For since the apparent diameter is reciprocally as the distance of the eye, when the distance of the eye is nothing, or when the eye is close to the object at C, the apparent diameter will be the reciprocal of nothing, or infinite.

There is, however, one great inconvenience in thus magnifying an object, without the help of glasses, by placing the eye nearer to it. The inconvenience is, that we cannot see an object distinctly, unless the eye is about five or six inches from it; therefore, if we bring it nearer to our eye than five or six inches, however it may be magnified, it will be seen confusedly. Upon this account, the greatest apparent magnitude of an object that we are used to, is the apparent magnitude when the eye is about five or six inches from it: and we never place an object much within that distance; because, though it might be magnified by these means, yet the confusion would prevent our deriving any advantage from seeing it so large. The size of an object seems extraordinary, when viewed through a convex lens; not because it is impossible to make it appear of the same size to the naked eye, but because at the distance from the eye which would be necessary for this purpose, it would appear exceedingly confused; for which reason, we never bring our eye so near to it, and consequently, as we have not been accustomed to see the object of this size, it appears an extraordinary one.

On account of the extreme minuteness of the atoms of light, it is clear, a single ray, or even a small number of rays, cannot make a sensible impression on the organ of sight, whose fibres are very gross, when compared to these atoms; it is necessary, therefore, that a great number should proceed from the surface of an object, to render it visible. But as the rays of light, which proceed from an object, are continually diverging, different methods have been contrived, either of uniting them in a given point, or of separating them at pleasure: the manner of doing this is the subject of dioptrics and catoptrics.

By the help of glasses, we unite in the same sensible point a great number or rays, proceeding from one point of an object; and as each ray carries with it the image of the point from whence it proceeded, all the rays united must form an image of the object from whence they were emitted. This image is brighter, in proportion as there are more rays united; and more distinct, in proportion as the order, in which they proceeded, is better preserved in their union. This may be rendered evident; for, if a white and polished plane be placed where the union is formed, we shall see the image of the object painted in all its colours on this plane; which image will be brighter, if all adventitious light be excluded from the plane on which it is received.

The point of union of the rays of light, formed by means of a glass lens, &c. is called the FOCUS.

Now, as each ray carries with it the image of the object from whence it proceeded, it follows, that if those rays, after intersecting each other, and having formed an image at their intersection, are again united by a refraction or reflection, they will form a new image, and that repeatedly, as long as their order is not confounded or disturbed.

It follows also, that when the progress of the luminous ray is under consideration, we may look on the image as the object, and the object as the image; and consider the second image as if it had been produced by the first as an object, and so on.

In order to gain a clear idea of the wonderful effects produced by glasses, we must proceed to say something of the principles of refraction.

Any body, which is so constituted as to yield a passage to the rays of light, is called a MEDIUM. Air, water, glass, &c. are mediums of light. If any medium afford an easy passage to the rays of light, it is called a RARE MEDIUM; but if it do not afford an easy passage to these rays, it is called a DENSE MEDIUM.

Let Z, Fig. 2. Plate I. be a rare medium, and Y a dense one; and let them be separated by the plane surface G H. Let I K be a perpendicular to it, and cutting it in C.

With the center C, and any distance, let a circle be described. Then let A C be a ray of light, falling upon the dense medium. This ray, if nothing prevented, would go forward to L; but because the medium Y is supposed to be denser than Z, it will be bent downward toward the perpendicular I K, and describe the line C B.

The ray A C is called the INCIDENT RAY; and the ray C B, the REFRACTED RAY.

The angle A C I is called the ANGLE OF INCIDENCE, and the angle B C K is called the ANGLE OF REFRACTION.

If from the point A upon the right line C I, there be let fall the perpendicular A D, that line is called the sine of the angle of incidence.

In the same manner, if from the point B, upon the right line I K, there be let fall the perpendicular B E, that line will be the sine of the angle of refraction.

The sines of the angles are the measures of the refractions, and this measure is constant; that is, whatever is the sine of the angle of incidence, it will be in a constant proportion to the sine of the angle of refraction, when the mediums continue the same. A general idea of refraction may be formed from the following experiments.

Experiment 1. Let A B C D, Fig. 3. Plate I. represent a vessel so placed, with respect to the candle E, that the shadow of the side A C may fall at D. Suppose the vessel to be now filled with water, and the shadow will withdraw to d; the ray of light, instead of proceeding to D, being refracted or bent to d. And there is no doubt but that an eye, placed at d, would see the candle at e, in the direction of the refracted ray d A. This is also confirmed by the following pleasing experiment.

2. Lay a shilling, or any piece of money, at the bottom of a bason; then withdraw from the bason, till you lose sight of the shilling; fill the bason nearly with water, and the shilling will be seen very plainly, though you are at the same distance from it.

3. Place a stick over a bason which is filled with water; then reflect the sun's rays, so that they may fall perpendicularly on the surface of the water; the shadow of the stick will fall on the same place, whether the vessel be empty or full.

What has been said of water, may be applied to any transparent medium, only the power of refraction is greater in some than in others. It is from this wonderful property, that we derive all the curious effects of glass, which make it the subject of optics. It is to this we owe the powers of the microscope and the telescope.

To produce these effects, pieces of glass are formed into given figures, which, when so formed, are called lenses. The six following figures are those which are most in use for optical purposes.

1. A PLANE GLASS, one that is flat on each side, and of an equal thickness throughout. F, Fig. 13. Plate I.

2. A DOUBLE CONVEX GLASS, one that is more elevated towards the middle than the edge. B, Fig. 13. Plate I.

3. A DOUBLE CONCAVE is hollow on both sides, or thinner in the middle than at the edges. D, Fig. 13. Plate I.

4. A PLANO CONVEX, flat on one side, and convex on the other. A, Fig. 13. Plate I.

5. A PLANO CONCAVE, flat on one side, and concave on the other. C, Fig. 13. Plate I.

6. A MENISCUS, convex on one side, concave on the other. E, Fig. 13. Plate I.

It has been already observed, that light proceeds invariably from a luminous body, in strait lines, without the least deviation; but if it happen to pass from one medium to another, it always leaves the direction it had before, and assumes a new one. After having taken this new direction, it proceeds in a strait line, till it meets with a different medium, which again turns it out of its course.

A ray of light passing obliquely through a plane glass, will go out in the same direction it entered, though not precisely in the same line. The ray CD, Fig. 4. Plate I. falling obliquely upon the surface of the plane glass AB, will be refracted towards the glass in the direction D E; but when it comes to E, it will be as much refracted the contrary way. If the ray of light had fallen perpendicularly on the surface of the plane glass, it would have passed through it in a strait line, and not have been refracted at all.

If parallel rays of light, as a b c d e f g, Fig. 6. Plate I. fall directly upon a convex lens A B, they will be so bent, as to unite in a point C behind it. For the ray d D which falls perpendicularly upon the middle of the glass, will go through it without suffering any refraction: but those which go through the sides of the lens, falling obliquely on its surface, will be so bent, as to meet the central ray at C. The further the ray a is from the axis of the lens, the more obliquely it will fall upon it. The rays a b c d e f g will be so refracted, as to meet or be collected in the point C, called the principal focus, whose distance, in a double convex lens, is equal to the radius or semi-diameter of the sphere of the convexity of the lens. All the rays cross the middle ray at C, and then diverge from it to the contrary side, in the same manner as they were before converged.

If another lens, of the same convexity, as A B, Fig. 6. Plate I. be placed in the rays, and at the same distance from the focus, it will refract them, so that after going out of it, they will all be parallel again, and go on in the same manner as they came to the first glass A B, but on the contrary sides of the middle ray.

The rays diverge from any radiant point, as from a principal focus: therefore, if a candle be placed at C, in the focus of the convex lens A B, Fig. 6. Plate I. the rays diverging from it will be so refracted by the lens, that after going out of it, they will become parallel. If the candle be placed nearer the lens than its focal distance, the rays will diverge more or less, as the candle is more or less distant from the focus.

If any object, A B, Fig. 7. Plate I. be placed beyond the focus of the convex lens E F, some of the rays which flow from every point of the object, on the side next the glass, will fall upon it, and after passing through it, they will be converged into as many points on the opposite side of the glass; for the rays a b, which flow from the point A, will converge into *a b*, and meet at C. The rays c d, flowing from the point G, will be converged into *c d*, and meet at g; and the rays which flow from B, will meet each other again at D; and so of the rays which flow from any of the intermediate points: for there will be as many focal points formed, as there are radiant points in the object, and consequently they will depict on a sheet of paper, or any other light-coloured body, placed at D g C, an inverted image of the object. If the object be brought nearer the lens, the picture will be formed further off. If it be placed at the principal focus, the rays will go out parallel, and consequently form no picture behind the glass.

To render this still plainer, let us divest what has been said of the A's and B's, and of the references to figures. When objects are viewed through a flat or plane glass, the rays of light in passing through it, from the object to the eye, proceed in a strait direction and parallel to each other, and consequently the object appeared at the same distance as to the naked eye, neither enlarged or diminished. But if the glass be of a convex form, the rays of light change their direction in passing through the glass, and incline from the circumference towards the center of convexity, in an angle proportional to the convexity, and meet at a point at a less or greater distance from the glass, as it is more or less convex. The point where the rays thus meet is called the focus; when, therefore, the convexity is small, the focus is at a great distance, but when it is considerable, the focus is near; the magnifying power is in proportion to the change made in the rays, or the degree of convexity, by which we are enabled to see an object nearer than we otherwise could; and the nearer it is brought to the eye, the larger will be the angle under which it appears, and consequently the more it will be magnified.

The human eye is so constituted, that it can only have distinct vision, when the rays which fall on it are parallel, or nearly so; because the retina, on which the image is painted, is placed in the focus of the crystalline humor, which performs the office of a lens in collecting rays, and forming the image in the bottom of the eye.

As an object becomes perceptible to us, by means of the image thereof which is formed on the retina, it will, therefore, be seen in that direction, in which the rays enter the eye to form the image, and will always be found in the line, in which the axis of a pencil of rays flowing from it enters the eye. We from hence acquire a habit of judging the object to be situated in that line. Note; as the mind is unacquainted with the refraction the rays suffer before they enter the eye, it judges them to be in the line produced back, in which the axis of a pencil of rays flowing from it is situated, and not in that in which it was before the refraction.

If the rays, therefore, that proceed from an object, are refracted and reflected several times before they enter the eye, and these refractions or reflections change considerably the original direction of the rays which proceed from the object, it is clear, that it will not be seen in that line, which would come strait from it to the eye; but it will be seen in the direction of those rays which enter the eye, and form the image thereof on it.

We perceive the presence and figure of objects, by the impression each respective image makes on the retina; the mind, in consequence of these impressions, forms conclusions concerning the size, position, and motion of the object. It must however be observed, that these conclusions are often rectified or changed by the mind, in consequence of the effects of more habitual impressions. For example, there is a certain distance, at which, in the general business of life, we are accustomed to see objects: now, though the measure of the image of these objects changes considerably when they move from, or approach nearer to us, yet we do not perceive that their size is much altered; but beyond this distance, we find the objects appear to be diminished, or increased, in proportion as they are more or less distant from us.

For instance, if I place my eye successively at two, at four, and at six feet from the same person, the dimensions of the image on the retina will be nearly in the proportion of 1, of $\frac{1}{2}$, of $\frac{1}{3}$, and consequently they should appear to be diminished in the same proportion; but we do not perceive this diminution, because the mind has rectified the impression received on the retina. To prove this, we need only consider, that if we see a person at 120 feet distance, he will not appear so strikingly small, as if the same person should be viewed from the top of a tower, or other building 120 feet high, a situation to which we had not been accustomed.

From hence, also, it is clear, that when we place a glass between the object and the eye, which from its figure changes the direction of the rays of light from the object, this object ought not to be judged as if it were placed at the ordinary reach of the sight, in which case we judge of its size more by habit than by the dimensions of the images formed on the retina; but it must be estimated by the size of the image in the eye, or by the angle formed at the eye, by the two rays which come from the extremity of the object.

If the image of an object, formed after refraction, be greater or less than the angle formed at the eye, by the rays proceeding from the extremities of the object itself, the object will appear also proportionably enlarged or diminished; so that if the eye approach to or remove from the last image, the object will appear to increase or diminish, though the eye should in reality remove from it in one case, or approach toward it in the other; because the image takes place of the object, and is considered instead of it.

The apparent distance of an object from the eye, is not measured by the real distance from the last image; for, as the apparent distance is estimated principally by the ideas we have of their size, it follows, that when we see objects, whose images are increased or diminished by refraction, we naturally judge them to be nearer or further from the eye, in proportion to the size thereof, when compared to that with which we are acquainted. The apparent distance of an object is considerably affected by the brightness, distinctness, and magnitude thereof. Now as these circumstances are, in a certain degree, altered by the refraction of the rays, in their passing through different mediums, they will also, in some measure, affect the estimation of the apparent distance.

In the theory of vision it is necessary to be cautious not to confound the organs of vision with the being that perceives, or with the perspective faculty. The eye is not that which sees, it is only the organ by which we see. A man cannot see the satellites of Jupiter but by a telescope. Does he conclude from this, that it is the telescope that sees those stars? By no means; such a conclusion would be absurd. It is no less absurd to conclude, that it is the eye that sees. The telescope is an artificial organ of sight, but it sees not. The eye is a natural organ of sight, by which we see; but the natural organ sees as little as the artificial.

The eye is a machine, most admirably contrived for refracting the rays of light, and forming a distinct picture of objects upon the retina; but it sees neither the object nor the picture. It can form the picture after it is taken out of the head, but no vision ensues. Even when it is in its proper place, and perfectly sound, it is well known, that an obstruction in the optic nerve takes away vision, though the eye has performed all that belongs to it.*

OF THE SINGLE MICROSCOPE.

The single microscope renders minute objects visible, by means of a small glass globule, or convex lens, of a short focus. Let E Y, Fig. 11. Plate I. represent the eye; and O B a small object, situated very near to it; consequently, the angle of its apparent magnitude very large. Let the convex lens R S be interposed between the eye and the object, so that the distance between it and the object may be equal to the focal length; and the rays which diverge from the object, and pass through the lens, will afterwards proceed, and consequently enter the eye parallel: after which, they will be converged, and form an inverted picture on the retina, and the object will be clearly seen; though, if removed to the distance of six inches, its smallness would render it invisible.

When the lens is not held close to the eye, the object is somewhat more magnified; because the pencils, which pass at a dis-

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* Reid on the Intellectual Powers of Man, p. 78.

tance from the center of the lens, are refracted inward toward the axis, and consequently seem to come from points more remote from the center of the object, as may be seen in Fig. 12. Plate I. where the pencils which proceed from O and B are refracted inwards, and seem to come from the point i and m.

Fig. 8. Plate I. may, perhaps give the reader a still clearer view, why a convex lens increases the angle of vision. Without a lens, as F G, the eye at A would see the dart B C under the angle b A c; but the rays B F and C G from the extremities of the dart in passing through the lens, are refracted to the eye in the directions f A and G a, which causes the dart to be seen under the much larger angle D A E (the same as the angle f A g.) And therefore the dart B C will appear so much magnified, as to extend in length from D to E.

The object, when thus seen distinctly, by means of a small lens, appears to be magnified nearly in the proportion which the focal distance of the glass bears to the distance of the objects, when viewed by the naked eye.

To explain this further, place the eye close to the glass, that as much of the object may be seen at one view as is possible; then remove the object to and fro, till it appear perfectly distinct, and well defined; now remove the lens, and substitute in its place a thin plate, with a very small hole in it, and the object will appear as distinct, and as much magnified, as with the lens, though not quite so bright; and it appears as much more magnified in this case, than it does when viewed with the naked eye, as the distance of the object from the hole, or lens, is less than the distance at which it may be seen distinctly with the naked eye.

From hence we see, that the whole effect of the lens is to render the object distinct, which it does by assisting the eye to increase the refraction of the rays in each pencil; and that the apparent magnitude is entirely owing to the object being seen so much nearer the eye than it could be viewed without it.

Single microscopes magnify the diameter of the object,* as we have already shewn, in the proportion of the focal distance (to the limits of distinct vision with the naked eye) to eight inches. For example, if the semi-diameter of a lens, equally convex on both sides, be half an inch, which is also equal to its focal distance, we shall have as $\frac{1}{2}$ is to 8, so is 1 to 16; that is, the diameter of the object in the proportion of sixteen to one. 2. As the distance of eight inches is always the same, it follows, that by how much the focal distance is smaller, there will be a greater difference between it and the eight inches; and consequently, the diameter of the object will be so much the more magnified, in proportion as the lenses are segments of smaller spheres. 3. If the object be placed in the focus of a glass globule or sphere, and the eye be behind it in the focus, the object will be seen distinct in an erect situation, and magnified as to its diameter, in the proportion of $\frac{3}{4}$ of the diameter of the globule to eight inches; thus suppose the diameter of the sphere to be $\frac{1}{10}$ of an inch, then $\frac{3}{4}$ of this will be equal to $\frac{3}{40}$; consequently, the real diameter of the object to the apparent one, as $\frac{3}{40}$ to 8, or as 3 to 320, or as 1 to 106 nearly.

OF THE DOUBLE OR COMPOUND MICROSCOPE.

In the compound microscope, the image is viewed instead of the object, which image is magnified by a single lens, as the object is in a single microscope. It consists of an object lens N L,

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* Cyclopedia, Article Microscope.

Fig. 5. Plate I. and an eye glass F G. The object B O is placed a little further from the lens than its principal focal distance, so that the pencils of rays proceeding from the different points of the object through the lens, may converge to their respective foci, and form an inverted image of the object at Q P; which image is viewed by the eye through the eye glass F G, which is so placed, that the image may be in its focus on one side, and the eye at the same distance on the other. The rays of each pencil will be parallel, after passing out of the glass, till they reach the eye at E, where they will begin to converge by the refractive powers of the humours; and after having crossed each other in the pupil, and passed through the crystalline and vitreous humours, they will be collected in points on the retina, and form a large inverted image thereon.

It will be easy, from what has been already explained, to understand the reason of the magnifying power of a compound microscope. The object is magnified upon two accounts; first, because if we viewed the image with the naked eye, it would appear as much larger than the object, as the image is really larger than it, or as the distance f R is greater than the distance f b; and secondly, because this picture is again magnified by the eye glass, upon the principle explained in the foregoing article on vision, by single microscopes.

But it is to be noted, that the image formed in the focus of a lens, as is the case in the compound microscope, differs from the real object in a very essential particular; that is to say, the light being emitted from the object in every direction, renders it visible to an eye placed in any position; but the points of the image formed by a lens, emitting no more than a small conical body of rays, which arrives from the glass, can be visible only when the eye is situate within its confine. Thus the pencil, which emanates from o in the object, and is converged by the lens to D, proceeds afterwards diverging towards H, and, therefore, never arrives at the lens F G, nor enters the eye at E. But the pencils which proceed from the points o and b, will be received on the lens F G, and by it carried parallel to the eye; consequently, the correspondent points of the image Q P will be visible; and those which are situate farther out towards H and I, will not be seen. This quantity of the image Q P, or visible area, is called the field of view.

Hence it appears, that if the image be large, a very small part of it will be visible; because the pencils of rays will for the most part fall without the eye glass F G. And it is likewise plain, that a remedy which would cause the pencils, which proceed from the extremes B and O of the object, to arrive at the eye, will render a greater part of it visible: or, in other words, enlarge the field of view. This is effected by the interposition of a broad lens D E, Fig. 5, of a proper curvature, at a small distance from the focal image. For, by those means, the pencil D N, which would otherwise have proceeded towards H, is refracted to the eye, as delineated in the figure, and the mind conceives from thence the existence of a radiant point at Q, from which the rays last proceeded. In like manner, and by a parity of reason, the other extreme of the image is seen at P, and the intermediate points are also rendered visible. On these considerations it is, that compound microscopes are usually made to consist of an object lens N L, by which the image is formed, enlarged, and inverted; an amplifying lens D E, by which the field of view is enlarged, and an eye glass or lens, by which the eye is allowed to approach very near, and consequently to view the image under a very great angle of apparent magnitude. It is now customary to combine two or more lenses together at the eye glass, in the manner of Eustachio Divinis and M. Joblot; by which means the aberration of light from the figure is in some measure corrected, and the apparent field increased.

OF THE SOLAR MICROSCOPE.

In this instrument, the image of the object is refracted upon a screen in a darkened room. It may be considered under two distinct heads: 1st, the mirror and lens, which are intended to reflect and transmit the light of the sun upon the object; and 2dly, that part which constitutes the microscope, or which produces the magnified image of the object, Fig. 10. Plate I. Let N O represent the side of a darkened chamber, G H a small convex lens, fixed opposite to a perforation in the side N O, A B a plane mirror or looking glass, placed without the room to reflect the solar rays on the lens C D, by which they are converged and concentrated on the object fixed at E F.

2. The object being thus illuminated, the ray which proceeds from E will be converged by the lens G H to a focus K, on the screen L M; and the ray which comes from F will be converged to I, and the intermediate points will be delineated between I and K; thus forming a picture, which will be as much larger than the object, in proportion as the distance of the screen exceeds that of the image from the object; a small object, such as a mite, &c. may be thus magnified to eight or ten feet in diameter.

From what has been said, it appears plainly, the advantages we gain by microscopes are derived, first, from their magnifying power, by which the eye is enabled to view more distinctly the parts of minute objects: secondly, that by their assistance, more light is thrown into the pupil of the eye, than is done without them. The advantages procured by the magnifying power, would be exceedingly circumscribed, if they were not accompanied by the latter: for if the same quantity of light be diffused over a much larger surface, its force is proportionably diminished; and therefore the object, though magnified, will be dark and obscure. Thus, suppose the diameter of the object to be enlarged ten times, and consequently the surface one-hundred times, yet, if the focal distance of the glass were eight inches, provided this were possible, and its diameter only about the size of the pupil of the eye, the object would appear one-hundred times more obscure when viewed through the glass, than when it was seen by the naked eye; and this even on the supposition that the glass transmitted all the light which fell upon it, which no glass can do. But if the glass were only four inches focal distance, and its diameter remained as before, the inconvenience would be vastly diminished, because the glass could be placed twice as near the object as before, and would consequently receive four times as many rays as in the former case, and we should, therefore, see it much brighter than before. By going on thus, diminishing the focal distance of the glass, and keeping its diameter as large as possible, we shall perceive the object proportionably magnified, and yet remain bright and distinct. Though this is the case in theory, yet there is a limit in optical instruments, which is soon arrived at, but which cannot be passed. This arises from the following circumstances.*

1. The quantity of light lost in passing through the glass.

2. The diminution in the diameter of the glass or lens itself, by which it receives only a small quantity of rays.

3. The extreme shortness of the focal distance of great magnifiers, whereby the free access of the light to the object we wish

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* Encyclopedia Britannica, last edition, vol. xiii. p. 357.

to view is impeded, and consequently the reflection of the light from it is weakened.

4. The aberration of the rays, occasioned by their different refrangibility.

To make this more clear, let us suppose a lens made of such dull kind of glass, that it transmits only one half the light that falls upon it. It is evident, that supposing this lens to be of four inches focus, and to magnify the diameter of the object twice, and its own breadth equal to that of the pupil of the eye, the object will be four times magnified in surface, but only half as bright as if it was seen by the naked eye at the usual distance; for the light which falls upon the eye from the object at eight inches distance, and likewise the surface of the object in its natural size, being both represented by 1, the surface of the magnified object will be 4, and the light which makes it visible only 2; because, though the glass receives four times as much light as the naked eye does at the usual distance of distinct vision, yet one half is lost in passing through the glass. The inconvenience, in this respect, can only be removed so far as it is possible to increase the transparency of the glass, that it may transmit nearly all the rays which fall upon it; and how far this can be done, has not been yet ascertained.

The second obstacle to the perfection of microscopic glasses, is the small size of great magnifiers; by which means, notwithstanding their near approach to the object, they receive a smaller quantity of light than might be expected. Thus, suppose a glass of only one-tenth of an inch focal distance, such a glass would increase the visible diameter eighty times, and the surface 6400 times. If the breadth of the glass could at the same time be preserved as great as the pupil of the eye, which we shall suppose one-tenth of an inch, the object would appear magnified 6400 times, and every part would be as bright as it appears to the naked eye. But if we suppose the lens to be only $\frac{1}{20}$ of an inch diameter, it will then only receive one-fourth of the light which would otherwise have fallen upon it; therefore, instead of communicating to the magnified object a quantity of light equal to 6400, it would communicate an illumination suited only to 1600, and the magnified object would appear four times as dim as it does to the naked eye. This inconvenience can, however, in a great degree be removed, by throwing a much larger quantity of light on the object. Various methods of effecting this purpose will be pointed out in the course of this work.

The third obstacle arises from the shortness of the focal distance in large magnifiers; this inconvenience can, like the former, be remedied in some degree, by artificial means of accumulating light; but still the eye is strained, as it must be brought nearer the glass than it can well bear, which in some measure supersedes the use of very deep lenses, or such as are capable of magnifying beyond a certain degree.

The fourth obstacle arises from the different refrangibility of the rays of light, which frequently causes such deviations from truth in the appearance of things, that many have imagined themselves to have made surprising discoveries, and have communicated them as such to the world; when, in fact, they have been only so many optical deceptions, owing to the unequal refraction of the rays. In telescopes, this error has been happily corrected by the late Mr. Dollond's valuable discovery of achromatic glasses; but how far this invention is applicable to the improvement of microscopes, has not yet been ascertained; and, indeed, from some few trials made, there is reason for supposing they cannot be successfully applied to microscopes with high powers; so that this improvement is yet a desideratum in the construction of microscopes, and they may be considered as being yet far from their ultimate degree of perfection.*

OF THE MAGNIFYING POWERS OF THE MICROSCOPE.

We have already treated of the apparent magnitude of objects, and shewn that they are measured by the angles under which they are seen, and that this angle is greater or smaller according as the object is nearer to, or further from, the eye; and, consequently, the less the distance at which it can be viewed, the larger it will appear: but from the limits of natural vision, the naked eye cannot distinguish an object that is very near to it; yet, when assisted by a convex lens, distinct vision is obtained, however short the focus of the lens, and, consequently, how near soever the object is to the eye; and the shorter the focus of the lens is, the greater will be the magnifying power thereof. From these considerations, it will not be difficult to estimate the magnifying power of any lens used as a single microscope; for this will be in the same proportion that the limits of natural sight bear to the focus of the lens. If, for instance, the convex lens is of one inch focus, and the natural sight of eight inches, an object seen through that lens will have its diameter apparently increased eight times; but, as the object is increased in every direction, we must square this apparent diameter, to know how much the object is really magnified; and thus multiplying 8 by 8, we find the superficies is magnified 64 times.

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* How many useful and ingenious discoveries have arisen from accidental circumstances? To adduce one recent instance only—Aerostation, a science, which after having baffled the skill and ingenuity of philosophers for a series of years, and by many illiterate persons deemed an idea bordering on absurdity, has been of late discovered, and usefully applied to practice.

EDIT.

From these principles, the following general rule for ascertaining the magnifying power of single lenses, is deduced. Place a small thin transparent object on the stage of the microscope, adjust the lens till the object appears perfectly distinct, then measure the distance accurately between the lens and the object, reduce the measure thus found to the hundredths of an inch, and calculate how many times this measure is contained in eight inches, first reducing the eight inches into hundredths, which will give you the number of times the diameter of the object is magnified; which number multiplied into itself, or squared, gives the apparent superficial magnitude of the object.

As only one side of an object can be viewed at a time, it is sufficient, in general, to know how much the surface thereof is magnified: but when it is necessary to know how many minute objects are contained in a larger, as for instance, how many given animalculæ are contained in the bulk of a grain of sand, then we must cube the first number, by which means we shall obtain the solidity or magnified bulk.

The foregoing rule has been also applied to estimate the magnifying power of the compound microscope. To this application, Mr. Magny, in the " Journal d'Economie pour les mois d'Aout 1753," has made several objections: one or two of these I shall just mention; the first is the difficulty of ascertaining with accuracy the precise focus of a small lens; the second is the want of a fixed or known measure, with which to compare the focus when ascertained. These considerations, though apparently trifling, will be found of importance in the calculations which are relative to deep magnifiers. To this it may be further added, that the same standard or fixed measure cannot be assumed for a short-sighted, that is used for a well-constituted eye. To obviate these difficulties, and some errors in the methods which were recommended by Mess. Baker and Needham, Mr. Magny offers the following

Proposition. All convex lenses of whatsoever foci, double the apparent diameter of an object, provided that the object be at the focus of the glass on one side, and the eye be at the same distance, or on the focus of the glass, at the opposite side.

Experiment. Take a double convex lens, of six or eight inches focus, and fix it as at A, Fig. 1, Plate II. A, into the piece A, which is fixed perpendicular to the rule F G, and may be slid along it by means of its socket: the rule is divided into inches and parts. Paste a piece of white paper, two or three tenths of an inch broad, and three inches long, on the board D; draw three lines with ink on this piece of paper, so as to divide it into four equal parts, taking care that the middle of the paper corresponds with the center of the lens. There is also a sliding eye-piece, which is represented at e.

Take this apparatus into the darkest part of the room, but opposite to the window; direct the glass towards any remarkable and distant object which is out of doors, and move the sliding piece B, until the image of the object on the paper be sharp and clear. The distance between the face of the paper and the lens (which is shewn on the side of the rule by the divisions thereon) is the focus of the glass; now set the eye-piece e E to the same distance on the other side of the glass, then with one eye close to the sight at e, look at the magnified image of the lines, and with the other eye at the lines themselves: the image, seen by means of the glass, and expressed in the figure by the dotted lines, will be double the breadth of the same object seen by the natural eye. This will be found to be true, whatsoever is the focus of the lens with which the experiment is made.

This experiment is rendered more simple to those who are not accustomed to observe with both eyes at the same time, by making use of half a lens, and placing the diameter perpendicular to the rule, as they may then readily view the magnified image and real object with the same glance of the eye, and thus compare them together with ease and accuracy.

Let the angle A F B, Fig. 3. Plate II. A, represent that which is formed at the naked eye, by the rays of light which pass from the extremities of the object, and unite at the eye in the point F. The angle D F E is formed of the two rays, which at first proceeded parallel to each other from the extremities of the object, but that were afterwards so refracted, or bent, by passing through the glass, as to unite at its focal point F. C O is equal to the focal distance of the lens on the side next the object, C F equal thereto on the side next the eye, F O the distance of the eye.

From the allowed principles of optics, it is evident, that the object would appear double the size to the eye at C, that it would to the eye when placed at F; because the distance F O is double the distance C O. We have only to prove then, that the angle A C B is equal to the angle I F K, in order to establish the proposition.

The optical axis is perpendicular to the glass and the surface of the object. The rays A I, B K, which flow from the points A B, are parallel to each other, and perpendicular to the glass, till they arrive at it; they are then refracted and proceed to F, where they form the triangle I F K, resting on the base I K: now as C F is equal to C O, and I K is equal to A B, the two triangles A C B, I F K, are similar, and consequently the angle at C is equal to the angle F. If the visual rays are continued to the surface of the object, they will form the triangle D F E, equiangled to the triangle A B C; and therefore, as C O is to A B, so is F D to D E; and consequently, the apparent diameter of the object seen through the lens is double the size that it is when viewed by the naked eye. No notice is here taken of the double refraction of the rays, as it does not affect the demonstration.

If you advance towards M, half the focal distance, the apparent diameter will be only increased one-third. If, on the contrary, the point of sight is lengthened to double the distance of its focus, then the magnified diameter will appear to be three times that of the real object. Mr. Magny concludes from hence, that there is an impropriety in estimating the magnifying power of the eye glass of compound microscopes, by seeing how often its focus is contained in eight or ten inches; and to obviate these defects, he recommends two methods to be used, which reciprocally confirm each other.

The first and most simple method to find how much any compound microscope magnifies an object, is the same which is described by Dr. Hooke in his Micrographia, and is as follows: place an accurate scale, which is divided into very minute parts of an inch, on the stage of your microscope; adjust the microscope, till these divisions appear distinct; then observe with the other eye how many divisions of a rule, similarly divided and held at the stage, are included in one of the magnified divisions: for if one division, as seen with one eye through the microscope, extend to thirty divisions on the rule, which is seen by the naked eye, is is evident, that the diameter of the object is increased or magnified thirty times.

For this purpose, we often use a small black ebony rule, (see Fig. 4. Plate II. A,) three or four tenths of an inch broad, and about seven inches long; at each inch is fixed a piece of ivory, the first inch is entirely of ivory, and subdivided into ten equal parts.

2. A piece of glass, Fig. 2, fixed in a brass or ivory slider; on the diameter of this are drawn two parallel lines, about three-tenths of an inch long; each tenth being divided, one into three, the second into four, the third into five parts. To use this, place the glass, Fig. 2, on the middle of the stage, and the rule, Fig. 4, on one side, but parallel to it; then look into the microscope with one eye, keeping the other open, and observe how many parts one-tenth of a line in the microscope takes in upon the parts of the rule seen by the naked eye. For instance, suppose with a fourth magnifier that one-tenth of an inch magnified answers in length to forty-tenths or parts on the rule, when seen by the naked eye, then this magnifier increases the diameter of the object forty times.

This mode of actual admeasurement is, without doubt, the most simple that can be used; by it we comprehend, as it were, at one glance, the different effects of combined glasses; it saves the trouble, and avoids the obscurity that attends the usual modes of calculation; but many persons find it exceedingly difficult to adopt this method, because they have not been accustomed to observe with both eyes at once. We shall therefore proceed to describe another method, which has not this inconvenience.

OF THE NEEDLE MICROMETER.

Fig. 8. Plate II. A, represents this micrometer. The first of this kind was made by my father, and was described by him in his Micrographia Illustrata. It consists of a screw, which has fifty threads to an inch; this screw carries an index, which points to the divisions on a circular plate, which is fixed at right angles

to the axis of the screw. The revolutions of the screw are counted on a scale, which is an inch divided into fifty parts; the index to these divisions is a flower de luce marked upon the slider, which carries the needle point across the field of the microscope. Every revolution of the micrometer screw measures $\frac{1}{50}$ part of an inch, which is again subdivided by means of the divisions on the circular plate, as this is divided into twenty equal parts, over which the index passes at every revolution of the screw; by which means, we obtain with ease the measure of one-thousandth part of an inch; for 50, the number of threads on the screw in one inch, being multiplied by 20, the divisions on the circular plate, are equal to 1000; so that each division on the circular plate shews that the the needle has either advanced or receded one-thousandth part of an inch.

To place this micrometer on the body of the microscope, open the circular part FKH, Fig. 8. Plate II. A, by taking out the screw G, throw back the semicircle FK which moves upon a joint at K, then turn the sliding tube of the body of the microscope, so that the small holes which are in both tubes may exactly coincide, and let the needle g of the micrometer have a free passage through them; after this, screw it fast upon the body by the screw G.

The needle will now traverse the field of the microscope, and measure the length and breadth of the image of any object that is applied to it. But further assistance must be had, in order to measure the object itself, which is a subject of real importance; for though we have ascertained the power of the microscope, and know that it is so many thousand times, yet this will be of little assistance towards ascertaining an accurate idea of its real size; for our ideas of bulk being formed by the comparison of one object with another, we can only judge of that of any particular body, by comparing it with another whose size is known: the same thing is necessary, in order to form an estimate by the microscope; therefore, to ascertain the real measure of the object, we must make the point of the needle pass over the image of a known part of an inch placed on the stage, and write down the revolutions made by the screw, while the needle passed over the image of this known measure; by which means we ascertain the number of revolutions on the screw, which are adequate to a real and known measure on the stage. As it requires an attentive eye to watch the motion of the needle point, as it passes over the image of a known part of an inch on the stage, we ought not to trust to one single measurement of the image, but ought to repeat it at least six times; then add the six measures thus obtained together, and divide their sum by six, or the number of trials; the quotient will be the mean of all the trials. This result is to be placed in a column of a table, next to that which contains the number of the magnifiers.

By the assistance of the sectoral scale, we obtain with ease a small part of an inch. This scale is shewn at Fig. 5, 6, 7. Plate II. A, in which the two lines c a c b, with the side a b, form an isosceles triangle; each of the sides is two inches long, and the base one-tenth of an inch. The longer sides may be of any given length, and the base still only of one-tenth of an inch. The longer lines may be considered as the line of lines upon a sector opened to one-tenth of an inch. Hence, whatever number of equal parts c a c b are divided into, their transverse measure will be such a part of one-tenth as is expressed by their divisions. Thus, if it be divided into ten equal parts, this will divide the inch into one-hundred equal parts; the first division next c will be equal to one-hundredth part of an inch, because it is the tenth part of one-tenth of an inch. If these lines be divided into twenty equal parts, the inch will be by those means divided into two hundred equal parts. Lastly, if a b c a be made three inches long, and divided into one-hundred equal parts, we obtain with ease the one-thousandth part. The scale is represented as solid at Fig. 6, but as perforated at Fig. 5 and 7; so that the light passes through the aperture, when the sectoral part is placed on the stage.

To use this scale, first fix the micrometer, Fig. 8. Plate II. A, to the body of the microscope; then fit the sectoral scale, Fig. 7, in the stage, and adjust the microscope to its proper focus or distance from the scale, which is to be moved till the base appears in the middle of the field of view; then bring the needle point g, Fig. 8, by turning the screw L, to touch one of the lines c a exactly at the point answering to 20 on the sectoral scale. The index a of the micrometer, Fig. 8, is to be set to the first division, and that on the dial plate to 20, which is both the beginning and end of its divisions; we are then prepared to find the magnifying power of every magnifier in the compound microscope which we are using.

Example. Every thing being prepared agreeable to the foregoing directions, suppose you are desirous of ascertaining the magnifying power of the lens marked No. 4; turn the micrometer screw, until the point of the needle has passed over the magnified image of the tenth part of one inch; then the division, where the two indices remain, will shew how many revolutions, and parts of a revolution, the screw has made, while the needle point traversed the magnified image of the one-tenth of an inch; suppose the result to be twenty-six revolutions of the screw, and fourteen parts of another revolution, this is equal to 26 multiplied by 20, added to 14; that is, 534 thousandth parts of an inch.

The twenty-six divisions found on the strait scale of the micrometer, while the point of the needle passed over the magnified image of one-tenth part of an inch, were multiplied by 20, because the circular plate C D, Fig. 8, is divided into twenty equal parts; this produced 520; then adding the fourteen parts of the next revolution, we obtain 534 thousandth parts of an inch, or 5-tenths and 34-hundredth parts of another tenth, which is the measure of the magnified image of 1-tenth of an inch, at the aperture of the eye glasses, or at their foci. Now if we suppose the focus of the two eye-glasses to be one inch, the double thereof is two inches; or if we reckon in the thousandth part of an inch, we have two thousand parts for the distance of the eye from the needle point of the micrometer. Again, if we take the distance of the image from the object at the stage at six inches, or six thousandths, and add thereto two thousand, double the distance of the focus of the eye glass, we shall have eight thousand parts of an inch for the distance of the eye from the object; and as from the proposition, page 51, we gather that the glasses double the image, we must double the number 534 found upon the micrometer, which then makes 1068: then, by the following analogy, we shall obtain the number of times the microscope magnifies the diameter of the object; say, as 240, the distance of the eye from the image of the object, is to 800, the distance of the eye from the object, so is 1068, double the measure found on the micrometer, to 3563, or the number of times the microscope magnifies the diameter of the object. By working in this manner, the magnifying power of each lens used with the compound microscope may be easily found, though the result will be different in different compound microscopes, varying, according to the combination of the lenses, their distance from the object, and one another, &c.

Having discovered the magnifying power of the microscope. with the different object lenses that are used therewith, our next subject is to find out the real size of the objects themselves, and their different parts; this is easily effected, by finding how many revolutions of the micrometer-screw answer to a known measure on the sectoral scale, or other object placed on the stage; from the number thus found, a table should be constructed, expressing the value of the different revolutions of the micrometer with that object lens, by which the primary number was obtained. Similar tables must be constructed for each object lens. By a set of tables of this kind, the observer may readily find the measure of any object he is examining; for he has only to make the needle point traverse over this object, and observe the number of revolutions the screw has made in its passage, and then look into his table for the real measure which corresponds to this number of revolutions, which is the measure required.

ACCOUNT OF GLASS, PEARL, &C. MICROMETERS,

BY THE EDITOR.

Having seen some glass, &c. micrometers with exquisite fine divisions, for the purposes of applying to microscopes and telescopes; and in accuracy, being equivalent to the micrometer just described by our author, I judge, some account of their application and uses here will be very acceptable to the curious and inquisitive reader. A particular description of these as made by the ingenious Mr. Coventry, has been already given in the Encyclopœdia Britannica, Vol. XI. p. 708.

The singular dexterity which Mr. Coventry and others now possess, of cutting by an engine fine parallel lines upon glass, pearl, ivory, and brass, at such minute distances as, by means of a microscope, are proved to be from the 100th to the 5000dth part of an inch, render this sort of micrometer the easiest and most accurate means of obtaining the exact natural size of the object to be magnified, and how many times that object is magnified. Mr. B. Martin, and other opticians, many years ago applied divided slips of glass, ivory, and horn to the body, in the focus of the eye glass of microscopes; but the thickness of the whole medium of the glass was found to diminish the distinct view of the object: ivory and horn, from their variable texture, were found to expand and contract too readily to be commodious. It is therefore to Mr. Cavallo that we are indebted for the happy thought of adapting slips of divided pearl to telescopes, to ascertain their power, &c. which substance the opticians now find to be the best for microscopical micrometers. It possesses a sufficient degree of transparency, when made about the thickness of writing paper; is a steady substance; admits very easily of the finest graduations, and is generally made in breadth about the 20th part of an inch.

Fig. 9. Plate II. A, is a representation of this scale, with divisions of the 200ths of an inch, every fifth and tenth division being left longer than the others, which only go to about the middle. If the eye glass of the microscope or telescope, to which this micrometer is to be applied, magnify very much, its divisions may be proportionably minute.

To measure by this micrometer the size of an object in a single microscope, nothing more is required than to lay it on the micrometer, and adjust it to the focus of the magnifier, noticing how many divisions it covers or coincides with. Supposing the parallel lines to be the 1000dths of an inch, and the object covers two divisions, its real size is the 500th of an inch; if five, 200th of an inch, &c.

To find how much the object is magnified, is not so easily done by the single, as by the compound microscope, as has been before explained. The following simple method has been adopted by Mr. Coventry, and which may be considered tolerably accurate. Adjust a micrometer under the microscope, suppose 100th of an inch of divisions, with a small object on it, if square, the better; notice how many divisions one side of the object covers; suppose ten; then cut a piece of white paper something larger than the magnified appearance of the object; fix one eye on the object through the microscope, and the other at the same time on the paper, lowering it down till the object and the paper appear level and distinct: then cut the paper till it appear exactly the size of the magnified object; the paper being then measured, suppose an inch square: now, as the object under the magnifier, which appeared to be one inch square, was in reality only ten hundredths, or the tenth of an inch, the experiment proves that it is magnified ten times in length, one hundred times in superficies, and one thousand times in cube, which is the magnifying power of the glass; and in the same manner a table may be made of the power of all the other glasses.

In using the compound microscope, the real size of the object is found by the same method as in the single; but to demonstrate the magnifying power to greater certainty, adopt the following method. Lay a two-feet rule on the stage, and a micrometer level with its surface, (an inch suppose, divided into 100 parts:) with one eye see how many of those parts are contained in the field of the microscope, suppose 50; and with the other, at the same time, look for the circle of light in the field of the microscope, which with a little practice will soon appear distinct; mark how much of the rule, from the center of the stage, is intersected by the circle of light, which will be half the diameter of the field. Suppose eight inches; consequently the whole diameter will be sixteen. Now, as the real size of the field by the micrometers appeared to be only 50 hundredths, or half an inch, and as half an inch is only one 32d part of 16 inches, it shews the magnifying power to be 32 times in length, 1024 superficies, and 32768 in cube or bulk. For accuracy, as well as for comparative observations, the rule should always be a certain distance from the eye; eight inches in general is a proper distance.

Another way, and the most easy for finding the magnifying power of compound microscopes, is by using two micrometers of the same divisions; one adjusted under the magnifier, the other fixed in the body of the microscope in the focus of the eye glass. Notice how many divisions of the micrometer in the body are seen in one division of the micrometer under the magnifier, which again must be multiplied by the power of the eye glass. Example: Ten divisions of the micrometer in the body are contained in one division under the magnifier; so far the power is increased ten times: now, if the eye glass be one inch focus, such glass will of itself magnify about eight times in length, which, with the ten times magnified before, will be eight times ten, or 80 times in length, 6400 superficies, and 512000 cube.

Fig. 10. Plate II. A, represents the field of view of the compound microscope, with the pearl micrometer, as applied to the aperture in the body, called the eye stop; and a magnified micrometer that is laid on the stop, shewing that one of the latter contains ten of the former.

A set of ivory and glass micrometers, about six in number, besides one or two pearl ones for the eye stops, are generally packed up with the best sort of microscopes made by Messrs. W. and S. Jones, Opticians, Holborn. They are divided into lines and squares, from the 100th to the 1000dth parts of an inch; and, besides measuring the magnifying powers of microscopes, are generally found useful in measuring the diameters, proportions, &c. of opake and transparent objects, even of the minutest kind. The smallest divisions of the glass micrometer to be useful, are those divided into the 4000dth part of an inch; and as these may be crossed again with an equal number of lines in the same manner, they form squares of the SIXTEEN MILLIONTH part of an inch surface, each square of which appearing under the microscope true and distinct. And, even small as this is, animalculæ are found so minute as to be contained in one of these squares!

Glass micrometers with squares, applied to the solar microscope, divide the objects into squares on the screen in such a manner, as to render a drawing from it very easy; and are employed with great advantage in the lucernal microscope.

The micrometers are constructed with moveable frames or tubes, so as to be either applied or taken away in the readiest manner.

For the uses of the pearl micrometer as applied to the telescope, see Mr. Cavallo's pamphlet descriptive of its use, 8vo. 1793, and the Philosophical Transactions for 1791.

CHAP. III.

A DESCRIPTION OF THE MOST APPROVED MICROSCOPES, AND THE METHOD OF USING THEM.

IN the preceding chapter I have endeavoured to give a comprehensive view of the theory of the microscope, and the principles on which the wonderful effects of this instrument depend. I shall now proceed to describe the various instruments themselves, their apparatus, and the most easy and ready mode of applying them to use; selecting for description those that, from some peculiar advantage in their construction, or from the reputation of the authors who have recommended and used them, are in most general use. What is said of these will, I hope, be sufficient to enable the reader to manage any other kind that may fall in his way.

DESCRIPTION OF ADAMS'S IMPROVED AND UNIVERSAL LUCERNAL MICROSCOPE. Fig. 1. Plate III.

This microscope was originally thought of, and in part executed by my father; I have, however, so improved and altered it, both in construction and form, as to render it altogether a different instrument. The approbation it has received from the most experienced microscopic observers, as well as the great demand I have had for them, has fully repaid my pains and expenses, in bringing it to its present state of perfection.

As the far greater part of the objects which surround us are opake, and very few sufficiently transparent to be examined by the common microscopes, an instrument that could be readily applied to the examination of opake objects, has always been a desideratum. Even in the examination of transparent objects, many of the fine and more curious portions are lost, and drowned as it were in the light which must be transmitted through them; while different parts of the same object appear only as dark lines or spots, because they are so opake, as not to permit any light to pass through them. These difficulties, as well as many more, are obviated in the lucernal microscope; by which opake objects of various sizes may be seen with ease and distinctness; the beautiful colours with which most of them are adorned, are rendered more brilliant, without in the least changing their natural teints. The concave and convex parts of an object retain also their proper form.

The facility with which all opake objects are applied to this instrument is another considerable advantage, and almost peculiar to itself; as the texture and configuration of the more tender parts are often hurt by previous preparation, every object may be examined by this instrument, first as opake, and afterwards, if the texture will admit of it, as transparent.

The lucernal microscope does not in the least fatigue the eye; the object appears like nature itself, giving ease to the sight, and pleasure to the mind: there is also in the use of this instrument, no occasion to shut that eye which is not directed to the object.

A further advantage peculiar to this microscope is, that by it the outlines of every object may be taken, even by those who are not accustomed to draw; while those who can draw well, will receive great assistance, and execute their work with more accuracy, and in less time than they would otherwise have been able to have performed it in. Most of the designs for this work were taken with the lucernal microscope; and I hope the accuracy with which they are executed, will be deemed a sufficient testimony in favour of the instrument. In this point of view it will, I think, be found of great use to the anatomist, the botanist, the entomologist, &c. as it will enable them not only to investigate the object of their researches, but to convey to others accurate delineations of the subject they wish to describe.

By the addition of a tin lanthorn, transparent objects may be shewn on a screen, as by the solar microscope.

Transparent objects may be examined with this instrument in three or four different modes; from a blaze of light almost too great for the eye to bear, to that which is perfectly easy to it.

When this instrument is fitted up in the best way, it is generally accompanied with a small double and single microscope.

Fig. 1. Plate III. represents the IMPROVED LUCERNAL MICROSCOPE, mounted to view opake objects; A B C D E is a large mahogany pyramidical box, about fourteen inches long, and six inches square at its larger end, which forms the body of the microscope; it is supported firmly on the brass pillar F G, by means of the socket H, and the curved piece I K.

L M N is a guide for the eye, in order to direct it in the axis of the lenses; it consists of two brass tubes, one sliding within the other, and a vertical flat piece, at the top of which is the hole for the eye. The outer tube is seen at M N, the vertical piece is represented at L M. The inner tube may be pulled out, or pushed in, to adjust it to the focus of the glasses. The vertical piece may be raised or depressed, that the hole, through which the object is to be viewed, may coincide with the center of the field of view; it is fixed by a milled screw at M, which could not be shewn in this figure.

At N is a dove-tailed piece of brass, made to receive the dove-tail at the end of the tubes M N, by which it is affixed to the wooden box A B C D E. The tubes M N may be removed from this box occasionally, for the convenience of packing it up in a less compass.

O P a small tube on which the magnifiers are screwed.

O one of the magnifiers; it is screwed into the end of a tube, which slides within the tube P; the tube P may be unscrewed occasionally from the wooden body.

Q R S T V X a long square bar, which passes through the sockets Y Z, and carries the stage or frame that holds the objects; this bar may be moved backward or forward, in order to adjust it to the focus, by means of the pinion which is at a.

b c is a handle furnished with an universal joint, for more conveniently turning the pinion. When the handle is removed, the nut, Fig. 2, may be used in its stead.

d e is a brass bar, to support the curved piece K I, and keep the body A B firm and steady.

f g h i is the stage for opake objects; it fits upon the bar Q R S T by means of the socket h i, and is brought nearer to, or removed farther from the magnifying lens, by turning the pinion a: the objects are placed in the front side of the stage, which cannot be seen in this figure, between four small brass plates; the edges of two of these are seen at k l. The two upper pieces of brass are moveable; they are fixed to a plate, which is acted on by a spiral spring that presses them down, and confines the slider with the objects; this plate, and the two upper pieces of brass, are lifted up by the small nut m.

At the lower part of the stage, there is a glass semiglobe n, which is designed to receive the light from the lamp, Fig. 3, and to collect and convey it to the concave mirror o, from whence it is to be reflected on the object.

The upper part, f g r S, of the opake stage takes out, that the stage for transparent objects may be inserted in its place.

Fig. 4. represents the stage for transparent objects; the two legs 5 and 6, fit into the under part r S of the stage for opake objects; 7 is the part which confines or holds the sliders, and through which they are to be moved; 9 and 10 a brass tube, which contains the lenses for condensing the light, and throwing it upon the object; there is a second tube within that, marked 9 and 10, which may be placed at different distances from the object by the pin 11.

When this stage is used as a single microscope, without any reference to the lucernal, the magnifiers or object lenses are to be screwed into the hole 12, and to be adjusted to a proper focus by the nut 13.

N. B. At the end A B of the wooden body there is a slider, which is represented as partly drawn out at A; when quite taken out, three grooves will be perceived, one of which contains a board that forms the end of the box, the next contains a frame with a greyed glass; the third, or that farthest from the end A B, two large convex lenses.

OF THE LAMP.

Fig. 3, represents one of Argand's lamps, which is the most suitable for microscopic purposes, on account of the clearness, the intensity, and the steadiness of the light. The following method of managing it, with other observations, is copied from an account given by Mr. Parker, with those he sells.

The principle on which the lamp acts, consists in disposing the wick in thin parts, so that the air may come into contact with all the burning fuel, by which means, together with an increase of the current of air occasioned by rarefaction in the glass tube, the whole of the fuel is converted into flame.

The wicks are circular, and, the more readily to regulate the quantity of light, are fixed on a brass collar with a wire handle, by means of which they are raised or depressed at pleasure.

To fix the wick on, a wood mandril is contrived, which is tapered at one end, and has a groove turned at the other.

The wick has a selvage at one end, which is to be put foremost on the mandril, and moved up to the groove; then putting the groove into the collar of the wick-holder, the wick is easily pushed forward upon it.

The wick-holder and wick being put quite down in their place, the spare part of the wick should, while dry, be set alight, and suffered to burn to the edge of the tubes; this will leave it more even than by cutting, and, being black by burning, will be much easier lighted: for this reason, the black should never be intirely cut off.

The lamp should be filled an hour or two before it is wanted, that the cotton may imbibe the oil, and draw the better.

The lamps which have a reservoir and valve, need no other direction for filling, than to do it with a proper trimming pot, carefully observing when they are full; then pulling up the valve by the point, the reservoir being turned by the other hand, may be replaced without spilling a drop.

Those lamps which fill in the front like a bird-fountain, must be reclined on the back to fill, and this should be done gently, that the oil in the burner may return into the body when so placed and filled; if, by being too full, any oil appear above the guard, only move the lamp a little, and the oil will disappear; the lamp may then be placed erect, and the oil will flow to its proper level.

The oil must be of the spermaceti kind, commonly called chamber oil, which may generally be distinguished by its paleness, transparency, and inoffensive scent; all those oils which are of a red and brown colour, and of an offensive smell, should be carefully avoided, as their glutinous parts clog the lamp, and the impurities in such oil not being inflammable, will accumulate and remain in the form of a crust on the wick. Seal oil is nearly as pale and sweet as chamber oil, but being of a heavy sluggish quality, is not proper for lamps with fine wicks.

Whenever bad oil has been used, on changing it, the wick must also be changed, because, after having imbibed the coarse particles in its capillary tubes, it will not draw up the fine oil.

To obtain the greatest degree of light, the wick should be trimmed exactly even, the flame will then be completely equal.

There will be a great advantage in keeping the lamp clean, especially the burner and air tubes; the neglect of cleanliness in lamps is too common: a candlestick is generally cleaned every time it is used, so should a lamp; and if a candlestick is not to be objected to, because it does not give light after the candle is exhausted, so a lamp should not be thought ill of, if it does not give light when it wants oil or cotton; but this last has often happened, because the deficiency is less visible.

The glass tubes are best cleaned with a piece of wash leather.

If a fountain lamp be left partly filled with oil, it may be liable to overflow; this happens by the contraction of the air when cold, and its expansion by the warmth of a room, the rays of the sun, or the heat of the lamp when re-lighted: this accident may be effectually prevented by keeping the reservoir filled, the oil not being subject to expansion like air. On this account, those with a common reservoir are best adapted for microscopic purposes.

TO EXAMINE OPAKE OBJECTS WITH THE LUCERNAL MICROSCOPE.

The microscope is represented as mounted, and entirely ready for this purpose, in Fig. 1. Plate III.

To render the use of this instrument easy, it is usually packed with as many of the parts together as possible; it occupies on this account rather more room, but is much less embarrassing to the observer, who has only three parts to put on after it is taken out of its box, namely, the guide for the eye, the stage, and the tube with its magnifier.

But to be more particular, take out the wooden slide A, then lift out the cover and the grey glass from their respective grooves under the slide A.

Put the end N of the guide for the eye L M N into its place, so that it may stand in the position which is represented in this figure.

Place the socket, which is at the bottom of the opake stage, on the bar Q X T, so that the concave mirror o may be next the end D E of the wooden body.

Screw the tubes P O into the end D E. The magnifier you intend to use is to be screwed on the end o of these tubes.

The handle G b, or milled nut, Fig. 2, must be placed on the square end of the pinion a.

Place the lamp lighted before the glass lump n, and the object you intend to examine between the spring plates of the stage, and the instrument is ready for use.

In all microscopes, there are two circumstances which must be particularly attended to; the modification of the light, or the proper quantity to illuminate the object; secondly, the adjustment of the instrument to the focus of the glasses and the eye of the observer. In the use of the lucernal microscope there is a third circumstance, which is the regulation of the guide of the eye, each of which I shall consider by itself.

1. To throw the light upon the object. The flame of the lamp is to be placed rather below the center of the glass semiglobe n, and as near it as possible; the concave mirror o must be so inclined and turned, as to receive the light from the semiglobe, and reflect it thence upon the object; the best situation of the concave mirror, and the flame of the lamp, depends on a combination of circumstances, which a little practice will best point out.

2. To regulate the guide for the eye, or to place the center of the eye piece L, so that it may coincide with the focal point of the lenses, and the axis of vision. Lengthen and shorten the tubes M N by drawing out or pushing in the inner tube, and raising or depressing the eye-piece M L, till you find the large lens, which is placed at the end A B of the wooden body, filled by an uniform field of light, without any prismatic colours round the edge; for, till this piece be properly fixed, the circle of light will be very small, and only occupy a part of the lens; the eye must be kept at the center of the eye-piece L, during the whole of the operation; which may be rendered somewhat easier to the observer, on the first use of the instrument, if he hold a piece of white paper parallel to the large lenses, removing it from or bringing it nearer to them, till he finds the place where a lucid circle, which he will perceive on the paper, is brightest and most distinct, then to fix the center of the eye-piece to coincide with that spot; after which a very small adjustment will set it perfectly right.

3. To adjust the lenses to their focal distance. This is effected by turning the pinion a, the eye being at the same time at the eye-piece L. I often place the grey glass before the large lenses, while I am regulating the guide for the eye, and adjusting for the focal distance.

If the observer, in the process of his examination of an object, advance rapidly from a shallow to a deep magnifier, he will save himself some labour by pulling out the internal tube at O.

The upper part f g r s of the stage, is to be raised or lowered occasionally, in order to make the center of the object coincide with the center of the lens at O.

To delineate objects, the grey or rough ground glass must be placed before the large lenses; the picture of the object will be formed on this glass, and the outline may be accurately taken, by going over the picture with a pencil.

The opake part may be used in the day-time without a lamp, provided the large lenses at A B be screened from the light.

TO USE THE LUCERNAL MICROSCOPE IN THE EXAMINATION OF TRANSPARENT OBJECTS.

The microscope is to remain as before: the upper part f g r s of the opake stage must be removed, and the stage for transparent objects, represented at Fig. 4, put in its place; the end, Fig. 9 and 10, to be next the lamp.

Place the rough glass in its groove at the end A B, and the objects in the slider-holder at the front of the stage; then transmit as strong a light as you are able on the object, which you will easily do, by raising or lowering the lamp.

The object will be beautifully depicted on the rough glass: it must be regulated to the focus of the magnifier, by turning the pinion a.

The object may be viewed either with or without the guide for the eye; a single observer will see an object to the greatest advantage by using this guide, which is to be adjusted as we have described, page 73. If two or three wish to examine the object at the same time, the guide for the eye must be laid aside.

Take the large lens out of the groove, and receive the image on the rough glass; in this case the guide for the eye is of no use: if the rough glass be taken away, the image of the object may be represented on a paper screen.*

Take out the rough glass, replace the large lenses, and use the guide for the eye; attend to the foregoing directions, and adjust the object to its proper focus. You will then see the object in a blaze of light almost too great for the eye, a circumstance that will be found very useful in the examination of particular objects; the edges of the object in this mode will be somewhat coloured, but as it is only used in this full light for occasional purposes, it has been thought better to leave this small imperfection, than by remedying it, to sacrifice greater advantages; the more so, as this fault is easily corrected, and a new and interesting view of the object is obtained, by turning the instrument out of the direct rays

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* A tin cover is sometimes made to go over the glass chimney of the lamp, Fig. 3, with only a small square aperture in front, sufficient to suffer the rays to pass into the microscope: this, by excluding all extraneous rays, adds in many cases most materially to the effect, particularly by day, and when objects are to be represented on the rough glass or screen only. EDIT.

of light, and permitting them to pass through only in an oblique direction, by which the upper surface is in some degree illuminated, and the object is seen partly as opake, partly as transparent. It has been already observed, that the transparent objects might be placed between the slider-holders k l of the stage for opake objects, and then be examined as if opake.

Some transparent objects appear to the greatest advantage when the lens at 9 and 10 is taken away; as, by giving too great a quantity of light, it renders the edges less sharp.

The variety of views which may be taken of every object, by means of the improved lucernal microscope, will be found to be of great use to an accurate observer: it will give him an opportunity of correcting or confirming his discoveries, and investigating those parts in one mode, which are invisible in another.

TO TRANSMIT THE IMAGE OF TRANSPARENT OBJECTS ON A SCREEN, AS BY THE SOLAR MICROSCOPE.

It has been long a microscopical desideratum, to have an instrument by which the image of transparent objects might be shewn on a screen, as by the common solar microscope; and this not only because the sun is so uncertain in this climate, and the use of the solar microscope requires confinement in the finest part of the day, when time seldom hangs heavy on the rational mind, but as it also affords an increase of pleasure, by displaying its wonders to several persons at the same instant, without the least fatigue to the eye.

This purpose is now effectually answered, by affixing the transparent stage, Fig. 4, of the lucernal to a lanthorn containing one of Argand's lamps. The lamp is placed within the lanthorn, and the end 9, 10 of the transparent stage is screwed into a female screw, which is rivetted in the sliding part of the front of the lanthorn; the magnifying lenses are to be screwed into the hole represented at 12; they are adjusted by turning the milled nut. The quantity of light is to be regulated, by raising and lowering the sliding plate, or the lamp. N. B. This part, with its lanthorn and lamp, may be had separate from the lucernal microscope.*

APPARATUS WHICH USUALLY ACCOMPANIES THE IMPROVED LUCERNAL MICROSCOPE.

The stage, Fig. f g h i, for opake objects, with its glass semiglobe, and concave mirror, which is moveable upon the bar Q R S T, and set readily to any distance by the screw at *a*. The glasses o and n are also moveable upon the bar for regulating and adjusting the light upon the object.

The stage, Fig. 4, for transparent objects, which fits on the upper part P S of the foregoing stage. When this is to be applied occasionally to a lanthorn for shewing transparent objects on a screen, &c. it is made of a much larger diameter, to admit of the illuminating lenses at 9, 10, and 11, of greater power of condensing the rays from the lamp.

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* This effect by the lanthorn and lamp is subject to much limitation in the field of view, or circle of light thrown upon the screen. A circle of not more than from 12 to about 15 inches can ever be obtained with any tolerable strength of light, to shew the most transparent sort of objects that can be found, such as the scale of a sole fish, a fly's wing; &c. The great difference between the light of the sun and a lamp is a natural obstacle to great performances in this way, and renders them far short of the effects of the solar microscope. The exhibition, however, is considerable, and much deserving of the notice of any observer disposed to this sort of apparatus. Probably, subsequent experiments may yet produce more light on this instrument. The best sort of apparatus for this purpose hitherto made, I shall describe in a following section.

EDIT.

The sliding tube O P, to which the magnifiers are to be affixed; one end of this is to be screwed on the end B of the wooden body; the magnifier in use is to be screwed to the other end on the inner tube. This tube slides inwards or outwards; it is first used to set the magnifier at nearly the right distance from the object, before the exact adjustment for the focus is made, by turning the pinion at a with Hook's joint and handle b e.

Eight magnifying lenses in brass cells, Fig. 5. Plate III. these are so constructed that any two of them may be combined together, and thus produce a very great variety of magnifying powers. The cells unscrew to admit of the glasses being cleaned.

A fish-pan, such as is represented at Fig. 6, whereon a small fish may be fastened in order to view the circulation of its blood; its tail is to be spread across the oblong hole at the smallest end, and tied fast by means of the attached ribbon. The knob on its back is to be put through a slit hole on the brass piece, No. 5, of Fig. 4. The tail of the fish is to be brought then immediately before the magnifier.

A steel wire, Fig. 7, with a pair of nippers at one end, and a steel point at the other; the wire slides backwards or forwards, in a spring tube which is affixed to a joint at the bottom, on which is a pin to fit the hole in the leg, No. 6, Fig. 4. This is used to confine small objects.

A slider of brass, Fig. 8, containing a flat glass slider and a brass slider, into which are fitted some small concave glasses. It is for confining small living objects, and when used is placed between the two plates, No. 7, Fig. 4.

A pair of forceps, Fig. 9, by which any occasional small object may be conveniently taken up.

Six large ivory sliders, with transparent objects placed between two plates of talc, and confined by brass rings, and six small ditto with ditto. Fig. 10. The larger ones usually contain a set of Custance's fine vegetable cuttings.

Fourteen wood sliders, containing on each four opake objects, and two spare sliders for occasional objects; all fitted to the cheeks k l of the stage. Fig. 11.

Some capillary tubes, Fig. 12, to receive small fish, and for viewing small animalcula. They are to be placed between the two plates of the stage No. 7, Fig. 4.

A small ivory double box, containing spare plates of talc and brass rings, for replacing any in the small ivory sliders, when necessary.

A single lens mounted in a tortoiseshell case, to examine minute objects previous to their being applied to the sliders.

Opake objects are easily put on the spare sliders by a wetted wafer; and, for good security, gum water may be added.

For the prices of the lucernal, as well as all the other sorts of microscopes, see the list annexed to these Essays..

A DESCRIPTION OF THE SEVERAL IMPROVEMENTS MADE UPON MR. ADAMS'S LUCERNAL MICROSCOPE. BY THE EDITOR.

The lucernal microscope being unquestionably the only instrument for exhibiting all sorts of opake objects under a brilliant and magnified appearance, was, as formerly constructed by the late Mr. G. Adams, attended with some inconveniences and imperfections. Upon a proper inquiry into various improvements, and from some observations made by myself, I can recommend, as a complete instrument, one with the following emendations, being, in my opinion, the best of any hitherto made known.

The lucernal microscope, when placed up for use, as represented in Fig. 1. Plate III. is of some considerable length. When the eye at L is viewing the image of the object upon the glasses, the objects themselves in the sliders placed at k l at the stage, are without the reach of the hand; so that the indispensible change of the parts of an object, or of one object to another, can only be obtained by the observer's moving himself from the object to the eye-piece, and vice versa. This adjustment, therefore, proves uncertain and troublesome. The application of rack-work motion to the stage has been contrived and applied to the lucernal microscope, Mr. W. Jones, of Holborn, accompanied with Hooke's joint and handle, and a lever rod; so that, without altering his position, the observer may change both the horizontal and vertical position of the sliders, and thereby readily investigate all the variety of the objects, and their parts, and with the same exactness as by other microscopes.

For persons who may not wish to be at the expense of the lucernal, as formerly mounted by Mr. Adams, Mr. Jones has altered the manner of its support; which, as well as the other particulars, and the method of using it, may be understood from the following description.

Plate IX. Fig. 3, is a representation of the instrument as placed up for use. A A, the top of a mahogany chest, about two feet long, thirteen inches and an half high, and eight inches broad, which serves both as a case to contain the instrument, and to support and preserve it steady when in use. A groove is cut in the top of the box, and another in the inside at the bottom, in both of which the base of the instrument is made to slide. When the instrument is placed inside, a long slip of mahogany slides in at the top, to secure the groove, and make the top perfect. Thus the instrument may be most readily slid out of its case, and then into the groove at top for use, and in much less time than by the brass frame and jointed stand adopted by Mr. Adams. Plate III. B, is the stage for the objects, with the condensing lens *a*, and concave mirror *b*, the same as in Mr. Adams's. C, the brass slider case for opake objects, with a rack cut into its lower edge, and which is turned by a pinion. To this pinion is applied an handle, D, with Hooke's universal joint; this contrivance gives a certain horizontal motion to the objects while viewing. The stage at C is also made to slide vertically, and a lever-rod or handle, E, to apply through the top, to bring the objects to a just height. Hence, by applying the left hand to the handle, E, and the right to the rod D, the adjustment or the changing of the objects, while under exhibition on the large lenses at F, is produced in the most convenient and accurate manner, and the observer has no occasion, for one slider, to shift from his seat or position.

Rack-work might be applied to the vertical motion, but it is not essentially necessary; for when once the center of the slider is observed, there requires very little change from that position for the complete exhibition of the objects. The whole of the stage, with the lense and mirror, is fixed to a brass dove-tailed slider at G, which slides in another brass piece fixed to the wooden slider or base of the instrument. A long brass rod, H, with an adjusting screw at its end, passes through the two brass pillars, K, K, to the stage at *f*, upon which it acts; and, according as it is turned to the right or left hand while examining the objects, moves the objects nearer to or farther from the magnifiers screwed on at L, and produces the just distance for rendering the appearance of the objects the most distinct and brilliant upon the glasses at F.

The management of the light from the lamp, through the lens, *a*, and from the concave mirror, *b*, to the objects, is exactly the same as before directed by Mr. Adams. For the exhibiting of transparent objects, the stage, C, is to be slid away, and the body, Fig. 4, applied in its place, in that position, with the large lens outwards next the lamp. The slider with the objects passes through at *a*, and the focus for the different magnifiers is adjusted by turning the long rod, D, to the right or left, as with the opake objects. In this case the lamp is to be raised to the center of the body of the microscope, or even with the magnifiers at L. The image of the objects may also, as in Mr. Adams's, be best received on the rough glass placed at F, for the simple reflected light through the body will sometimes be so strong, as to irritate the eye; the operator must, therefore, both modify that from the lamp, and place the roughed glass to his own ease and pleasure. The guide for the eye, N, in this instance is not necessary. Care being taken that the roughed glass at F be kept in as dark a situation as possible, there will be a certainty of a clear and well-defined view of the object.

A tin chimney placed over the glass of the lamp about ten inches long, with a suitable aperture to admit the light to pass through it to the glasses, is of material service; it excludes all superfluous light from the eye of the observer, keeps the room sufficiently darkened, and enables the observer to view his object with the proper brilliancy. As a pleasing relief to the eye, the interposition of a small piece of blue or green glass at the sight hole, N, Mr. Jones has sometimes found necessary, but it gives rather a false teint to the colour of the objects.

In the year 1789 the same artist applied a brass screw pillar and arm to the top of the box at O, on which is occasionally slid the condensing lens, *a*. The lamp being then applied at the side of the box at O, instead of the end, and the lens, *a*, moved to such a distance as to give the strongest possible light upon the opake objects at C; they were found to be more strongly illuminated by this simple refracted light than by the refracted and reflected light before used. Light is always somewhat diminished by reflection, although condensed; therefore, as it is sometimes best to view the objects from oblique reflected light, and sometimes from direct refracted, he constructs the apparatus so as to give the operator the means of easily using either. The dotted lines, O P, shew the manner that the glass semiglobe, *a*, is occasionally applied to refract or converge directly the light from the lamp to the objects on the stage.

It is scarcely necessary to observe to the reader, the propriety of all the glasses of the apparatus being perfectly clean before the observations; for if, after being laid aside some time, or by dust, &c. they should appear soiled, it will be necessary to wipe them previously with a piece of soft shammy leather usually sent in the box for that purpose, or a clean soft cloth. The two large lenses at F, Fig. 3, may be readily separated by turning aside the two brass screws that act upon a brass ring.

From the various ingenious admirers of this sort of instrument, many improvements and alterations have been suggested; among several that have been communicated, those by the two following gentlemen appear to me the most deserving of notice, and which I shall leave to the reader's judgment and experience.

The Rev. John Prince, LL. D. now of Salem, Massachuset's States, North America, a valuable correspondent and friend of our late author, transmitted to him an alteration in the construction; and of which I here insert the brief account, in nearly the words given by Mr. Adams.

Dr. Prince applies a strong joint similar to that of a telescope at about the middle of the center part of the pyramidical box, and a sort of adjusting screw at the large end. The joint is nearly in the center of gravity, so that a very small motion is sufficient to bring any object less than an inch in diameter into the field of view. This motion is effected by two screws at right angles to each other; one screw raising or levelling the body, the other moving it sidewise, the screw at the same time forming a double joint to accommodate the parts to the movement.*

To secure the image formed upon the rough glass more completely from the light, at times essentially necessary, there is a

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* A figure of this, with an explanation, as recommended by Mr. John Hill, Wells, in Norfolk, may be seen in the Gentleman's Magazine, Vol. LXVI. 2d part, page 897. In this particular, as well as in the deviation from the parallel position of the glasses to the surfaces of the objects, I think the construction not so simple and perfect, as that by rack-work and pinion applied by Mr. Jones. Probably, Dr. Prince had not, at the time of his contriving the joint-work to the box, seen or heard of the other method. His subsequent contrivances shew real ingenuity; and to the inquisitive in this instrument, will afford much useful entertainment and advantage.

pyramidical mahogany box, of the same size, to pack, when not used, in the body of the microscope; when in use, the broad end of this screen box is to be slid into the groove, from which the exterior cover at the end has been taken. This method is peculiarly useful in the day-time; as, by screening the large lenses from the light, it may even then be used with satisfaction.

One of the large lenses may occasionally be placed on the outer edge of the screen box, the other lens being taken out; the view on the rough glass is by these means magnified, and appears to greater advantage. But, besides the grey glass used in the former construction, there is a second in this, placed farther within the body, about half way; and, when the large lens is in the screen box, objects appear better in this than in the former way. It has a still greater effect upon those who are unacquainted with the nature of lenses, as it makes them judge the distance and magnitude much greater than they really are, and is therefore more pleasing than the grey glass in front. Only one grey glass can be used at a time; both being removed when opake objects are viewed.

The stage, F, Fig. 5, is considerably different from that at C, Fig. 4; it is judged more convenient and commodious than the other, and serves, with a small alteration, for both transparent and opake objects. A truncated cone can also be here applied for cutting off superfluous rays of light occasionally.

The method of illuminating the objects is also different. The mode now adopted answers better for opake and transparent objects, throws a stronger light, and is more convenient in application. It consists of two lenses, 1 and 2, Fig. 5; the larger one is to be placed at the end of the bar next the lamp. The smaller one to be adjusted so as to give a strong light. A third is also added, to be used occasionally with opake objects; it is to be applied close to the large lens. Experience will shew when it is to be used, or not. By moving the bar, G, on which these lenses are placed round the stage pillar, M, you bring it so much fronting the stage as effectually to enlighten opake objects by means of the lamp. The light thus afforded is received directly, and none lost by reflection. The objects are fixed on circular wheels of wood, see Fig. 7, the brass centers of which, are fitted to the hole, *h*, of the stage, Fig. 5; and about this center they are to be turned by the hand for the changing of the objects.

As some objects, such as sections of wood, are seen to advantage both as transparent and opake, a frame containing a plane and a concave mirror is added to this instrument, serving two purposes: by bringing the bar to the front of the stage, removing the large lens, and putting the mirror in its place, the object may be viewed either way, without moving from the seat, by turning the instrument a little round. This experience will discover. The light of the sun may be thrown by the plane mirror on the condensing lens, so as to produce a strong full field of light on the grey glass. This has a grand effect when the large lens is at the end of the screen box, and could not be applied in this manner in former constructions. It becomes also an opake solar microscope, by turning the bar round to enlighten opake objects.

By bringing the concave mirror to a focus that will burn objects, a set of very curious and entertaining experiments may be made and exhibited on the grey glass. The object for combustion should be put in the nippers, and a piece of slate tied as a ground on the stage. The ebullition of a piece of alum viewed in this manner is very beautiful; the bubbles, as they rise and pass off rapidly, appear tinged with all the colours of the rainbow.

There are large-sized magnifiers for the purpose of throwing transparent objects on a screen, in imitation of the solar microscope. By removing the large lenses in front and the grey glass, and placing the black tin cylinder represented in the drawing by dotted marks, over the lamp, they may be shewn in that manner to several persons; thus, this instrument in a great degree supersedes the use of a lanthorn. The image may be contracted occasionally by one of the large lenses.

The following improvement consists in the manner of applying the lamp, by Mr. Hill. By attaching it to the instrument, it renders the light more permanent and steady, and reduces considerably the bulk as well as the trouble of this appendage, and is to be preferred when the lamp is not wanted separately for other uses or experiments.

H, a brass support to the arm, G, for sustaining the weight of the lamp; it turns round with the bar on the pillar, M. At about I is a brass cap soldered to the above support, and which slips over the slider carrying the larger lens, 2. At K, is a strong joint connected with the said cap, and by which an horizontal motion of the cap is given, when an oblique light is required. To the end of this the lamp is fixed, and in such a manner as to admit of its being easily slid upwards or downwards in a perpendicular direction, to procure the just height of the flame. L is a square brass rod to be occasionally screwed into the reservoir of the lamp, for supporting the tin cylinder screen, when transparent objects are to be represented on a screen in a darkened room.

The transparent microscope, part of the lucernal, is sometimes adapted to a large japanned tin lanthorn, such as represented at Fig. 6. A brass female screw is soldered to the front of the lanthorn, which has a motion upwards or downwards, fitted to the male screw of the transparent microscope. A tall chimney is placed at the top of the lanthorn to conduct the heated air from an Argand's lamp withinside. The transparent objects in the sliders are magnified by the lenses screwed on at *a*, and shewn on the screen A; this screen may be about three feet square, of white paper, the objects on which, if represented in a field larger than twelve or eighteen inches, will not be sufficiently vivid.

Mr. Jones has found that a large square glass, from twelve to sixteen inches in the side, rough ground on one of its surfaces, exhibits the objects the best of any other contrivance; answers tolerably well for opake objects, and gives the artist the means of tracing their figure most correctly on its surface. Such sort of objects he fixes upon slips of glass for that purpose, or applies them to a pair of nippers shewn at *b*, sent with the microscope. A concave silver speculum screws on at *c*, before the magnifiers, which reflects upon the objects the light that issues from the lamp through the body of the microscope. The least dimensions of the lanthorn are about ten inches square, and fourteen inches high.

This microscope and lanthorn, when made as a separate apparatus from the lucernal, is called the LANTHORN MICROSCOPE. Its effect is considerably short of what is produced by the solar microscope, and not equal to what is much wished for in this manner of magnifying minute objects; see note, page 77.

Partly from the improvements just described, Mr. Jones is now constructing a lucernal microscope that he conceives will be the most simple and perfect yet made. It could not be completed in time to be described in this work; but its improvent and advantages will be quite evident to any reader who has attended to the description which I have just given.

DESCRIPTION OF CUFF'S DOUBLE-CONSTRUCTED MICROSCOPE, REPRESENTED AT Fig. 1. Plate VII. A.*

This instrument was first described by Mr. Baker, and recommended by him. It was also described by my father in the fourth edition of his Micrographia Illustrata, page xix.

A B C represents the body of this microscope; it contains an eye-glass at A, a large lens at B, and a magnifier which is screwed on at C, one of which is represented at Q.

The body of the microscope is supported by the arm D E, from which it may be removed at pleasure.

The arm D E is fixed on the sliding bar F, and may be raised or depressed to any height within its limits.

The main pillar a b is fixed in the box b c, and by means of the brass foot d is screwed to the mahogany pedestal X Y, in which is a drawer containing all the apparatus.

O, a milled-headed screw, to tighten the bar F when the adjusting screw c g is used.

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* The compound or double microscope is in more general use than any other sort. Besides its being less expensive than the lucernal or complete solar, it is found commodious and portable in the observer's apartment, when only a confined degree of microscopical pursuit is intended, and that chiefly for a few hours amusement; it may be used both by day and night. In the most improved of this kind the objects appear magnified in a field of view from about 12 to 15 inches in diameter. It is better adapted to transparent than to opake objects, yet the latter may often be viewed to great advantage by the assistance of the sun's rays or the light of a candle condensed on them. The intelligent reader, by attending to the accounts of the different microscopes described in this work, will be enabled to select that best adapted to the kind of objects he wishes to explore, and the manner in which he is desirous of having them exhibited. EDIT.

p q is the stage or plate which carries the objects; it has a hole at the center n.

G, a concave mirror, that may be turned in any direction, to reflect the light of the candle, or the sky, upon the object.

A LIST OF THE APPARATUS TO CUFF'S DOUBLE-CONSTRUCTED MICROSCOPE.*

H, a convex lens, to collect the rays of light from the sun or a candle, and condense them on the object, or to magnify a flower or other large object placed upon the stage.

L, a cylindrical tube, open at each side, with a concave silver speculum screwed to the lower end h.

P, the slider-holder; it consists of a cylindrical tube, in which an inner tube is forced upwards by a spiral spring, it is used to receive an ivory slider K, which is to be slid between the plates h and i. The cylinder P fits the hole n in the stage: the hollow part at k is designed to receive a glass tube N.

R is a brass cone, to be put under the bottom of the cylinder P, to intercept occasionally some of the rays of light.

S, a box containing a concave and a flat glass, between which a small living insect may be confined; it is to be placed over the hole n.

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* This microscope is made oftentimes with a joint at the bottom of the main pillar at *c*, to admit placing the instrument into any oblique situation, and connected to the bottom of a mahogany chest; on which account, it is by some of the instrument makers called the Chest Compound Microscope. EDIT.

T, a flat glass to lay any occasional object upon; there is also a concave one u, for fluids.

O, a long steel wire, with a small pair of pliers at one end, and a point at the other, designed to stick or hold objects; it slips backwards and forwards in the short tube o; the pin p fits into an hole m, in the stage for that purpose.

W, a little round ivory box, to hold a supply of talc and rings for the sliders.

Z, a hair brush, to wipe any dust off the glasses, or to take up by the other end a drop of any liquid.

V, a small ivory cylinder, that fits on the pointed end of the steel wire O; it is designed for opake objects. Light-coloured ones are to be stuck upon the dark side, and vice versa.

Y, a common magnifying glass for any occasional purpose.

M, a fish-pan whereon to fasten a small fish, to view the circulation of the blood: the tail is to be spread across the oblong hole at the small end k, and tied fast by means of a ribband fixed thereto; the knob l is to be put through the slit made in the stage, and the tail may be brought under the magnifier.

X is a wire to clean the glass tubes by.

TO USE THIS MICROSCOPE.

Screw the magnifier you intend to use to the end C of the body, place the slider-holder P in the hole n, and the ivory slider K with the object, between the plates *h i* of the slider-holder;

set the upper edge of the bar D E to coincide with the division which corresponds to the magnifier you have in use, and tighten it by the milled nut O; now reflect a proper quantity of light upon the object, by means of the concave mirror G, and regulate the body exactly to the eye and the focus of the glasses by the adjusting screw c g, at the same time you are viewing the object.

To view opake objects, take away the slider-holder P, and place the object on a flat glass u, under the center of the body, or on one end of the jointed nippers o. Then screw the silver concave speculum to the end of the cylinder L, and slide this cylinder on the lower part of the body, so that the upper edge thereof may coincide with the line which has the same mark with the magnifier that is then used; reflect the light from the concave mirror G to the silver speculum, from which it will be again reflected on the object. The glasses are to be adjusted to their focal distance as before directed.

THE DESCRIPTION AND USE OF JONES'S IMPROVED COMPOUND OR DOUBLE MICROSCOPES, REPRESENTED IN Fig. 1 AND 2. Plate IV. BY THE EDITOR.

The chief imperfections of Cuff's microscope, as well as of others formerly made, are, their construction rendering them only compound microscopes, the body of the instrument having but a fixed position over the object, and the smallness of the field of view by the old construction of the glasses in the body. To obviate these defects, as well as for the application of material improvements, the late Messrs. Martin and Adams, and the present Messrs. W. and S. Jones, have constructed this kind of microscope in various ways. Two microscopes by the latter artists, which I am now going to describe, appear to me to be the best of any hitherto invented.

Fig. 1 is a representation of the second best sort of compound microscopes. The improvements, though few in number, are essential to the use thereof. The field of view is considerably larger than in the former microscope. The stage and the mirrors are both moveable, so that their respective distances may be easily varied. The magnifiers may be moved about over the object. There is also a condensing glass, for increasing the density of the light, when it is reflected by the mirror from a candle or lamp. It is furnished with two mirrors, one plane and the other concave, and may likewise be used as a complete single microscope.

A B, Fig. 1. represents the body of the microscope, containing a double eye glass, and a body glass; it is here shewn as screwed to the arm C D, from whence it may be occasionally removed, either for the convenience of packing, or when the instrument is to be used as a single microscope.

The eye glasses and the body glasses are contained in a tube which fits into the exterior tube A B; by pulling out a little this tube, when the microscope is in use, the magnifying power of each lens is increased.

The body A B of the microscope is supported by the arm C D; this arm is moveable in a square socket cut in the head that is connected to the main pillar E F, which is screwed firmly to the mahogany pedestal G H; there is a drawer to this pedestal, which holds the apparatus. This arm may be slid backwards and forwards in its socket, carrying the magnifiers and the body of glasses, and also turned horizontally quite round upon the pillar, giving a general motion all over the object on the stage below; which is a material improvement and advantage of this microscope over a similar one described in the former edition of this work, as any unavoidable motion of the living object to be viewed may be followed, by the observer's hand moving the arm C D as the object changes its place.

N I S is the plate or stage which carries the slider-holder K, this stage is moved up or down the pillar E F, by turning the milled nut M; this nut is fixed to a pinion, that works in a toothed rack cut on one side of the pillar. By means of this pinion the stage may be gradually raised or depressed, and the object adjusted to the focus of the different lenses.

K is the slider-holder, which fits into a hole that is in the middle of the stage N I S; it is used to confine and guide either the motion of the sliders which contain the objects, or the glass tubes that are designed to confine small fishes, for viewing the circulation of the blood. The sliders and tubes are to be passed between the two upper plates.

L is a brass tube, in the upper part of which is fixed the condensing lens before spoken of; it screws into the wire arm *a*, which is placed in the hole I of the stage, with the glass underneath, and may be set at different distances from the object, according to its distance from the mirror or the candle.

O is the frame which holds the two reflecting mirrors, one of which is plane, the other concave. These mirrors may be moved in various directions, in order to reflect the light properly, by means of the pivots on which they move, in the semicircle Q, and the motion of the semicircle itself on the pin R; the concave mirror generally answers best in the day-time; the plane mirror combines better with the condensing lens in L, and a lamp or candle at night.

At S is a hole and slit for receiving either the nippers *b*, or the fish-pan *c*; when these are used, the slider-holder R must be removed.

T, a hole to receive the pin of the convex lens and illuminator *d*.

There are six magnifying lenses contained in a brass wheel screwed in a circular brass box P; this wheel is moveable about its center with the finger, and stops by a click when the magnifiers are each centrally under the body A B above, or the hole in the arm C D. They are marked from No. 1, to 6, and the proper number shewn in a small opening made in the side of the brass box. This wheel P screws into the arm C D, and may occasionally be taken off to admit of the silver speculum, or a single magnifier, hereafter to be described.

There is a small line cut on the edge of the arm C D, which must be brought to the right hand edge of its socket, in order to center the magnifier to the body and the stage.

By unscrewing the body A B, the single magnifiers in the wheel P being then only left, the instrument readily forms a single microscope.

A small pocket hand single or opake microscope may easily be extracted from this apparatus. When the body A B is screwed off, and the arm C D slipt away from its frame with the wheel of magnifiers, and the forceps, wire, and joint *b* applied to it, by a hole made in the arm for that purpose, as represented at V, it is then ready for the examination of any small object that may present itself in the garden, &c. and will be found very convenient whenever the whole instrument is not required.

LIST OF APPARATUS GENERALLY MADE TO THIS MICROSCOPE.

The wheel, with the magnifiers, P. Fig. 1.

The body of the microscope, A B.

The slider-holder, K.

The tube, with the condensing lens L, to be used by candle-light.

The pin and arm *a*, either for the above lens, or for the silver concave speculum *e*.

The silver concave speculum *e*, fitted to the arm above, and used common to all the magnifiers in the wheel and body A B, it is to reflect the light from the concave or plane mirror O below, upon the opake objects, then called the compound opake microscope.

A silver concave speculum *f*, with a single magnifier; it screws to the under part of the arm C D in room of the wheel of magnifiers, and forms then the single opake microscope.

A brass cone *g*, to place under the stage N I S, and serves to diminish the reflected light when necessary.

The jointed nippers *b*, fitted to the stage, to hold any small insect, or other opake object.

A cylinder of ivory *h*, to fix on the pointed end of the nippers, black on one side and white on the other, to make a contrast to the opake object used.

Six ivory sliders, *i*, each having four holes, and objects contained between two talcs confined together by brass circular wires. One of the sliders is usually sent without objects, to be supplied at pleasure. When used, they are placed between the perforated plates of the slider-holder K; where also is to be applied the brass frame slider *k*, containing in one brass piece four small concave glasses fixed; a narrow slip of glass slides over these, all within the frame; so that any very small living object, as a mite, &c, may be viewed with the proper security.

A set of glass tubes, *l*, three in number, to contain tadpoles, water newts, small frogs, eels, &c. which are curious objects for affording a fine view of the circulation of the blood, &c. they are also to be placed in the slider-holder K. There is a small hole at one end to admit air, the other end is to be stopped with cork, to contain the fluid and prevent the escape of the animal. A brass twisted wire is sent, to assist in the cleaning of these tubes.

A small ivory box, *m*, containing talcs and wires to supply the ivory sliders with, should any be lost or damaged.

A lens set in a brass cell, *n*, of such a focus as to view objects under a magnifying power sufficient for the applying them to the instrument for further inspection; hence it has been called the explorator. It may occasionally be screwed to the arm CD, and is then well adapted for viewing objects of the larger kind, or the whole of an insect, &c. before the observing of it in part under the regular magnifiers.

A concave, or a circular plane glass, *o*, for transparent objects, or animalcula in fluids, &c. it is fitted to the side, I, of the stage.

It is necessary to describe the lens and frame, *d*, noticed at page 95; it is either for converging the sun's rays upon opake objects laid upon the stage, or for magnifying a flower, or other large objects applied to the stage, or on the nippers or point, *b*. By its pin and spring socket it is easily raised to any height, for the sun, candle, or the eye of the observer.

A brass insect box, *h*, consisting of a concave and plane glass that screw close together; by means of which a louse, flea, &c. may be secured, viewed alive, and retained for any time. It is applied to the hole I, of the stage, Fig. 1.

A pair of small brass forceps, *q*, by which any small object may be conveniently taken up or moved.

This microscope packs into a mahogany pyramidical shaped case, about seven inches square at its base, and fourteen inches in height. For its price, see the general list annexed to this work.

TO USE THIS MICROSCOPE.

It will be obvious to the reader from the preceding description that it must be put together as represented in the figure; that he has to place the slider-holder, K, to the stage, N I S, with one slider of objects; to reflect as strong a light as possible from the concave mirror, O, below, by turning it into the best position, and moving it upwards or downwards all the while he is looking down the body, A B. Then, for a distinct view of the object, to turn the pinion, M, in a slow and gentle manner. A small degree of practice will render the management very familiar.

For opake objects, the slider-holder, K, is to be removed; the silver speculum, *e*, screwed to the arm, *a*, and by its pin placed in the hole, I, of the stage, with the concave part downward above the stage; the glass, *o*, or the nippers, *b*, with ivory, *h*, placed at the stage: then the light reflected from the mirror, O, up to the speculum above, which will again reflect the light very strongly upon the object. Practice also in this case can make it easy to the beginner. The use of the rest of the apparatus has been sufficiently explained.

OF THE MOST IMPROVED COMPOUND MICROSCOPE, BEING UNIVERSAL IN ITS USES, AND FORMING THE SINGLE, COMPOUND, OPAKE, AND AQUATIC MICROSCOPES.

A person much accustomed to observations by the microscope, will readily discern the several advantages of this instrument over the preceding one. Besides its containing an additional quantity of useful apparatus, it is more commodious and complete for the management while observing, as it may instantly be placed in a vertical, oblique, or horizontal situation, turned laterally at the ease of the observer, and the objects viewed by the primary direct light, or reflected as usual, at pleasure. These particulars the following description will clearly shew. I shall not again so fully describe the same apparatus, as the reader must already understand their uses from the preceding references.

Fig. 2 is a representation of this instrument as placed up for use. A B is the compound body. The eye-glasses are contained in an inner tube that slides outwards or inwards, thus altering its distance from a glass at B, and thereby increasing or diminishing the magnifying power, when thought necessary. This body may be screwed on or off to the arm C D, as in the microscope just described; the arm C D may also be moved in any direction over the object. E F is the square stem or bar, on which is moved by the rack-work and pinion M, the stage N I S, to adjust a distinct view to any of the magnifiers, or apparatus used. V is a strong brass pillar with a joint-piece at top, connected to the stem E F; by means of this joint the position of the microscope is readily altered from a vertical to an oblique or horizontal one, as may be desired or found most easy and convenient to the observer, while sitting or standing; it will also enable him to view objects by direct unreflected light; for, when the stem, E F, is put into an horizontal position, the mirrors, O, R, may be drawn off and laid aside. Against or before the condensing lens, U, the common day-light or the light of a candle may then be directed.

At the stage N I S, is a sliding brass spring, N, serving to confine down slips of glass or large sliders, when objects placed thereon are intended to be viewed out of the horizontal position of the stage. A lens, U, called the condensing lens, fixed in a frame connected to a socket, is for condensing and modifying the rays of light reflected from the concave or plane mirror, O, below; it may be set to a proper distance by raising it up by two little screws, one of which is shewn at *u.* This lens is of considerable use by candle-light, as it serves to fill the whole body, A B, beautifully with light on the object. It is turned aside on a joint pin, when not in use. Six magnifiers are contained in the wheel at P, as in the former microscope. The mirrors, O, below may also be slid upwards or downwards on the stem, by pushing against the screws at *r*. Thus the stage, lens U, and mirrors below, being all in one axis of motion, admit the adjustment of the distinct view, light, &c. in the most accurate and pleasing manner. When the instrument is packed into its case, the feet, G G H, may all be folded together as one, and the body A B, screwed off, for the advantage of being portable. The body, as screwed off, leaves the instrument a single microscope.

THE GENERAL APPARATUS TO THIS MICROSCOPE IS AS FOLLOWS.

First, such as accompany the preceding microscope. The brass wheel with magnifiers, P, Fig. 2. The slider-holder, K. The brass pin and arm, *a*, for receiving the concave speculum, *e*, which is applied to the upper side of the stage, and used common to all the magnifiers. The silver concave speculum, *f*, with a magnifier set therein, used by itself in the arm C D. These two speculums form the instrument into what is called an OPAKE MICROSCOPE.

A brass cone, *g*, fitting the under side of the stage, N I S, to exclude superfluous light. The illuminator, or convex lens, *d*, Fig. 1, fitted to T of the stage. The jointed nippers, *b*, fitted to the stage, and either on the point or nippers to hold any small insect, or other opake object. An ivory black and white piece, *h*, is also fitted to the point to contrast the colour of any object laid thereon; the light upon this is reflected from the silver concaves placed above, which reflect the light downwards received from the mirrors at O. Six ivory sliders as shewn at *i*, containing a selection of objects, placed between Muscovy talc, and fastened by spring wires; and a brass frame slider, *k*: all for the stage, K, when in use. A set of glass tubes for fish or liquids, *l*, to be filled with water and stopped with cork, for the slider-holder K. A pan, *c*, for fish or frogs, fitted to the stage at S. A small ivory box, *m*, with spare talcs and wires. The explorator, *n*, a lens set in a brass cell, for viewing the larger sort of objects either by the hand, or from the arm C D, Fig. 2. A plane glass, *o*, and a concave ditto, *s*, both fitted to the hole of the stage, N I S, for viewing fluids, and confining the animalcula, &c. between them, and so forming what is called the AQUATIC MICROSCOPE.

A brass box, *p*, with a concave and plane glass, for insects and other objects, fitted to the stage N I S, when they are to be examined by the instrument. A pair of brass forceps, *q*, to take or hold any object by. A camel hair brush, *t*.

ADDITIONAL APPARATUS TO THIS BEST MICROSCOPE.

Three large wood sliders, as shewn at X, with talcs and wires, for the larger sort of wings of flies, and other objects which are too large for the small ivory sliders, *i*; they are to be placed in the slider-holder K, when on the stage N I S, and the objects to be magnified either by the magnifiers in the wheel P, or the lens shewn at *n*, screwed on the arm C D. A brass cell, *y*, with a very small globule or lens, or an extraordinary great magnifier, usually about the 30th or 40th of an inch focus; it is to be screwed into the arm C D, when the wheel, P, is first unscrewed away. It is for the purpose of viewing extreme minute objects, which may be so small as to elude the power of the magnifiers in the wheel, P.

A moveable stage, W, which by the pin, *a*, is applied to the hole, S, of the stage Fig. 2, and thereby has an horizontal motion under the whole field of view, without disturbing any other part of the instrument. To the large hole of this stage are fitted a deep concave glass, *r*, and the concave and plane glasses, *s* and *o*; and to the small holes, *x x*, a black and white piece of ivory, *w*, for opake objects, and a concave and plane glass similar to *o* and *s*. An extra concave silver speculum with a less magnifier than the other, as shewn at *f*, used for the larger kind of opake objects, like the other, fitted to the arm C D, and used instead of the magnifiers in the wheel, P.

Rack-work is sometimes cut in the arm C D, to turn the pinion above, so as to move the magnifiers in a linear direction over the objects in the most accurate degree; and also the stage N I S jointed, to turn by a screw and teeth in an horizontal direction at right angles to the above, thereby rendering a slow and accurate motion, perfectly suitable to the various positions of any living animal under examination.

Six or more larger ivory sliders, with cuttings of different woods, &c. are also frequently added; but as these enhance the expense, and may be extended to the desire of the purchaser, his choice, and not my description here, will determine the extent of the apparatus to the microscope. When packed up into its mahogany, or black shagreen case, the outside dimensions are about twelve inches and an half long, nine inches broad, and three inches three-quarters deep.

A microscope from this plan is frequently made of smaller dimensions, for the convenience of persons who frequently travel, and is contained in a fish-skin case about seven inches long, four inches and an half broad, and two inches deep, and is the most complete instrument of the sort.

TO USE THIS MICROSCOPE.

As in the former one, place the slider-holder K, with a slider of objects in it, in the stage N I S; move the arm C D, in its socket, so that a mark on the side is brought to the edge of the socket; then turn the arm till the magnifier is directly central over the object; look down the tube A B, and during that time, reflect the light strongly and clearly up into it from the mirror O below; and then, while you are looking through the body, gently turn the pinion at M to the right or left, till you see the object magnified in the most distinct and well-defined manner.

Attending properly to this mode is the only care necessary to use any microscope whatsoever; and for want of doing which, many a beginner finds a difficulty in using properly his instrument. For price, see the list at the end.

For opake objects, you take away the slider-holder, K; place on the stage either the concave glass, *s*, or the nippers, *b*; screw the concave speculum, *e*, to the arm, *a*, which place on the stage with the arm in the hole, I. The light is now to be reflected into this concave dish from one of the mirrors, O, below, and it will thus be strongly condensed upon the object. With this concave speculum any of the magnifiers in the wheel, P, may be used. When the single silver concave, *f*, is used, it is screwed to the arm CD, and the one, *e*, and arm, *a*, are not then applied.

For further directions for the management of microscopes, the light, &c. see Chap. IV. p. 129, and sequel.

A DESCRIPTION OF CULPEPER'S, OR THE COMMON THREE-PILLARED MICROSCOPE. Plate IV. Fig. 3.

The only recommendations of this original instrument are, its simple construction and lowness of price. It gives a pleasing view of the object. It is precluded by its form from some of the advantages of the two foregoing instruments, because both the stage and the mirror are confined. This microscope consists of a large exterior brass body, AB, supported on three brass scrolls, which are fixed to the stage F; the stage is supported by three larger scrolls that are screwed to the mahogany pedestal GH. There is a drawer in the pedestal which holds the apparatus. The concave mirror, I, is fitted to a socket in the center of the pedestal. The lower part, B, of the body forms an exterior tube, into which the upper part of the body, C, slides, and may be moved up or down by the hand, so as to bring the magnifiers which are screwed on at D, nearer to, or further from the object.

A LIST OF THE APPARATUS TO CULPEPER'S MICROSCOPE.

Five magnifiers, each fitted in a brass cell; one of these is seen screwed on at D. Six ivory sliders, *k*, five of them with objects; and a small ivory box, *m*, containing some spare talcs, and wires for them. A brass tube, N, to hold the concave speculum. A brass box, M, for the same speculum. A fish-pan, *c*. A set of glass tubes, *b*. A flat and a concave glass, both fitted to the stage. A brass cone, *g*, to exclude superfluous light; it applies at the under side of the stage, F. A brass box, *p*, with plane and concave glasses for living objects. A pair of forceps, *q*. A steel wire, *l*, with a pair of nippers at one end, a point at the other, and a small ivory cylinder, *h*, to fit on the pointed end of the nippers. A convex lens, E, moveable in a brass semicircle; this is affixed to a long brass pin, which fits into a hole, F, on the stage. The uses of the above apparatus have been sufficiently described in the preceding pages.

TO USE THIS MICROSCOPE.

Screw one of the five cells, which contains a magnifying lens, to the end, D, of the body; place the slider *i* or *k*, with the objects, between the plates of the slider-holder, K. Then, to attain distinct vision and a pleasing view of the object, adjust the sliding body to the focus of the lens you are using, by moving the upper part, C, gently up and down while you are looking at the object, and regulate the light by the concave mirror, I, below. The image of the objects in this microscope is seen in a field of view of about six inches in diameter; but, in the improved ones before described, it is from about twelve to fifteen inches.

For opake objects, two additional pieces must be used; the first is a cylindrical tube of brass, represented at N, which fits on the cylindrical snout above D of the body: the second piece is the concave speculum, L; this is to be screwed to the lower end of the aforesaid tube. The upper edge of this tube should be made to coincide with the line which has the same number affixed to it as the magnifier you are using; that is, if you are making use of the magnifier marked 5, slide the tube to the circular line on the tube above D, that is marked also with No. 5.

The slider-holder, K, should be removed when you are going to view opake objects, and a plane glass should be placed on the stage in its stead to receive the object; or it may be placed on the nippers, *b*, the pin of which fits into the hole in the stage.

A DESCRIPTION OF MARTIN'S IMPROVED SOLAR MICROSCOPE, WHICH IS CONSTRUCTED TO EXHIBIT TRANSPARENT AND OPAKE OBJECTS. Plate V.

The solar microscope is generally supposed to afford the most entertainment, on account of the wonderful extent of its magnifying power, and the ease with which several persons may view each single object at the same time. The use of it was, however, confined for many years only to transparent objects. About the year 1774, Mr. B. Martin so far improved this instrument, as to render it applicable to opake, as well as to transparent objects, exhibiting the magnified image of either kind on a large screen. Treating of it himself, he says*, " With this instrument all opake objects, whether of the animal, vegetable, or mineral kingdom, may be exhibited in great perfection, in all their native beauty; the lights and shades, the prominences and cavities, and all the

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[*] Description and Use of an Opake Solar Microscope. 8vo. 1774.

varieties of different hues, teints, and colours, heightened by the reflection of the solar rays condensed upon them." From its enlarged dimensions, transparent objects are also shewn with greater perfection than in the common solar microscope.

Plate V. Fig. 1, represents the solar opake microscope, placed together for exhibiting opake objects.

Fig. 2, is that part called the single tooth and pinion microscope, which is used for shewing transparent objects; the cylindrical tube, Y, thereof, being made to fit into the tube E F, Fig. 1. It may be occasionally used as a hand single, or Wilson's microscope, and for which purpose, the handle, *c*, is fitted by a screw to the body at *g*, and the tube, Y, screwed away.

Fig. 3, the slider which contains the six magnifiers; it fits into a dove-tail under P, Fig. 2, at the upper part of the microscope.

Fig. 4 represents a brass dove-tail slider, containing a small lens: it is called a condenser. There are three in number, marked 1 and 2, &c. corresponding to the number of the magnifiers used: they serve to condense the sun's rays strongly upon the object, and enlarge the circle of light. They slide in at *h*, Fig. 2.

ABCDEF, Fig. 1, represents the body of the solar microscope; one part thereof, ABCD, is conical, the other, CDEF, is cylindrical. The cylindrical part receives the tube, G, of the opake object box, or the tube, Y, of the single microscope, Fig. 2. At the large end, AB, of the conical part there is a convex lens to receive the rays from the mirror, and refract them convergingly into the box, HIKL.

NOP is a brass frame which is fixed to the moveable circular plate, *a b c*; in this frame there is a plane mirror, to reflect the solar rays through the afore-mentioned lens. This mirror may be moved into the proper positions for reflecting the solar rays, by means of rack-work turned by the nuts Q and R. By the nut Q, it may be moved from right to left; it may be elevated or depressed by the nut, R. *d e*, two screws to fasten the microscope to a window-shutter, or a board fitted entirely before the window.

The box for opake objects is represented as open at H I K L; it contains a plane mirror, M, for reflecting the light that it receives from the large lens to the object, and thereby illuminating it; S is a screw to adjust this mirror to its proper angle for reflecting the light. V X, two tubes of brass, one sliding within the other, the exterior one in the box, H I K L; these carry two magnifying lenses: the interior tube is sometimes taken out, and the exterior one is then used by itself. Part of this tube may be seen in the plate as within the box, H I K L.

At H, is a brass plate, the back part of which is fixed to a tube, *h*, containing a spiral wire, which keeps the plate always bearing against the side, H, of the brass box H I K L. The sliders, with the opake objects, Fig. 5, pass between this plate and the side of the box; to apply which, the plate is to be drawn back by means of the nut, *g*. *k i*, a door to one side of the opake box, to be opened when adjusting the mirror, M.

The foregoing pieces constitute the several parts necessary for viewing opake objects. We shall now proceed to describe the single microscope, which is used for transparent objects; but, in order to examine these, the box, H I K L, must be first removed; and in its place we must insert the tube, Y, of the single microscope, Fig. 2, now to be explained.

Fig. 2 represents a large tooth and pinion microscope; at *m*, within the body of this microscope, are two thin plates that are to be separated, in order to let the ivory sliders, Fig. 7, pass between them; they are pressed together by a spiral spring, which bears up the under plate, and forces it against the upper one. The slider, Fig. 3, that contains the magnifiers, fits into a hole at *n*; any of the magnifiers may be placed before the object, by moving the aforesaid slider: when the magnifier is at the center of the hole P, a small spring falls into one of the notches which is on the side of the slider, Fig. 3. At *h*, slides a condenser, Fig. 4, for condensing the sun's rays, and enlarging the field of view on the screen: the number must correspond with that of the magnifier used. This microscope is adjusted to the focus, while exhibiting the object, by turning the milled nut O.

APPARATUS TO THE OPAKE SOLAR MICROSCOPE.

The mirror O P, Fig. 1, and square plate, and the tubular body of the microscope, A F. The opake box and its tube, I K G. The tooth and pinion or single microscope, Fig. 2. The slider of magnifiers, Fig. 3. The megalascope magnifier, Fig. 6, fitted to P of Fig. 2. Six ivory sliders with transparent objects, Fig. 7. Twelve wood sliders with opake objects, and a brass frame to hold them, Fig. 5. A brass square-formed slider case, Fig. 8, to hold any animal, piece of ore, or other opake object, and is to be placed like the other slider at H, Fig. 1. A pair of nippers and point, Fig. 9, the pin, *a*, of which fits into the hole of the slider, Fig. 4, and holds before the magnifiers at P, Fig. 2, any small fly or other complete object to be magnified. A four-glass slider in a brass frame, Fig. 10, for any animalcula, &c. to be placed between the plates at *m*, Fig. 2. A set of glass fish tubes, Fig. 11. A pair of forceps, Fig. 12. Two brass nuts for the window-shutter or board, Fig. 13; and the two brass fastening screws, *d e*, Fig. 1, which may be either used with or without the above two nuts.

The figures on the plate are about half the original size, and the apparatus now made by Messrs. Jones packs into a case thirteen inches long, nine inches broad, and four inches deep. For price, see the list at the end.

TO USE THE SOLAR MICROSCOPE.

Make a round hole in a window-shutter or window-board, that is opposite to the meridian sun, or as nearly so as possible, a little larger than the circle *a b c*; pass the mirror, N O P, through this hole, and apply the square plate to the shutter; then mark with a pencil the places which correspond to the two holes through which the screws are to pass; take away the microscope, and bore two holes at the marked places, large enough to admit the milled screws, *d e*, to pass through them. These screws are to pass from the outside of the shutter, to go through it, and being then screwed into their respective holes in the square plate, they will, when screwed home, hold it fast against the inside of the shutter, and thus support the microscope.

Another way, and perhaps more convenient, is to previously screw the two brass nuts, Fig. 13, to the shutter or window-board, at the inside at a suitable distance, to receive the two milled screws; these nuts will always be ready for use, and the operator may in a minute, within his room, fasten the plate, *a b c*, to the shutter by the two milled screws, being placed contrarywise.

Screw the conical tube, A B C D, to the circle, *a b c*, and then slide the tube, G, of the opake box into the cylindrical part, C D

E F, of the body, if opake objects are to be examined; but if transparent objects are intended to be shewn, then place the tube Y, Fig. 2, within the tube C D E F. The room is to be darkened as much as possible, that no light may enter but what passes through the body of the microscope; for, on this circumstance, together with the brightness of the sun, the perfection and distinctness of the image in a great measure depend.

We shall first consider the microscope as going TO BE USED FOR OPAKE OBJECTS. Adjust the mirror, N O P, so as to receive the solar rays, by means of the two finger-screws or nuts, Q, R; the first, Q, turns the mirror to the right or left; the second, R, raises or depresses it: this you are to do, till you have reflected the sun's light through the lens at A B, strongly upon a white-paper screen or cloth, from four to eight feet square (about the latter dimensions for transparent objects) placed from about five to eight feet distance from the window, and formed thereon a round spot of light: a white wainscot or wall at a suitable distance answers very well. An unexperienced observer will find it more convenient to obtain the light by first forming this spot, before he puts on either the opake box, or the tooth and pinion microscope, Fig. 2.

Now apply the opake box, and place the object between the plates at H; open the door, *k i*, and adjust the mirror, M, till you see you have illuminated the object strongly. If you cannot effect this by the screw S, you must move the screws Q, R, in order to get the light reflected strongly from the mirror, N O P, on the mirror M; without which the latter cannot illuminate the object. The object being strongly illuminated, shut the door, *k i*, and a distinct view of the object will soon be obtained on your screen, by adjusting the tubes V K, with the magnifiers, which is effected by moving them backwards or forwards.

A perfectly round spot of light cannot always be procured in northern latitudes, the altitude of the sun being often too low; neither can it be obtained when the sun is directly perpendicular to the front of the room. As the sun is continually changing its place, it will be necessary, in order to keep his rays full upon the object, to keep them continually directed through the axis of the instrument, by turning the two screws Q and R.

To view transparent objects, remove the opake box, and insert the tube, Y, of Fig. 2, in its place; put the slider, Fig. 3, into its place at *n*, a condenser, Fig. 4, at *h*, and the slider with the objects between the plates at *m*; then adjust the mirror, N O P, as before directed, by the screws, Q, R, so that the light may pass through the object; regulate the focus of the magnifier by the pinion, O. The most pleasing magnifiers in use are the fourth and fifth. The size of the object is generally from four to eight feet, and may be increased or diminished by altering the distance of the screen from the microscope; five or six feet is a convenient distance.

The effect by this sort of microscope is stupendous, and never fails to excite wonder in an observer at the first view, in seeing a flea, &c. augmented in appearance to SEVEN, EIGHT, or even TEN FEET in length, with all its colours, motions, and animal functions, distinctly and beautifully exhibited.

TO EXAMINE TRANSPARENT OBJECTS OF A LARGER SIZE, or to render the instrument what is usually called a megalascope, take out the slider, Fig. 3, from its place at *n*; screw the cell and lens, Fig. 6, into the hole at P, Fig. 2; remove the glass which is placed at *h*, and regulate the light and focus agreeable to the foregoing directions.

At CD, is placed a lens for increasing the density of the rays, for the purpose of burning or melting any fusible substance; this lens must be removed in most cases, lest the objects should be burnt. The intensity of the light is also varied by moving the tube G, and Fig. 2, Y, inwards or outwards.

DESCRIPTION OF THE TRANSPARENT SOLAR MICROSCOPE AND APPARATUS. Plate VI. Fig. 4, to 14.

The foregoing description will, in great part, answer for this microscope; but, the dimensions, apparatus, &c. varying in a small degree from the preceding, a distinct description here, may be acceptable to those, who possess this sort of microscope only.

A B C D, Fig. 4, represents the body of the microscope, consisting of two brass tubes. E F is the end of the inner moveable tube; *e f*, that of the single tooth and pinion microscope. Fig. 5, screws into the end of this inner tube; at the end, A B, of the external tube there is a convex lens, to receive the sun's rays from the mirror, K L, and to condense them on the object; the end, A B, screws into the circular plate, G H I. This part may also be used as a single microscope, and may have at *m* the handle, *c*, screwed to it. K L, a long frame fixed to the moveable circular plate, with a plane mirror, to reflect the rays of the sun on the lens at A B. An endless worm or screw, which is cut on the lower part of the nut, M, works in a small wheel which is fixed to the frame, K L, so that by turning the nut, the frame, K L, is moved up or down: the nut, N, moves the mirror to the right or left. O, P, two screws to fasten the square plate to the window-shutter.

Fig. 5, the single microscope; *e f*, the end which screws on to the part, E F, Fig. 4, of the internal tube of the body; *q*, the dovetailed slit for receiving the slider, Fig. 8; *g*, the hole in which the megalascope magnifier, Fig. 6, is to be screwed, when the slider, Fig. 8, is removed. At *h*, are the moveable plates, between which the object sliders are placed; under the lowermost of these, the lens represented at Fig. 11 is to be placed, when the magnifiers in the slider, Fig. 8, are to be used. *a k* is a small piece of rack-work, which is moved backwards and forwards by the pinion fixed to the milled nut, *b*; by the gradual motion of this rack, the objects are adjusted to the foci of the different lenses. Fig. 8 is a brass slider, with six lenses, or magnifying glasses; it is to be inserted into the hole at *q*; either of the magnifiers may be placed before the object, by sliding it one way or the other: you may perceive when the glass is in the center of the eye-hole by a small spring acting upon a notch which is made on the side of the slider opposite to each lens.

APPARATUS BELONGING TO THIS SOLAR MICROSCOPE.

Square plate and mirror. The body, A D, consisting of two tubes, one within the other. The single microscope, Fig. 5. The megalascope lens, Fig. 6. The slider, Fig. 8, with six lenses. The two screws O, P. Six ivory sliders and a talc box, Fig. 7 and 13. Some glass tubes, Fig. 9. A slider or brass case, Fig. 10, containing a plane piece of glass, and a brass slider with holes, into which are cemented small concave glasses, designed for confining minute insects between the plane and concave glasses, which are thus preserved from being crushed, or from moving out of the field of view. Three condensing lenses to enlarge the field of view, such as Fig. 11, that are fitted to the hole, *l*, of Fig. 5. Their numbers correspond with the numbers used. Fig. 12, two brass nuts for the window-shutter or board, to receive the two screws, O and P.

TO USE THE TRANSPARENT SOLAR MICROSCOPE. Fasten the square plate against the inside of a window-shutter, by the two screws O, P, which are to go from the outside of the window-shutter through it, and then be screwed into their respective holes in the square plate at G H I. The mirror is to be on the outside of the shutter, passing through a hole made for that purpose. Darken the room; then place a screen at about six or eight feet distance from the window, the farther it is from it the larger is the image: now move the mirror, K L, by the two nuts M N, till the sun's rays come through the instrument in an horizontal direction to the screen, forming a round spot thereon; screw the microscope, Fig. 5, into its place E F; put the slider with the lenses, Fig. 8, at *g*, Fig. 5, and the object slider between the plates at *h*; adjust the object to the focus of the magnifying lens by the screw *b*, till the object appears distinct and clear on the screen. By moving the internal tube of the body, the object may be placed at different distances from the lens which is fixed at A B, so as to be sufficiently illuminated, and not burnt by the solar rays. If the screws O, P, are to pass inside the room, the two nuts, Fig. 12, must be previously fixed.

THE SCREW BARREL, OR WILSON'S SINGLE POCKET MICROSCOPE. Plate II. B. Fig. 1 and 2.

This microscope of Mr. Wilson's is an invention of many years standing, and was in some measure laid aside, till Dr. Lieberkühn introduced the solar apparatus to which he applied it, there being no other instrument at that time which would answer his purpose so well; it is much esteemed in particular cases. The body of the microscope is represented at A B, Fig. 1, and is made either of silver, brass, or ivory. C C is a long fine-threaded male screw, that turns into the body of the microscope. D, a convex glass at the end of the said screw, on which may be placed, as occasion requires, one of the two concave apertures of thin brass to cover the said glass, and thereby diminish the aperture when the greatest magnifiers are used. E, three thin plates of brass within the body of the microscope, one whereof is bent to an arched cavity for the reception of a tube of glass. F, a piece of wood or brass, curved in the manner of the said plate, and fastened thereto. G, the other end of the microscope, where a female screw is adapted to receive the different magnifiers. H, a spiral spring of steel, between the said end, G, and the plates of brass, E, intended to keep the plates in a due position, and counteract against the long screw, C. I, a small ivory handle. To this microscope belong seven different magnifying glasses, six of which are set in cells, as in Fig. K, and are marked from 1, to 6: the lowest numbers to the greatest magnifiers. L is the seventh magnifier, set in the manner of a little barrel, to be held in the hand for viewing any large object. M is an ivory slider with the objects. Six of these, and one of brass, are usually sold with this microscope. There is also a brass slider not shewn in the figure, to confine any small object, that it may be viewed without crushing or destroying it. N, a pair of forceps, or pliers, for the taking up of insects or other objects, and applying them to the sliders or glasses. O, a camel hair brush, to take up and examine a small drop of liquid, brush the dust away, &c. P is a glass tube to confine living objects, such as frogs, fishes, &c.

When you view an object, push the ivory slider, in which the said object is placed, between the two flat brass plates, observing always to put that side of the slider, where the brass rings are, farthest from the eye; then screw in the magnifying glass you intend to use at the end of the instrument G, and looking through it against the light, turn the long screw, C C, till your object is brought to appear distinct, or to the true focal distance. To examine any object accurately, view it first through a magnifier that will shew the whole at once, and afterwards inspect the several parts more particularly with one of the greatest magnifiers; for thus you will gain a true idea of the whole, and all its parts: and, though the greatest magnifiers can shew but a minute portion of any object at once, such as the claw of a flea, the horn of a louse, &c. yet by gently moving the slider that contains your object, the eye will gradually see the whole; and if any part should be out of the focal distance, the screw, C C, will easily bring it to the true focus. As objects must be brought very near the glass, when the greatest magnifiers are used, be particularly careful not to rub the slider against the glasses as you move it in or out. A few turns of the screw, C C, will easily obviate this.

DESCRIPTION OF A SCROLL FOR FIXING WILSON'S POCKET MICROSCOPE, AND A MIRROR FOR REFLECTING LIGHT INTO IT.

A B C, Fig. 2, is a brass scroll, which, for the better conveniency of carriage, is made to unscrew into three parts, and may be put into the drawer upon which it stands, with its reflecting mirror D, and Wilson's pocket microscope, G. The upper part of the scroll is taken off at B, by unscrewing half a turn of the screw; then, if lifted up, it will come out of the socket. The lower part unscrews at C, and the base at E. The mirror lifts out at F, which, with the scroll, lies in one partition of the box.

To apply this scroll for use, fix the body of the microscope to the top thereof by the screw, A, as in Fig. 2, by screwing it in the same hole as the ivory handle was applied to before. The brass or ivory slider being fixed as before described, and the microscope placed in a perpendicular position, move the mirror, D, in such a manner as to reflect the light of the sky, of the sun, or a candle, directly upwards through the microscope; by which means the object will be most conveniently viewed. It is further useful for viewing opake objects, by screwing the arm, Q R, Fig. 1, into the body of the microscope at G; then screwing into the round hole, R, that magnifier which you think will best suit your object, and putting the concave speculum, S, on the outside of the ring, R, you will observe in the body of the microscope, between the wood or brass, F, and the end of the male screw, C C, a small hole, *u*, through which slides the long wire, T, which has a point at one end, and forceps at the other, that may be used occasionally as your objects require. When you have fixed this, and your object on it, turn the arm, R, till the magnifier is brought over the object; it may be then adjusted to the true focus, by turning the screw, as before. It must also be brought exactly over the speculum, by turning the upper part of the scroll to one side, till your object and the two specula are in one line, as will be found by trial; and then fix it by the screw, B, at which time the upper surface of the object will be enlightened by the light reflected from the mirror, D, to the concave speculum.

DESCRIPTION OF A SMALL MICROSCOPE FOR OPAKE OBJECTS.

Plate II. B. Fig. 3 and 4.

A, Fig. 3, is a fixed arm, through which passes a screw, B, the other end is fastened to the moveable arm, C. D, a nut fitted to the said screw, which, when turned, will either separate or bring together the two arms, A C. E, a steel spring, that separates the two sides when the nut is unscrewed. F, a piece of brass turning round in a spring socket, moving on a rivet, in which moves a steel wire pointed at the end G, and the other end a pair of pliers, H: these are either to thrust into, or take up and hold any object, and may be turned round as required. I, a ring of brass, with a female screw fixed on an upright piece of the same metal, turning on a rivet, that it may be set at a due distance when the least magnifiers are used, and is adapted to the screws of all the magnifiers.

Fig. 4, K, a concave speculum of polished silver, in the center of which a lens is placed. On the back of this speculum a male screw, L. is made to fit the brass ring I, Fig. 3, Four of these specula of different concavities, with four glasses of different magnifying powers, as the objects may require. The greatest magnifiers have the least apertures. M, a round object plate, one side white and the other black, intended to render objects the more visible, by placing them, if black, upon the white, and if white, on the black side. A steel spring, N, turns down on each side, to secure any object; from the object plate there is a hollow pipe, to screw it on the needle's point G, Fig. 3. O, a small box of brass, with a glass on each side, to confine any living object in order to examine it, having a pipe to screw upon the end of the needle at G. P, an ivory handle. Q, a pair of pliers to take up any object. R, a soft hair brush.

To view any object, screw the speculum, with the magnifier you intend to use, into the brass ring, I; place your object either on the needle G, in the pliers H, on the object plate M, or in the brass hollow box O, as may be most convenient; then holding up your instrument by the handle P, look against the light through the magnifying lens, and by means of the nut, D, together with moving of the needle at its lower end, the object may be turned about, raised or depressed, brought nearer the glass, or put farther from it, till you have the true focal distance, and the light be seen reflected from the speculum strongly upon the object.*

OF ELLIS'S SINGLE OR AQUATIC MICROSCOPE. Plate VII. B.

This instrument takes its name from Mr. John Ellis, author of "An Essay towards a Natural History of Corallines," and of the

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* Opake microscopes are now constructed more elegantly and simply. The chief merit of Wilson's microscope appears, in being particularly adapted to minute objects, and these principally of the transparent kind; the barrel form is useful for excluding adventitious light. Excepting these peculiarities, its general utility is considered far short of the universal pocket microscope hereafter to be described. EDIT.

"Natural History of many curious and uncommon Zoophytes." By this instrument he was enabled to explain many singularities in the œconomy and construction of these wonderful productions of nature. To the practical botanist this instrument is recommended by the respectable authority of Mr. Curtis, author of the Flora Londinensis, a work which does credit to the author and the nation. This microscope is simple in its construction, easy in its use, and very portable; these advantages, as well as some others which it also has over other portable microscopes, have accelerated the sale thereof, and caused it to be very much adopted.

DESCRIPTION OF THE VARIOUS PARTS OF THE MICROSCOPE.

K, the box which contains the whole apparatus; it is generally made of fish-skin; on the top of the box there is a female screw, for receiving the screw which is at the bottom of the brass pillar A, and which is to be screwed on the top of the box, K. D, a brass pin which fits into the pillar; on the top of this pin is a hollow socket to receive the arm which carries the magnifiers; the pin is to be moved up and down, in order to adjust the lenses to their focal or proper distance from the object.

In the representation of this microscope, Plate VII. B. Fig. 1, the pin, D, is delineated as passing through a socket at one side of the pillar, A; it is now usual to make it pass down a hole bored through the middle of the pillar.

E, the bar which carries the magnifying lens; it fits into the socket, X, which is at the top of the pillar, D. This arm may be moved backwards and forwards in the socket X, and sidewise by the pin, D; so that the magnifier, which is screwed into the ring at the end, E, of this bar, may be easily made to traverse over any part of the object lying on the stage or plate B. F is a polished silver speculum, with a magnifying lens placed at the center thereof, which is perforated for this purpose. The silver speculum screws into the arm E, as at F. G, another speculum of a different concavity from the former, with its lens. H, the brass semicircle which supports the mirror, I; the pin, R, affixed to the semicircle, H, passes through the hole which is towards the bottom of the pillar, A. B, the stage or the plane on which the objects are to be placed; it fits into a small dove-tailed arm which is at the upper end of the pillar, A. C, a plane glass, with a small piece of black silk stuck on it; this glass is fitted to a groove made in the stage, B. M, a deep concave glass, to be laid occasionally on the stage instead of the plane glass, C. L, a pair of nippers; these are fixed to the hole of the stage, *a*, by the pin K; the steel wire of these nippers slides backwards and forwards in the socket, and this socket is moveable upwards and downwards by means of the joint, so that the position of the object may be varied at pleasure. The object may be fixed in the nippers, stuck on the point, or affixed by a little gum-water, &c. to the ivory cylinder, N. O, a small pair of brass forceps to take up minute objects by. P, a brush to clean the glasses.

To use this microscope; begin by screwing the pillar, A, to the cover thereof; pass the pin, R, of the semicircle which carries the mirror through the hole that is near the bottom of the pillar, A; push the stage into the dove-tail at B; slide the pin into the pillar, then pass the bar, E, through the socket, X, which is at the top of the pin D, and screw one of the magnifying lenses into the ring at F.

Now place the object either on the stage, or in the nippers L, and in such a manner, that it may be as nearly as possible over the center of the stage; bring the speculum, F, over the part you mean to observe; then get as much light on the speculum as you can, by means of the mirror, I; the light received on the speculum is reflected by it on the object. The distance of the lens, F, from the object is regulated by moving the pin, D, up and down, until a distinct view of it is obtained. The rule usually observed is, to place the lens beyond its focal distance from the object, and then gradually slide it down, till the object appears sharp and well defined. The adjustment of the lenses to their foci, and the distribution of the light on the object, are what require the most attention.

These microscopes are sometimes fitted up with a rack and pinion to the pillar A, and pin D, for the more ready adjustment of the glasses to their proper foci.

DESCRIPTION OF LYONET'S ANATOMICAL MICROSCOPE.

Plate VI. Fig. 3.

Fig. 3 represents the instrument with which M. Lyonet made his microscopical and wonderful dissection of the chenille de saule or caterpillar of the goat moth,* of which a specimen is given in Plate XII. Fig. 1, &c. of this work. This portable instrument needs no further recommendation. By it, other observers may be enabled to dissect insects in general with the same accuracy as M. Lyonet, and thus advance the knowledge of comparative anatomy, by which alone the characteristic, nature, and rank of animals, can be truly ascertained.

A B is the anatomical table, which is supported by the pillar O N; this is screwed on the mahogany foot, D C. The table A B, is prevented from turning round by means of two steady pins; in this table or board there is a hole, G, which is exactly over the center of the mirror, F E, that is to reflect the light on the

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* Phalæna cossus. Linn. 63.

object; the hole, G, is designed to receive a flat or a concave glass, on which the objects are to be placed that you design to examine or dissect. R X Z is an arm formed of several balls and sockets, by which means it may be moved in every possible position; it is fixed to the board by means of the screw, H; the last arm, 1 Z, has a female screw, into which a magnifier may be screwed, as at Z. By means of the screw, H, a small motion may be occasionally given to the arm 1 Z, for adjusting the lens with accuracy to its focal distance from the object. Another chain of balls is sometimes used, carrying a lens to throw light upon the object; the mirror is also so mounted, as to be taken from its place at K, and fitted on a clamp, by which it may be fixed to any part of the table, A B.

TO USE THE DISSECTING TABLE. Let the operator sit with his left side near a light window; the instrument being placed on a firm table, the side, D L, towards his breast, the observations should be made with the left eye: this position is well adapted for observing, drawing, or writing. In dissecting, the two elbows are to be supported by the table on which the instrument rests, the hands resting against the board, A B, in order to give it greater stability, as a small shake, though imperceptible to the naked eye, is very visible in the microscope; the dissecting instruments are to be held one in each hand, between the thumb and two fore-fingers. Farther directions are given on the mode of dissecting small objects in the following chapter.

DR. WITHERING'S BOTANICAL MICROSCOPE. Plate VI. Fig. 1.

This small instrument consists of three brass parallel plates, A, B, C; two wires, D and E, are rivetted into the upper and lower plate; the middle plate or stage is moveable on the aforesaid wires, by two little sockets which are fixed to it. The two upper plates each contain a magnifying lens, but of different powers; one of these confines and keeps in their places the fine point F, the forceps G, and the small knife H.

To use this instrument; unscrew the upper lens, and take out the point, the knife, and the forceps; then screw the lens on again, place the object on the stage, and then move it up or down till you have gained a distinct view of the object, as one lens is made of a shorter focus than the other; and spare lenses of a still deeper focus are sometimes added. The principal merit of this microscope is its simplicity.

THE POCKET BOTANICAL AND UNIVERSAL MICROSCOPE.

This pocket instrument is represented at Plate VI. Fig. 2. It is by most naturalists deemed preferable to Dr. Withering's, being equally simple, more extensive in its application, and the stage unincumbered; though that of M. Lyonet seems better adapted than either to the purposes of dissection only.

A B, a small arm, carrying three magnifiers, two fixed to the upper part, as at B, the other to the lower part of the arm, at C; these may be used separately or combined together, by which you have seven powers. The arm, A B, is supported by the square pillar I K, the lower end of which fits into the socket, E, of the foot, F G; the stage, D L, is made to slide up and down the square pillar. H, a mirror for reflecting light on the object.

To use this microscope, place the object on the stage, L, reflect the light on it from the mirror H, and regulate it to the focus, by moving the stage nearer to or further from the lenses at B C. The ivory sliders pass under the stage, L; other objects may be fixed in the nippers, M N, and then brought under the magnifiers; or they may be laid on one of the glasses fitted to the stage. The apparatus to this instrument consists of three ivory sliders, a pair of nippers, a pair of forceps, a flat glass, and a concave ditto, all fitted to the stage, L. By taking out the pin, M, the pillar, I K, may be turned half round, and the foot, F G, made to answer as an handle.*

BOTANICAL MAGNIFIERS.

Since botany has been cultivated with so much ardor, it has been found necessary to contrive some very portable instrument, by which the botanist might investigate the object of his pursuits as it rises before him. Plate VIII. Fig. 7 and 8, represent two of the most convenient sort.

In the tortoiseshell case, Fig. 7, three lenses are contained, *d, e, f,* of different foci, which are all made to turn into the case, and may be used combined or separately. The three lenses in themselves afford three different magnifying powers; by combining two and two, we make three more; and the three together make a seventh magnifying power. When the three lenses are used together, it is best to turn them into the case, and look through the hole, for more distinctness, and the exclusion of superfluous light. In the case, Fig. 8, are also three lenses, *g, h, i,* of different magnifying powers, that all turn up, and shut into the case; but these are not capable of combination.

DESCRIPTION OF A PORTABLE MICROSCOPE AND TELESCOPE.

Plate VIII. Fig. 1, to 6.

The telescope is one of those which are composed of several sliding drawers or tubes, for the convenience of being put into the

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* An adjusting screw, Fig. 13, to move the stage, with other additions, are made by Messrs. Jones; and which then, in my opinion, constitute the most complete pocket microscope hitherto made; for the particulars of which, I refer the reader to their printed description. Fig. 14, represents the common flower or insect microscope. There are two lenses, *a* and *b,* that are used separately or conjointly. EDIT.

pocket; the sliding tubes are made of thin brass, the outside tube of mahogany. The sliding tubes are contrived to stop, when drawn out to a proper length, so that by applying one hand to the outside tube, and the other hand to the end of the smallest tube, the telescope may at one pull be drawn out to its full length; then any of the tubes (that next the eye is most generally used) may be pushed in gradually, while you are looking through it, till the object is rendered distinct to the eye. To make the tubes slide properly, they all pass through short springs or tubes; these springs may be unscrewed from the ends of the sliding tubes, by means of the milled edges which project above the tubes, and the tubes taken from each other if required, and the springs set closer if at any time they be too weak.

Fig. 5 represents the exterior tube of the telescope, which is to be unscrewed from the rest, at *m l*, as it does not make any part of the microscope; the cover, *k*, which protects the object-glass, serves also as a box to contain two ivory wheels, Fig. 1 and 2, with the objects, and a small mirror, Fig. 6.

Fig. 4 is a view of this cover when taken off: unscrew the top part of it, and the mirror, Fig. 6, may be taken out; unscrew the cover of the lower part, and you will find therein the two circular object-wheels above mentioned.

Fig. 3 represents the three internal tubes of the telescope, which constitute the microscopic part thereof. Draw the tubes out in the manner as shewn in the figure; then at the inside, but at the lower end of the exterior tube, a, you will find a short tube, which serves as a stage to hold the object and support the mirror; pull this tube partly out, and turn it, so that a circular hole which is pierced in it may coincide with a similar hole in the exterior tube. This tube is represented as drawn out at Fig. 3, the mirror, Fig. 6, placed therein at *b c*, and the transparent object-wheel fixed at a.

Fig. 1 represents the slider with transparent objects.

Fig. 2, that with the opake. They are made of ivory, and turn on a pin at the center; the slit end of this pin fits on the edge of the tube, which is then to be pushed up, so that the lower end of the exterior tube may bear lightly on the upper side of the slider, agreeable to the view which is given at a, Fig. 3. Now push down the second tube till the milled part falls on the milled edge of the extreme tube, being careful of the circular hole in the exterior one. Nothing now remains to be done but to adjust for the focus, which is effected by pushing in the tube R, and moving only the first, *n*.

The instrument may be used in two ways for transparent objects: first, in a vertical position, when the light is to be thrown on the object by the mirror, *b c*; or it may be examined by looking up directly at the light; in the latter case the mirror must be taken away. In viewing opake objects the mirror is not used; as much light as possible must be admitted on them through the circular holes of the tubes. Any object may be viewed by first pushing in the tube, R, and then bringing the tube, *n*, to its focal distance from the object. The telescope, when shut up, is about eight inches in length, and when drawn out, is about twenty inches. It is of the achromatic construction.

DESCRIPTION OF AN INSTRUMENT FOR CUTTING THIN TRANSVERSE SECTIONS OF WOOD. Plate IX. Fig. 1.

It consists of a wooden base, which supports four brass pillars; on the top of the pillars is placed a flat piece of brass, near the middle of which there is a triangular hole. A sharp knife which moves in a diagonal direction, is fixed on the upper side of the afore-mentioned plate, and in such a manner, that the edge always coincides with the surface thereof. The knife is moved backwards and forwards by means of the handle, *a*. The piece of wood is placed in the triangular trough, which is under the brass plate, and is to be kept steady therein by a milled screw which is fitted to the trough; the wood is to be pressed forward for cutting, by the micrometer screw, *b*. The pieces of wood should be applied to this instrument immediately on being taken out of the ground, or else they should be soaked for some time in water, to soften them, so that they may not hurt the edge of the knife. When the edge of the knife is brought in contact with the piece of wood, a small quantity of spirit of wine should be poured on the surface of the wood, to prevent its curling up; it will also make it adhere to the knife, from which it may be removed by pressing a piece of blotting paper on it.

Fig. 2, is an appendage to the cutting engine, which may be used instead of the micrometer screw, being by some practitioners preferred to it. It is placed over the triangular hole, and kept flat down upon the surface of the brass plate, while the piece of wood is pressed against a circular piece of brass which is on the under side of it. This circular piece of brass is fixed to a screw, by which its distance from the flat plate on which the knife moves may be regulated.*

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* Many other kinds of cutting engines have been constructed, but the specimens from them have not yet appeared with that perfection which is requisite to this sort of objects; whether it lies in the preparation of the woods, or engine, I do not take upon me to determine. Mr. Custance has certainly produced the most exquisite. EDIT.

CHAP. IV.

GENERAL INSTRUCTIONS FOR USING THE MICROSCOPE AND PREPARING THE OBJECTS.

AS the advantages which are obtained from any instrument are considerably increased, if it be used by a person who is master of its properties, attentive to its adjustments, and habituated by practice to the minutiæ of management, it is the design of this chapter to point out those circumstances which more peculiarly require the attention of the observer, and to give such plain directions, as may enable him to examine any object with ease; to shew how he may place it in the best point of view, and if necessary, prepare it for observation.

A small degree of diligence will render the observer master of every necessary rule, and a little practice will make them familiar and habitual: the pains he takes to acquire these habits will be rewarded by an increasing attachment to his instrument, and the wonders it displays. Let him only persevere till he has overcome the natural indolence that opposes the advancement of every kind of knowledge, and he will most assuredly find himself very amply recompensed, by the gratification arising from the acquisition of a science that has the unlimited treasures of INFINITE WISDOM for the object of its researches: and his mind being strengthened by the victory it has gained, will be more keen in perceiving, and more patient in the investigation of truth.

It has long been a complaint,* that many of those who purchase microscopes are so little acquainted with their general and extensive usefulness, and so much at a loss for objects to examine by them, that after diverting themselves and their friends some few times with what they find in the sliders, which generally accompany the instrument, or perhaps two or three common objects, the microscope is laid aside as of little further value: whereas no instrument has yet appeared in the world capable of affording so constant, various, and satisfactory an entertainment to the mind. This complaint will, I hope, be obviated by these Essays, in which I have endeavoured to make the use of the microscope easy, point out an immense variety of objects, and direct the observer how to prepare them for examination.

The subject treated of in this chapter naturally divides itself into three heads: the first describes the necessary preparation and adjustment of the microscope; the second treats of the proper quantity of the light, and the best method of adapting it to the objects under examination; and the third shews how to prepare and preserve the various objects, that their nature, organization, and texture, may be properly understood.

OF THE NECESSARY PREPARATION OF THE MICROSCOPE FOR OBSERVATION.

We have in the last chapter explained those particulars that constitute the difference of one microscope from another, and shewn the manner of using each instrument, and how the several

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* Baker's Microscope made Easy, p. 51.

parts are to be applied to it. We shall now proceed to give some general directions applicable to every microscope. The observer is therefore supposed to have made himself master of his instrument, and to know how to adapt the different parts of the apparatus to their proper places.

The first circumstance necessary to be examined into, is, whether the different glasses belonging to the microscope are perfectly clean or not; if they be not clean, they must be taken out and wiped with a piece of wash leather, taking care at the same time not to soil the surface of the glass with the fingers: in replacing the glasses, you must also be careful not to lay them in an oblique situation, to place the convex sides as before, and if one glass be taken out, wiped, and replaced before the next, it may prevent the misplacing of them by an unskilful hand.

The object should be brought as near the center of the field of view as possible, for there only will it be exhibited in the greatest perfection.

The eye should be moved up and down from the eye-glass of a compound microscope, till you find that situation where the largest field, and most distinct view of the object is obtained; and as the sight differs very much in different persons, and even in the same person, we frequently find each eye to have a different sight from the other, particularly in those called myopes, or short-sighted, every one ought to adjust the microscope to his own eye, and not depend upon the situation in which it was placed by another.

Care must be taken not to let the breath fall upon the eye-glass, nor to hold that part of the body of the microscope where the glasses are placed with a warm hand, because the damp that is expelled from the metal by the heat will be attracted and condensed by the glasses, and obstruct the sight of the object.

The observer should always begin with a small magnifying power; with this he will gain an accurate idea of the situation and connection of the whole, and will therefore be less liable to form any erroneous opinion, when the parts are viewed separately by a deeper lens. By a shallow magnifier he will also discover those parts which merit a further investigation. Objects that are transparent will bear a much greater magnifying power than those that are opake.

Every object should, if possible, be examined first in that position which is most natural to it: if this circumstance be neglected, very inadequate ideas of the structure of the whole, as well as of the connection and use of the parts, will be formed. If it be a living animal, care must be taken not to squeeze, hurt, or discompose it.

There is a great difference between merely viewing an object by the microscope, and investigating its nature: in the first, we only consider the magnified representation thereof; in the second, we endeavour to analyse and discover its nature and relation to other objects. In the first case, we receive the impression of an image formed by the action of the glasses; in the second, we form our judgment by investigating this image. It is easy to view the image which is offered to the eye, but not so easy to form a judgment of the things that are seen; an extensive knowledge of the subject, great patience, and many experiments, will be found necessary for this purpose: for there are many circumstances where the images seen may be very similar, though originating from substances totally different; it is here the penetration of the observer will be exercised, to discover the difference, and avoid error.*

Hence Mr. Baker cautions us against forming too suddenly an opinion of any microscopic object, and not to draw our inferences till after repeated experiments and examinations of the objects, in all lights and various positions; to pass no judgment upon things extended by force, or contracted by dryness, or in any manner out of a natural state, without making suitable allowances.

The true colour of objects cannot be properly determined when viewed through the deepest magnifiers; for, as the pores and interstices of an object are enlarged, according to the magnifying power of the glasses made use of, the component parts of its substance will appear separated many thousand times farther asunder than they do to the naked eye; it is, therefore, very probable, that the reflection of the light from these particles will be very different, and exhibit different colours.

Some consideration is also necessary in forming a judgment of the motion of living creatures, or even of fluids, when seen through the microscope; for as the moving body, and the space wherein it moves, are magnified, the motion will also be increased.

If an object be so opake as not to suffer any light to pass through it, as much as possible must be thrown on its upper surface, by that part of the apparatus which is peculiarly adapted to opake objects. As the apertures of deep magnifiers are but small, and consequently admit but little light, they are not proper for

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* Fontana sur les Poisons, vol. ii. p. 245.

the examination of opake objects: this, however, naturally leads us to our second head.

OF THE MANAGEMENT OF THE LIGHT.

The pleasure arising fron a just view of a microscopic object, the distinctness of vision, &c. depend on a due management of the light, and adapting the quantity of it to the nature of the object, and the focus of the magnifier; therefore, an object should always be viewed in various degrees of light. It is difficult to distinguish in some objects between a prominency and a depression, between a shadow and a black stain; and in colour, between a reflection and a whiteness; a truth which the reader will find fully exemplified in the examination of the eye of the libellula, and other flies, which will be found to appear exceedingly different in one position of the light from what they do in another.

The brightness of an object depends on the quantity of light; the distinctness of vision, on regulating the quantity to the object; for some will be lost and drowned, as it were, in a quantity of light that is scarce sufficient to render another visible, as a different portion of light under the same apparatus will often exhibit in perfection, or totally conceal an object in the substance to be examined. This is more particularly the case with the animalculæ infusoriæ, whose thin and transparent form blend as it were with the water in which they swim; the degree of light must therefore be suited to the object, which, if dark, will be seen best in a strong and full light, but if very transparent, it should be examined in a fainter.

A strong light may be thrown on an object various ways: first, by means of the sun and a convex lens; for this purpose, place the microscope about three feet from a southern window; take a deep convex lens, that is mounted in a semicircle and fixed on a stand, so that its position may be easily varied; place this lens between the object and the window, so that it may collect a considerable number of the solar rays, and refract them on the object, or the mirror of the microscope. If the light thus collected from the sun be too powerful, it may be tempered by placing a piece of oil paper, or a glass lightly greyed, between the object and the lens: by these means, a convenient degree of light may be obtained, and diffused in an equal manner over the whole surface of an object, a circumstance that should be particularly attended to; for if the light be thrown in an irregular manner, that is, larger portions of it on some parts than on others, it will not be distinctly exhibited.

Where the solar light is preferred, it will be found very convenient to darken the room, and to reflect the rays of the sun on the above mentioned lens, by means of the mirror of a solar microscope fitted to the window-shutter; for, by this apparatus, the observer will be enabled to preserve the light on his object, notwithstanding the motion of the sun.

Cutting off the adventitious light as much as possible, by darkening the room where you are using the microscope, and admitting the light only through a hole in the window-shutter, or at most, keeping one window only open, will also be found very conducive towards producing a distinct view of the object.

As the motion of the sun, and the variable state of our atmosphere, render solar observations both tedious and inconvenient, it will be proper for the observer to be furnished with a large tin lanthorn, made something like the common magic lanthorn, fit to contain one of Argand's lamps.* The lanthorn should have an aperture in front, that may be moved up and down, and capable of holding a lens; by this a pleasing uniform dense light may be easily procured. The lamp should move on a rod, that it may be readily elevated or depressed. The lanthorn may be used for many other purposes, as for viewing of pictures, exhibiting microscopic objects on a screen, &c.

Many transparent objects are seen best in a weak light; among these we may place the prepared eyes of flies and animalculæ in fluids; the quantity of light from a lamp or candle may be lessened by removing the microscope to a greater distance from them, or it may be more effectually lessened by cutting off a part of the cone of rays that fall on the object, either by placing the cone, as already described with the apparatus to different microscopes, under the stage, or by forming circular apertures of black paper of different sizes, and placing either a large or small one on the reflecting mirror, as occasion may require.

There is an oblique position of the mirrors, and consequently of the light, which is easily acquired by practice, but for which no general rule can be given, that will exhibit an object more beautifully and more distinctly than any other situation, shewing the surface, as well as those parts through which the light is transmitted.

A better view of most objects is obtained by a candle or lamp than by day-light; it is more easy to modify the former than the latter, and to throw it on the object with different degrees of

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* The lamp should not be of the fountain kind, because the rarefaction of the air in the lanthorn will often force the oil over.

density. From what has been said, the reader will have observed the importance of being able to examine the object in the greatest variety of positions and appearances, which cannot be effected with equal convenience by any microscope, but the improved lucernal.

OF THE PREPARATION OF OBJECTS FOR THE MICROSCOPE.

In the preparation of objects, no man was more successful or more indefatigable than Swammerdam. In minutely anatomizing, in patiently investigating, and in curiously exhibiting the minute wonders of the creation, he stands unrivalled, far exceeding all those that preceded, as well as those which have succeeded him. Deeply impressed and warmly animated by the amazing scenes that he continually discovered, his zeal in pursuit of truth was not to be abated by disappointment, or alarmed by difficulty; and he was never satisfied till he had attained a rational and clear idea of the organization of the object, whose structure he wished to explore; his "Book of Nature," of which a translation was published by Dr. Hill, is a work of such vast extent of knowledge, and so excellent in execution, as to raise the highest admiration in even a superficial observer.

It is much to be regretted, that we are ignorant of the methods he employed in his investigations. To discover these, the great Boerhaave examined with a scrupulous attention all the letters and manuscripts of Swammerdam, and has communicated the result of his researches, which, though but small, may enable us to form some idea of his immense labours in the field of science.

For dissecting of small insects he had a brass table, which was made by that excellent artist, S. Musschenbroeck; to this table were affixed two brass arms, moveable at pleasure to any part of it. The upper portion of these arms was constructed so as to have a slow vertical motion, by which means the operator could readily alter their height, as he saw most convenient to his purpose; the office of one of these arms was to hold the minute bodies, and that of the other to apply the lens or microscope.

His microscopes or lenses were of various foci, diameters, and sizes, from the least to the greatest, and the best that could be procured in regard to the exactness of the workmanship, and transparency of the substance. His mode was, to begin his observations with the smallest magnifiers, and from thence proceed by degrees to the greatest. Formed by nature, and habituated by experience, he was so incomparably dexterous in the management of these instruments, that he made every observation subservient to the next, and all tend to confirm each other, and complete the description.

His chief art seems to have been in constructing very fine scissars, and giving them an extreme sharpness: these he made use of to cut very minute objects, because they dissected them equally; whereas knives and lancets, let them be ever so fine and sharp, are apt to disorder delicate substances, as in going through them, they generally draw after and displace some of the filaments. His knives, lancets and styles, were so very fine, that he could not see to sharpen them without the assistance of a magnifying glass; but with them he could dissect the intestines of bees with the same accuracy and distinctnes that the most celebrated anatomist does those of large animals. He was particularly expert in the management of small glass tubes, which were no thicker than a bristle, and drawn to a very fine point at one end, but thicker at the other. These he made use of to shew and blow up the smallest vessels discovered by the microscope, to trace, distinguish, and separate their courses and communications, or to inject them with very subtil coloured liquors.

He used to suffocate the insects in spirit of wine, in water, or spirit of turpentine, and likewise preserved them for some time in these liquids; by which means he kept the parts from putrefaction, and consequently from collapsing and mixing together; and added to them besides such strength and firmness, as rendered the dissections more easy and agreeable. When he had divided tranversely with his fine scissars the little creature he intended to examine, and had carefully noted every thing that appeared without further dissection, he then proceeded to extract the viscera in a very cautious and deliberate manner, with other instruments of great fineness; first taking care to wash away and separate with very fine pencils, the fat with which insects are very plentifully supplied, and which always prejudices the internal parts before it can be extracted. This operation is best performed upon insects while in the nympha state.

Sometimes he put into water the delicate viscera of the insects he had suffocated; and then shaking them gently he procured himself an opportunity of examining them, especially the air vessels, which by these means he could separate from all the other parts whole and intire, to the great admiration of all those who beheld them; as these vessels are not to be distinctly seen in any other manner, or indeed seen at all without damaging them, he often made use of water, injected by a syringe, to cleanse thoroughly the internal parts, then blew them up with air and dried them, and thus rendered them durable, and fit for examination at a proper opportunity. Sometimes he has examined with the greatest success, and made the most important discoveries in insects that he had preserved in balsam, and kept for years together in that condition. Again, he has frequently made punctures in other insects with a very fine needle, and after squeezing out all their moisture through the holes made in this manner, he filled them with air, by means of very slender glass tubes, then dried them in the shade, and last of all anointed them with oil of spike, in which a little rosin had been dissolved; by which processs they retained their proper forms a long time. He had a singular secret, whereby he could so preserve the nerves of insects, that they used to continue as limber and perspicuous as ever they had been.

He used to make a small puncture or incision in the tail of worms, and after having gently and with great patience squeezed out all their humours, and great part of their viscera, he then injected them with wax, so as to give and continue to them all the appearance of healthy vigorous living creatures. He discovered that the fat of all insects was perfectly dissoluble in oil of turpentine; thus he was enabled to shew the viscera plainly; only after this dissolution he used to cleanse and wash them well and often in clean water. He frequently spent whole days in thus cleansing a single caterpillar of its fat, in order to discover the true construction of this insect's heart. His singular sagacity in stripping off the skin of caterpillars that were upon the point of spinning their cones, deserves particular notice. This he effected by letting them drop by their threads into scalding water, and suddenly withdrawing them; for, by these means the epidermis peeled off very easily; and when this was done, he put them into distilled vinegar and spirit of wine, mixed together in equal portions, which, by giving a proper firmness to the parts, gave him an opportunity of separating them with very little trouble from the exuviæ, or skins, without any danger to the parts; so that by this contrivance, the nymph could be shewn to be wrapped up in the caterpillar and the butterfly in the nymph. Those who look into the works of Swammerdam, will be abundantly gratified, whether they consider his astonishing labour and unremitted ardour in these pursuits, or his wonderful devotion and piety. On one hand, his genius urged him to examine the miracles of the great Creator in his natural productions; whilst, on the other, the love of that same all-perfect Being rooted in his mind struggled hard to persuade him that God alone, and not the creatures, were worthy of his researches, love, and attention.

M. Lyonet always drowned first those insects he intended to anatomize, as by these means he was enabled to preserve both the softness and transparency of the parts. If the insect, &c. be very small, for instance one-tenth of an inch, or a little more in length, it should be dissected in water, on a glass which is a little concave; if, after a few days, there be any fear that the insect will putrefy, it should be placed in weak spirit of wine, instead of water. In order to fix the little creature, it must be suffered to dry, and then be fastened by a piece of soft wax; after which it may be again covered with water.

Larger objects require a different process; they should be placed in a small trough of thin wood; the bottom of a common chip box will answer very well, by surrounding the edge of it with soft wax, to keep in the water or spirit of wine. The insect is then to be opened, and if the parts be soft, like those of a caterpillar, they should be turned back and fixed to the trough by small pins; the pins are to be set by a pair of small nippers, the skin being stretched at the same instant by another pair of finer forceps; the insect must then be placed in water, and dissected therein, and after two or three days it should be covered with spirit of wine, which should be renewed occasionally; by these means the subject is preserved in perfection, and its parts may be gradually unfolded, without any other change being perceived than that the soft elastic parts become stiff and opake, and some others lose their colour.

M. Lyonet used the following instruments in his curious dissection of the caterpillar of the cossus. As small a pair of scissars as could be made, the arms long and fine; a small and sharp knife, the end brought to a point; a pair of forceps, the ends of which had been so adjusted, that they would easily lay hold of a spider's thread or a grain of sand. But the most useful instruments were two fine steel needles, fixed in small wooden handles, about 2¾ of an inch in length.

An observation of Dr. Hooke's may be very useful if attended to, for fixing objects intended to be delineated by the microscope. He found no creature more troublesome to draw than the ant or pismire, not being able to get the body quite in a natural posture. If, when alive, its feet were fettered with wax or glue, it would so twist and twine its body, that it was impossible any way to get a good view of it; if it was killed, the body was so small, that the shape was often spoiled before it could be examined. It is the nature of many minute bodies, when their life is destroyed, for the parts to shrivel up immediately; this is very observable in many small plants, as well as in insects; the surface of these small bodies, if porous, being affected by almost every change of the air, and this is particularly the case with the ant. But if the little creature be dropped in well rectified spirit of wine, it is immediately killed; and when taken out, the spirit of wine evaporates, leaving the animal dry and in its natural posture, or at least so constituted, that you may easily place it with a pin in what posture you please.*

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* Hooke's Micrographia, p. 203.

Having thus given a general account of the methods used by Swammerdam and Lyonet, in their examination and dissection of insects, we shall proceed to shew how to prepare several of their parts for the microscope, beginning with the WINGS. Many of these are so transparent and clear, as to require no previous preparation; but the under wings of those that are covered with elytra, or crustaceous cases, being constantly folded up when at rest, they must be unfolded before they can be examined by the microscope; for this purpose a considerable share of dexterity and some patience is necessary, for the natural spring of the wings is so strong, that they immediately fold themselves again, except they are carefully prevented.

One of the most curious and beautiful wings of this kind, is that of the FORFICULA AURICULARIA, or EARWIG, of which we have given a drawing, Plate XIV. Fig. 1, represents it considerably magnified, and Fig. 2, the same object of its natural size. When expanded, it is a tolerably large wing, yet folds up under a case not one-eighth part of its size. It is very difficult to unfold these wings, on account of their curious texture. They are best opened immediately after the insect is killed. Hold the earwig by the thorax, between the finger and thumb; then with a blunt-pointed pin endeavour gently to open the wing by spreading it over the fore-finger, gradually sliding at the same time the thumb over it. When fully expanded, separate it from the insect by a sharp knife, or a pair of scissars. The wing should be pressed for some time between the thumb and finger before it be removed; it may then be placed between two pieces of paper, and again pressed for at least an hour; after which it may be put between the talcs without any danger of folding up again.

The wings of the NOTONECTA, or BOAT-FLY, and other water insects, as well as most species of the grylli, require equal care and delicacy with that of the earwig to display them properly.

The wings of BUTTERFLIES and MOTHS are covered with very minute scales or feathers, that afford a beautiful object for the microscope; near the shoulder, the thorax, the middle of the wing, and the fringes of the wings, they are generally intermixed with hair. The scales of one part, also, often differ in shape from those of another; they may be first scraped off or loosened from the wing with a knife, and then brushed into a piece of paper with a camel's hair pencil; the scales may be separated from the hairs with the assistance of a common magnifying glass.

The proboscis of insects, as of the CULEX or GNAT, the TABANUS or BREEZE-FLY, &c. requires much attention and considerable care to be dissected properly for the microscope; and many must be prepared before the observer desides upon the situation and shape of the parts; he will often also be able to unfold in one specimen some parts that he can scarce discover in another. It is well known that the COLLECTOR OF THE BEE forms a most beautiful object; a figure of it is given in plate XIII. Fig. 3, shews it greatly magnified, and Fig. 4, of the natural size. In it is displayed a most wonderful mechanism, admirably adapted to collect and extract the various sweets from flowers, &c. To prepare this, it should first be carefully washed with spirit of turpentine, by which means it will be freed from the unctuous and melliferous particles which usually adhere to it; when dry, it must be again washed with a camel's hair pencil, to disengage and bring forward the small hairs which form one part of its microscopic beauty.

The case which encloses THE STING OF THE BEE, the wasp, and the hornet, are so hard, that it is very difficult to extract them without breaking or otherwise injuring them. It will be found, perhaps, the best way to soak the case, and the rest of the apparatus for some time in spirit of wine or turpentine, then lay it on a piece of clean paper, and with a blunt knife draw out the sting, holding the sheath by the nail of the finger, or by any blunt instrument; great care is requisite to preserve the feelers, which when cleaned add much to the beauty of the object.

The EYES OF THE LIBELLULA OR DRAGON-FLY, and different flies, of the LOBSTER, &c. are first to be cleaned from the blood and other extraneous matter; they should then be soaked in water for some days, after which you may separate one or two skins from the eye, which, if they remain, render it too opake and confused; some care is, however requisite in this separation, otherwise the skin may be made too thin, so as not to enable you to form an accurate idea of its organization.

The EXUVIÆ OR CAST OF SKINS of insects are in general very pleasing objects, and require but little preparation. If they be curled or bent up, keep them in a moist atmosphere for a few hours, and they will soon become so relaxed that you may extend them with ease to their natural positions. The steam of warm water answers the purpose very well.

The BEARD OF THE LEPAS ANATIFERA OR BARNACLE is to be soaked in clean soft water, and frequently brushed, while wet, with a camel's hair pencil; it may then be left to dry; after which it must be again brushed with a dry pencil, to disengage and separate the hairs, which are apt to adhere together. A picture of this object is represented in plate XIII. Fig. 1, magnified; Fig. 2, natural size.

To view the MUSCULAR FIBRES, take a very thin piece of dried flesh, lay it upon a slip of glass, and moisten it with warm water; when this is evaporated, the vessels will appear plain and more visible, and by repeated macerations the parts may be further disengaged.

To examine FAT, BRAINS, and other similar substances, we are advised by Dr. Hooke to render the surface smooth, by pressing it between two thin plates of flat glass, by which the substance will be made much thinner and more transparent; otherwise, the parts lying thick one upon the other, it appears confused and indistinct.

Some substances are, however, so organized, that if their peculiar form be altered, the parts we wish to discover are destroyed; such as nerves, tendons, muscular fibres, pith of wood, &c. many of these are best to be examined while floating in some convenient transparent fluid. For instance, very few of the fibres of any of the muscles can be discovered when they are viewed in the open air; but if placed in water or oil, great part of their wonderful fabric may be discovered. If the thread of a ligament be viewed in this manner, it will be seen to consist of an indefinite number of smooth round threads lying close together.

Objects of an elastic nature should be pulled or stretched out while they are under the microscope, that the texture and nature of those parts, whose figure is altered by being thus pulled out, may be more fully discovered.

To examine BONES with the microscope. These should first be viewed as opake objects; afterwards, by procuring thin sections, they should be looked at as if transparent. The sections should be cut in all directions, and be well washed and cleaned; a degree of maceration will be useful in some cases. Or the bones may be put in a clear fire till they are red hot, and then taken out; by these means the bony cells will appear more conspicuous and visible, being freed from extraneous matter.

To examine the PORES OF THE SKIN. First, cut or pare off with a razor as thin a slice as possible of the upper skin; then cut a second from the same place; apply the last to the microscope.

The SCALES OF FISH should be soaked in water for a few days, and then be carefully rubbed, to clean them from the skin and dirt which may adhere to them.

To procure the scales of the eel, which are a great curiosity, and the more so, as the eel was not known to have any, till they were discovered by the microscope, take a piece of the skin of the eel that grows on the side, and while it is moist spread it on a piece of glass, that it may dry very smooth; when thus dried, the surface will appear all over dimpled or pitted by the scales, which lie under a sort of cuticle or thin skin; this skin may be raised with the sharp point of a penknife, together with the scales which will then easily slip out, and thus you may procure as many as you please.*

On the lizard, the guana, &c. are two skins; one of these is very transparent, the other is thicker and more opake; by separating these we procure two beautiful objects.

The LEAVES of many trees, and some plants, when dissected, form a very pleasing object. To dissect them, take a few of the

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* Martin's Micrographia Nova, p. 29.

most perfect leaves you can find, and place them in a pan with clean water; let them remain three weeks or a month without changing the water, then take them up, and try if they feel very soft, and appear almost rotten; if so, they are sufficiently soaked. You are then to lay them on a flat board, and holding them by the stalk, draw the edge of the knife over the upper side of the leaf, which will take off most of the skin; turn the leaf, and do the same with the under side. When the skin is taken off on both sides, wash out the pulpy matter, and the fibres will be exhibited in a beautiful manner. By slitting the stalk you may separate the anatomized leaf into two parts. The skins that are peeled from the fibres will also make a very good object. The autumn is the best season for the foregoing operation, as the fibres of the leaves are much stronger at that season, and less liable to break.

Ores and minerals should all be carefully washed and cleansed with a small brush, to remove any extraneous matter that may adhere to them. Shells may be ground down on a hone, by which their internal structure will be displayed.

To view the circulation and examine the particles of the blood. The principal part the observer must aim at, in order to view the circulation of the blood, is to procure those small animals or insects that are most transparent, that by seeing through them he may be enabled to discover the internal motion. The particular kinds best adapted for the purpose will be enumerated in the descriptive catalogue at the end of this work.

If a small eel be used for this purpose, it must be cleansed from the slime which covers it; after which it may be put either in the fish-pan, or a glass tube filled with water, and then placed under the microscope. If the eel be small enough, the circulation may be viewed in the most satisfactory manner. Leeuwenhoeck has given, in his 112th Epistle, an accurate description of the blood vessels in part of the tail of an eel. The same figure may also be seen in my father's Micrographia Illustrata, fourth edition, Plate XVII. The tail of any other small fish may be applied in the same manner, or tied on a slip of flat glass, and be thus laid before the microscope. Flounders, eels, and gudgeons, are to be had at almost any time in London. N. B. By filling the tube with water, when an eel is used, it will in a great measure prevent the sliminess of the eel from soiling the glass.

To view the particles of the blood, take a small drop of it when warm, and spread it as thin as possible upon a flat piece of glass. By diluting it a little with warm water, some of the larger particles will divide from the smaller, and many of them will be subdivided into still smaller; or a little drop of blood may be put into a capillary tube of glass, and be then presented before the microscope. Mr. Baker advises the mixing the blood with a little warm milk, which he says, will cause the unbroken particles to be very distinctly seen. But the most accurate observer of these particles was Mr. Hewson, and he says they have been termed globules with great impropriety, being in reality flat bodies. When we consider how many ingenious persons have been employed in examining the blood with the best microscopes, it appears surprizing that the figure of the particles should be mistaken; but the wonder is lessened when we reflect how many obvious things are overlooked, till our attention is particularly directed towards them; and besides, the blood in the human subject, and in quadrupeds, is so full of these particles, that it is with great difficulty they can be seen separate, until the blood is diluted. It was by discovering a proper method to effect this, that Mr. Hewson was indebted for his success. He diluted the particles with serum, in which they would remain undissolved, and as he could dilute them to any degree with the serum, he could easily examine the particles distinct from each other; for example, take a small quantity of the serum of the human blood, and shake a piece of crassamentum in it, till it be coloured a little with the red particles; then with a soft hair pencil spread a little of it on a piece of thin glass, and place this glass under the microscope, in such a manner as not to be quite horizontal, but rather higher at one end than the other; by which means the serum will flow from the higher to the lower extremity, and as it flows, some of the particles will be found to swim on their flat sides, and will appear to have a dark spot in the middle; others will turn over from one side to the other, as they roll down the glass.

Several authors have described an apparatus for viewing the circulation of the blood in the mesentery of a frog; but as the cruelty attendant on these kinds of investigations would deprive the humane reader of a great part of the gratification which might otherwise result from them, he will probably rest satisfied with the accounts of such experiments to be met with in authors; especially as there is an abundant variety of objects on which he may exercise his ingenuity without sacrificing the nicer feelings of humanity.*

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* Whatever right mankind may claim over the lives of every creature that is placed in a subordinate rank of being to themselves, in respect of food and self-defence, as well as for the improvement of science, and their judicious and ingenious application to the various purposes of use and ornament in human life, we certainly cannot, on the principles of reason and justice, assert a privilege to gratify a wanton curiosity, or the sports of an inordinate fancy, by the exercise of an unnecessary cruelty over them. The immortal SHAKSPEARE, in a passage which has often been quoted, says,

——— the poor beetle that we tread upon
In corporal sufferance finds a pang as great
As when a giant dies.

It may, however, be doubted whether this particular instance is strictly conformable to fact; different animals certainly possess different degrees of sensibility, and some are consequently more susceptible of pain than others. It is a remarkable circumstance that the Hippobosca

OF ANIMALCULA IN INFUSIONS, &c.

These require little or no preparation. The first object is to procure them, the second, to render them visible by the microscope. A few observations, however, may be of use. Many drops of water may be examined before any can be found; so that if the observer be too hasty, he may be easily disappointed, though other parts of the same water may be fully peopled by them.

The surface of infused liquors is generally covered with a thin pellicle, which is easily broken, but acquires thickness by standing; the greatest number of animalcula are generally to be found in this superficial film.

In some cases it is necessary to dilute the infusions; but this is always to be done with distilled water, and that water should be examined in the microscope before it is made use of: the neglect of this precaution has been a source of many errors.

equina, or Horse-fly, will live, run, nay even copulate, after being deprived of its head; most flies will survive that loss for some time, and the loss of a leg or two does not prevent their appearing as lively and alert as if they had sustained no injury. Many insects, on being caught, will freely and voluntarily part with their limbs to escape; and it is well known that lobsters shed their claws. Numbers of other instances might be adduced, but on this subject it may be prudent not to enlarge.

Montaigne remarks, that there is a certain claim of kindness and benevolence which every species of creatures has a right to, from us. It is to be regretted, that this general maxim is not more attended to in the affairs of education, and pressed home upon tender minds in its full extent and latitude; the early delight which children discover in tormenting different animals should by all possible means be discouraged, as, by being unrestrained in such sports, they may at least acquire a habit of confirmed inattention to every kind of suffering but their own, if not progressively be led to the perpetration of more atrocious acts of cruelty. The supreme court

Animalcula are in general better observed when the water is a little evaporated, as the eye is not confused, nor the attention diverted by a few objects. To separate one or two animalcula from the rest, place a small drop of water on the glass near that of the infusion; make a small neck or gutter between the two drops with a pin, which will join them together; then the instant you perceive that an animalculum has traversed the neck or gutter, and entered the drop, cut off the communication between the two drops.

To procure the eels in paste, boil a little flower and water, till it becomes of a moderate consistence; expose it to the air in an open vessel, and beat it together from time to time, to prevent the surface thereof from growing hard or mouldy; after a few days, especially in summer time, it will turn sower, then if it be examined with attention, you will find myriads of eels on the surface.

To preserve these eels all the year, you must keep the surface of the paste moist, by putting a little water or fresh paste from

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of judicature at Athens thought an instance of this sort not below its cognizance, and punished a boy for putting out the eyes of a poor bird that had unhappily fallen into his hands; and the inimitable HOGARTH, "the great painter of mankind," has in his "Five Stages of Cruelty," admirably depicted the consequences which may result from an early indulgence of a propensity towards cruelty.

In order to awaken as early as possible in the minds of children an extensive sense of humanity, it might be prudent to indulge them with a view of several sorts of insects as magnified by the microscope, and to explain to them that the same marks of divine wisdom prevail in the formation of the minutest insect, as in the most enormous leviathan; that they are equally furnished with whatever is necessary, not only for the preservation, but the happiness of their beings, in that class of existence which Providence has assigned them: in a word, that the whole construction of their respective organs distinctly and decisively, proclaims them the objects of divine benevolence, and therefore they justly ought to be so of ours. EDIT.

time to time to the other. Mr. Baker advises a drop or two of vinegar to be put into the paste now and then. The continual motion of the eels, while the surface is moist, will prevent the paste getting mouldy. Apply them to the microscope upon a slip of flat glass, first putting on it a drop of water, taken up by the head of a pin, for them to swim in.

To make an infusion of pepper. Bruise as much common black pepper as will cover the bottom of an open jar, and lay it thereon about half an inch thick; pour as much soft water in the vessel as will rise about an inch above the pepper. The pepper and water are then to be well shaken together; after which they must not be stirred, but be left exposed to the air for a few days, when a thin pellicle will be formed on the surface of the water, containing millions of animalcula.

The observer should be careful not to form a judgment of the nature, the use, and the operations of small animalcula, from ideas which he has acquired by considering the properties of larger animals: for, by the assistance of glasses, we are introduced as it were into a new world, and become acquainted not only with a few unkown animals, but with numerous species thereof, which are so singular in their formation and habits, that without the clearest proofs even their existence would not be credited; and while they afford fresh instances of the Creator's power, they also give further proofs of the limits and weakness of the human understanding.

DIRECTIONS FOR FINDING, FEEDING, AND PRESERVING THE POLYPES.

These little animals are to be found upon all sorts of aquatic plants, upon branches of trees, pieces of board, rotten leaves, stones, and other substances that lie in the water; they are also to be met with upon the bodies of several aquatic animals, as on the water-snail, on several species of the monoculus, &c. they generally fix themselves to these by their tail, so that it is a very good method when you are in search of the polypes, to take up a great many of these substances, and put them in a glass full of water. If there be any polypes adhering to these, you will soon perceive them stretching out their arms, especially if the glass be suffered to be at rest for a while; for the polypes, which contract themselves on being first taken out of the water, will soon extend again when they are at rest.

They are to be sought for in the corners of ditches, puddles, and ponds, being frequently driven into these with the pieces of wood or leaves to which they have attached themselves. You may, therefore, search for them in vain at one period, in a place where at another they will be found in abundance. They are more easily perceived in a ditch when the sun shines on the bottom, than at another time. In winter they are seldom to be met with; about the month of May they begin to appear and increase.

They are generally to be found in waters which move gently; for neither a rapid stream, nor stagnant waters ever abound with them. As they are always fixed to some substance by their tails, and are very rarely loose in the water, taking up water only can signify but little; a circumstance which has probably been the cause of much disappointment to those who have searched for them.

The green polypes are usually about half an inch long when stretched out; those of the second and third sort are between three quarters of an inch and an inch in length, though some are to be found at times which are an inch and a half long.

Heat and cold has the same effect upon these little creatures, that it has upon those of a larger size. They are animated and enlivened by heat, whereas cold renders them faint and languid; they should therefore be kept in such a degree of heat, that the water may not be below temperate.

It is convenient for many experiments to suspend a polype from the surface of the water. To effect this, take a hair pencil in one hand, and hold a pointed quill in the other; with the pencil loosen the polype from the receiver in which it is kept, and gradually raise it near the top of the water, so that the anterior end may be next the point of the pencil; then lift it out of the water, and keep it so for a minute; after which, thrust the point of the pencil, together with the anterior end, by little and little under water, until no more than about the twentieth part of an inch of the polype's tail remains above its surface; at this instant, with the pointed quill remove that part of the polype from the pencil which is already in the water, at the same time blowing against the polype, by which it will be loosened, and remain out of the water.

When the polypes were first discovered, Mr. Trembley had some difficulty to find out the food which was proper for them; but he soon discovered, that a small species of the millepede answered the purpose very well: the pulices aquatices have also been recommended. The small red worms, which are to be found on the mud-banks of the Thames, particularly near the shores, answer the purpose also, they are easily found when the tide is out, when they rise in such swarms on the surface of the mud, that it appears of a red colour. These worms are an excellent food for the polype. If a sufficient quantity be gathered in November, and put into a large glass full of water, with three or four inches of earth at the bottom, you will have a supply for the polypes all the winter. They may also be fed with common worms, with the larva of gnats and other insects, and even with butcher's meat, &c. if it be cut small enough.

River, or any soft water, agrees with them; but that which is hard and sharp prevents their thriving, and generally kills them in a few days. The worms with which they are fed should be always cleansed before you feed the polypes with them.

The polypes are commonly infested with little lice; from these it is necessary to free them, in order to preserve your polypes in a good state of health. They may be cleansed from the lice by rubbing them with a hair pencil; this cannot be easily done, unless they adhere to some substance: so that if they are suspended from the surface of the water, you must endeavour to get them to fix themselves to a piece of packthread; when they are fastened thereto, you may then rub them with a hair pencil, without loosening them from the thread.

The lice which torment the polype are not only very numerous, but they are also very large proportionably to its size: they may be said to be nearly as large with respect to them, as a common beetle is to us. If not rubbed off, they soon cover their bodies, and in a little time totally destroy them.

To preserve the polypes in health, it is also necessary often to change the water they are kept in, and particularly after they have done eating; it is not sufficient to pour the water off, all the polypes should be taken out, and the bottom and sides of the vessel rubbed from the slimy sediment adhering thereto; this is caused by their fæces, and is fatal to them if not cleaned away. The fæces often occasion a species of mortification, which daily increases; its progress may be stopped by cutting off the diseased part. To take them out, first loosen their tails from the sides or bottom of the glass; then take them up one by one, with a quill cut in the shape of a scoop, and place them in another glass with clean water; if they cling to the quill, let it remain a minute or two in the water, and they will soon disengage themselves.

They are preserved best in large glasses that hold three or four quarts of water; for in a glass of this size the water need not be renewed so often, particularly, if the fæces are taken out from time to time with the feathered end of a pen, to which they readily adhere; and further, the trouble of feeding each individual is in some measure saved, as you need only throw in a parcel of worms, and let the polypes divide them for themselves.

To observe with accuracy the various habitudes, positions, &c. of this little animal, it will be necessary to place some of them in narrow cylindrical glasses; then, by means of the microscope, Fig. 3. Plate VI. you may observe them exerting all their actions of life with ease and convenience; the facility with which the lens of the fore-mentioned microscope may be moved and placed in any direction, renders it a most convenient instrument for examining any object that requires to be viewed in water.

It is also very proper to dry some of them, and place them between talcs in a slider; this, however requires some dexterity and a little practice; though, when executed with success, it fully rewards the pains of the observer. Choose a proper polype, and put it into a small concave lens, with a drop of water; when it is extended, and the tail fixed, pour off a little of the water, and then plunge it with the concave into some spirit of wine contained in the bowl of a large spoon; by this it is instantly killed, the arms and body contracting more or less; rub it gently while in the spirit with a small hair pencil, to cleanse it from the lice.

The difficulty now begins; for the parts of the polype, on being taken out of the spirit, immediately cling together, so that it is not practicable to extend the body, and separate the arms on the talc, without tearing them to pieces; therefore the only method is, to adjust them upon the talc while in the spirit: this may be done by slipping the talc under the body of the polype, while it lies in the spirit, and displaying its arms thereon by the small hair pencil and a pair of nippers; then lift the talc, with the polype upon it, out of the spirit; take hold of it with the nippers in the left hand, dip the pencil in the spirit with the right hand, and therewith dispose of the several parts, that they may lie in a convenient manner, at the same time brushing away any lice that may be seen upon the talc; now let it dry, which it does in a little time, and place the talc carefully in the hole of the slider. To prevent the upper talc and ring pressing on the polype, you must cut three pieces of cork, about the bigness of a pin's head, and the depth of the polype, and fix them by gum in a triangular position, partly on the edges of the said talc, and partly to the sides of the ivory hole itself; the upper talc may then be laid on these corks, and pressed down by the ring as usual.*

OF VEGETABLES.

It were to be wished a satisfactory account could here be given of all the preparations which are requisite to fit for the microscope the objects of the vegetable kingdom. Dr. Hill is the only writer who has handled this subject. I shall, therefore, extract from his

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* Baker on the Polypes.

"Treatise on the Construction of Timber," what he has said; this, together with the improvements I have made on the cutting engine, will enable the reader to pursue the subject and extend it further, both for his own pleasure, and the advantage of the public.

THE MANNER OF OBTAINING THE PARTS OF A SHOOT SEPARATE.

In the beginning of April, take a quantity of young branches from the scarlet oak, and other trees. These are first cut into lengths, of the growth of different seasons; and then part is left entire, part split, and the rest quartered. In this state they are put into a wicker basket, with large openings, or of loose work, and a heavy stone is put in with them; a rope is tied to the handle of the basket, and it is thrown into a brook of running water: at times it is taken up, and exposed a little to the air; it is frequently shook about under water, to wash off filth; and once in ten days the sticks are examined.

By degrees the parts loosen from one another, and by gentle rubbing in a bason of water just warmed, they will be so far separated, that a pencil brush will perfect the business, and afford pieces of various sizes, pure, distinct, and clean. One part will in this way separate at one time, and another, at another; but by turning the sticks to the water, and repeating the operation, in the course of four or five weeks every part may be obtained distinct. They are best examined immediately; but if any one wish to preserve them for repeated inquiries, it may be done in this manner: dissolve half an ounce of alum in two quarts of water; drop the pieces thus separated, for a few moments, into this solution, then dry them upon paper, and put them up in vials of spirit of wine, no other fluid being so well adapted to preserve these tender bodies.

TO PREPARE THE RIND FOR OBSERVATION.

As the vessels of the rind are of different diameters in various trees, though their construction and that of the blebs is perfectly the same in all, it will be best to choose for this purpose the rind of a tree wherein they are largest. The rind of the ash-leaved maple is finely suited. A piece of this may be obtained of two inches long, and will very successfully answer the intention. Such a piece being prepared without alum or spirit, but dried from the water in which it had been macerated, it is to be impregnated with lead in the following manner, to shew the apertures by their colour.

Dissolve one drachm of sugar of lead in an ounce and an half of water; filter this through paper, and pour it into a tea-cup. Clip off a thin slice of what was the lower end of the piece of rind as it grew on the tree, and plunge it near an inch deep into the liquor; keep it upright between two pieces of stick, so that one half or more may be above the water; whelm a wine-and-water glass over the tea-cup, and set the whole in a warm place. When it has stood two days, take it out, clip off all that part which was in the liquor, and throw it away.

The circumstances here mentioned, trivial as they may seem, must be attended to: the operation will not succeed, even if the covering-glass be omitted; it keeps a moist atmosphere about the rind, and makes its vessels supple.

While this is standing, put into a bason two ounces of quick lime, and an ounce of orpiment; pour upon them a pint and an half of boiling water; stir the whole together, and when it has stood a day and a night, it will be fit for use. This is the "liquor probatorius vini" of some of the German chymists; it discovers lead when wines are adulterated with it, and will shew it any where.

Put a little of this liquor in a tea-cup, and plunge the piece of rind half way into it.

In the former part of this experiment, the vessels of the rind have been filled with a solution of lead, that makes of itself no visible alteration in them; but this colourless impregnation, when the orpiment lixivium gets to it, becomes of a deep brown; the vessels themselves appear somewhat the darker for it; but these dots, which are real openings, are now plainly seen to be such, the colour being perfectly visible in them, and much darker than in the vessels. This object must be always viewed dry.

If a piece of the rind, thus impregnated, be gently rubbed between the fingers, till the parts are separated, we shall be able in one place or other, to get a view of the vessels all round, and of the films which form the blebs between them.

Every part of the rind, and every coat of it, even the interstitial place between its innermost coat and bark, are filled with a fine fluid. The very course and progress of the fluid may be shewn in this part, even by an easy preparation; only that different rinds must be sought for this purpose, the vessels in some being larger than in others. Repeated trials have shewn me that the whole progress may be easily marked in the three following kinds, with only a tincture of cochineal.

Put half an ounce of cochineal, in powder, into half a pint of spirit of wine; set it in a warm place, and shake it often for four days; then filter off the clear tincture. Put an inch depth of this into a cup, and set upright in it pieces of the rind of ash, white willow, and ozier, prepared as has been directed, by maceration in water; for in that way one trouble serves for an hundred kinds. Let an inch of the rinds also stand up out of the tincture. After twenty-four hours take them out, clip off the part which was immersed in the fluid, and save the rest for observation.

TO PREPARE THE BLEA.

Cut the pieces in a fit season, either just before the first leaves of Spring, or in the Midsummer shooting time. Then we see all the wonders of the structure; the thousands of mouths which open throughout the course of these innumerable vessels, to pour their fluid into the interstitial matter.

These vessels, wich are in nature cisterns of sap for the feeding the growth of the whole tree, are so large, that they are capable of being filled with coloured wax, in the manner of the vessels in anatomical injections; and this way they present pleasing objects for the microscope, and afford excellent opportunities of tracing their course and structure.

A METHOD OF FILLING THE SAP VESSELS OF PLANTS.

A great many shoots of the scarlet and other oaks are to be taken off in the Spring; they must be cut into pieces of about two inches in length, and immediately from the cutting they must drop into some warm rain water: in this they are to stand twenty-four hours, and then be boiled a little. When taken out, they are to be tied on strings, and hung up in a place where the air passes freely, but the sun does not shine. When they are perfectly dry, a large quantity of green wax, such as is used for the seals of law deeds, is to be gently melted in an earthen pipkin set in water; the water to be heated and kept boiling. As soon as the wax runs, the sticks are to be put in, and they are frequently to be stirred about. They must be kept in this state about an hour, and then the pipkin is to be taken out of the water, and set upon a naked fire, where it is to be kept with the wax boiling for two or three hours; fresh supplies of the same wax being added from time to time.

After this it is to be removed from the fire, and the sticks immediately taken out with a pair of nippers; when they are cold, the rough wax about them is to be broken off. Both ends of each stick are to be cut off half an inch long, and thrown away, and the middle pieces saved. These are then to be cut in smaller lengths, smoothed at the ends with a fine chissel, and many of them split in various thicknesses.

Thus are obtained preparations, not only of great use, but of wonderful beauty. Many trees this way afford handsome objects as well as the oak; and in some, where the sap vessels are few, large, and distinct, the split pieces resemble striped satins, in a way scarce to be credited. It is in such that the outer coats of these vessels are most happily of all to be examined.

THE METHOD OF PREPARING SALTS AND SALINE SUBSTANCES, FOR THE VIEWING THEIR CONFIGURATIONS.

Dissolve the subject to be examined in no larger a quantity of river or rain water than is sufficient to saturate it; if it be a body easily dissoluble, make use of cold water, otherwise make the water warm or hot, or even boiling, according as you find it necessary. After it is perfectly dissolved, let it rest for some hours, till, if over-charged, the redundant saline particles are precipitated, and settle at the bottom, or shoot into crystals; by which means you are most likely to have a solution of the same strength at one time as at another; that is, a solution fully charged with as much as it can hold up, and no more; and by these precautions the configurations appear alike, how often soever tried: whereas, if the water be less saturated, the proportions, at different times, will be subject to more uncertainty; and if it be examined before such separation and precipitation of the redundant salts, little more will be seen than a confused mass of crystals.

The solution being thus prepared, take up a drop of it with a goose quill, cut in fashion of a scoop, and place it on a flat slip of glass, of about three quarters of an inch in width, and between three and four inches long, spreading it on the glass with the quill, in either a round or oval figure, till it appears a quarter of an inch or more in diameter, and so shallow as to rise very little above the surface of the glass. When it is so disposed, hold it as level as you can over the clear part of a fire that is not too fierce, or over the flame of a candle, at a distance proportionable to the degree of heat it requires, which experience only can direct, and watch it very carefully till you discover the saline particles beginning to gather and look white, or of some other colour, at the extremities of the edges; then having adjusted the microscope before-hand for its reception, armed with the fourth glass, which is the fittest for most of these experiments, place it under your eye, and bring it exactly to the focus of the magnifier; and after running over the whole drop, fix your attention on that side where you observe any increase or pushing forwards of crystalline matter from the circumference towards the center.

This motion is extremely slow at the beginning, unless the drop has been over-heated, but quickens as the water evaporates, and in many kinds, towards the conclusion, produces configurations with a swiftness inconceivable, composed of an infinity of parts, which are adjusted to each other with an elegance, regularity, and order, beyond what the exactest pencil in the world, guided by the ruler and compass, can ever equal, or the most luxurious imagination fancy.

When action once begins, the eye cannot be taken off, even for a moment, without losing something worth observation; for the figures alter every instant, till the whole process is over; and in many sorts, after all seems at an end, new forms arise, different entirely from any that appeared before, and which probably are owing to some small quantity of salt of another kind, which the other separates from, and leaves to act after itself has done; and in some subjects three or four different sorts are observable, few or none being simple and homogeneous.

When the configurations are fully formed, and all the water evaporated, most kinds of them are soon destroyed again by the moisture or action of the air upon them; their points and angles lose their sharpness, become uneven and defaced, and moulder as it were away; but some few are permanent, and by being inclosed between glasses, they may be preserved months or even years.

It happens oftentimes that a drop of a saline solution can hardly be spread on the slip of glass, by reason of the glass's smoothness, but breaks into little globules, as it would do were the surface greasy: the way to prevent this is, by rubbing the broken drop with your finger over the glass, so as to leave the glass smeared with it; on which smeared place, when dry, another drop of the solution may be spread very easily in whatever form is agreeable.

It sometimes happens, that when a heated drop is placed properly for examination, the observer finds such a cloudiness that he can distinguish nothing of the object; which is owing to saline steams that arise from the drop, covering and obscuring the object glass, and therefore must immediately be wiped away with a soft cloth or leather.

In all examinations of saline solutions by the microscope, even though made in the day-time, you must use a candle; for the configurations, being exceedingly transparent, are rendered much more distinguishable by the brown light a candle affords, than by the more white and transparent day-light; and besides, either by moving the candle, or turning the microscope, such light may be varied or directed just as the subject requires.

It may be also proper to take notice, that no kinds of microscopes are fit for these observations, but such as have an open stage, whereon the slips of glass, with the liquor upon them, may be placed readily, and in a perfect horizontal position; and moreover, where they can be turned about freely, and without disordering the fluid.

CHAP. V.

THE IMPORTANCE OF NATURAL HISTORY; OF INSECTS IN GENERAL, AND OF THEIR CONSTITUENT PARTS.

THERE is no human science which to a rational mind exhibits a greater variety of attractions, or which is more deserving of general esteem, than that of NATURAL HISTORY; accordingly we find, that from the earliest times in which the sciences have been promulgated, it has never been entirely destitute of its votaries; but, on the contrary, has for ages employed the lives of many learned men, as being, in fact, the study of DIVINE WISDOM displayed in the creation: the farther our researches are carried, the more striking proofs of it every where abound. In the present century, an æra particularly devoted to investigation, and propitious to discovery and improvement in various branches of science, Natural History, so far from being neglected, has been more generally cultivated, and pursued with an ardor unprecedented at any former period. Men of the first rank in literature have become indefatigable labourers in the vast and unbounded field which it presents to the eyes of an accurate and attentive observer. The animal, the vegetable, and the mineral kingdoms, have been examined with the utmost care; that confusion and perplexity which seemed unavoidably to result from a view of the immense variety of articles contained in each of those departments, and which frequently deterred persons from engaging in the pursuit, have been in a great measure removed by the introduction of systematic arrangement; by these means, the various subjects are distributed into classes and genera, enabling us to form distinct and comprehensive ideas of them. To the same methodical plan, and the nicety of discrimination thence arising, we must attribute the discovery and description of many new species; this has excited an emulation still farther to pursue the inquiry, nor need any apprehension be entertained that the subject will be exhausted, as, no doubt, an infinite variety still remains unexplored to engage the utmost attention of the philosophic mind, and fully to compensate the pains bestowed on so interesting a branch of knowledge.

Of the abundance of articles enumerated in books of Natural History, there are comparatively few, whose uses are as yet known, or their properties fully understood. The true naturalist should always bear in mind that there is a vast difference between retaining the names, and investigating the nature and peculiar qualities of the creatures to which they belong. It is highly proper, indeed necessary, that the multifarious objects of Natural History should be well ascertained and distinguished with nicety in all their varieties; the science and admirers of it are, therefore, unquestionably indebted to the able naturalists who have devoted their time, and exercised their ingenuity in devising commodious methods of arrangement, and invented systems for identifying the several subjects with accuracy, and less danger of fallacy or mistake: but all who are, or would wish to be thought naturalists, ought to consider, that the best possible mode of classification is, after all, but an introduction to Natural History. The ingenious and indefatigable LINNÆUS, who spent his life in fabricating the curious system now generally adopted, intended it certainly for the improvement of the science, as a basis for the service of knowledge and the benefit of mankind; let us be cautious not to mistake the means for the end, but in the prosecution of the science, think of the true ends of knowledge, and endeavour to promote our own instruction, and the advancement of others, with a view to the adoration of that DIVINE BEING to whom all creation is indebted for existence, and their application to the occasions and uses of life, all along conducting and perfecting the study in the spirit of benevolence.

The study of nature, or in other words, a serious contemplation of the works of GOD, is indeed a great and proper object for the exercise of our rational faculties; nor can we perhaps employ them better, than in endeavouring to make ourselves acquainted with the works of that glorious Being from whom they were received.

Though there is a great deal of pleasure in contemplating the material world, or that system of bodies into which the DIVINE ARCHITECT has so admirably wrought the mass of dead matter, with the several relations which those bodies bear to one another; there is still something more wonderful and surprizing arising from the contemplation of the animated world; by which is to be understood all those animals with which every part of the universe is furnished. The material world is only the shell of the universe; the animated world is its inhabitants.

Existence is a blessing to those beings only which are endowed with perception, and appears useless when bestowed upon dead matter, any farther than as it is subservient to beings which are conscious of their existence. Thus we find, from the bodies which lie under our observation, that matter is only made as the basis and support of animals, and that there is no more of the one than what is necessary for the exigence of the other.

There are some living creatures which are raised but just above dead matter; there are many others, but one remove from these, which have no other senses but those of feeling and taste; others have still an additional sense of hearing,; others of smell, and again others of sight. It is wonderful to observe, by what a gradual progress life advances through a prodigious variety of species, before a creature is formed that possesses all these senses; and even among these, there is such a different degree of perfection in the senses which one animal enjoys beyond what appears in another, that, though the sense in different animals be distinguished by the same common denomination, it seems almost of a different nature. If, after this, we look into the several inward qualities of sagacity, or what is generally called instinct, we find them rising after the same manner imperceptibly one above another, and receiving additional improvements, according to the species in which they are implanted. This progress in nature is so very gradual, that what appears to us the most perfect of an inferior species, comes very near to the most imperfect, as we are accustomed to call it, of that which is immediately above it.

The exuberant and overflowing goodness of the SUPREME BEING, whose mercy extends to all his works, is plainly seen, as before observed, from his having made so very little matter, at least what falls within our knowledge, that does not swarm with life; nor is his goodness less visible in the diversity than in the multitude of living creatures. Had he only made one species of animals, none else could have enjoyed the happiness of existence; he has, therefore, included in his creation, every degree of life, every capacity of being. The whole chasm of nature, from a plant to a man, is filled up with diverse kinds of creatures, rising one above another, by such a gentle and easy ascent, that the little transitions and deviations from one species to the other are almost insensible. This intermediate space is so prudently managed, that there is scarce a degree of perception which does not appear in some one part of the animated world. Is the goodness or the wisdom of the DIVINE BEING more manifest in this his proceeding?

In this system of creation there is no creature so wonderful in its nature, and which so much merits our particular attention, as man, who fills up the middle space between the animal and intellectual nature, the visible and invisible world; and is that link, in the chain of beings, which has been often termed the "nexus utriusque mundi." So that he, who in one respect being associated with angels and arch-angels, may look upon a BEING of infinite perfection as his father, and the highest order of spirits as his brethren, may, in another respect, say to corruption, "Thou art my father, and to the worm, thou art my mother and my sister." *

There are, however, many who form their judgments of the works of nature from external appearance only; hence they imagine, that the greatest and most magnificent are the only perfect parts of creation, and worthy of our regard. Hence they confine their attention to the more splendid and shining branches of philosophy, and are too apt to treat the other parts with coolness and indifference, not to say contempt.

But surely a true philosopher is one who diligently pursues the study of nature in all its branches; who can behold with admiration her noblest productions, yet view with pleasure the smallest of her works: in short, one who thinks every thing excellent that owes its formation to the GOD of nature; and we need only take a transient view of the smaller creatures with which the

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* Spectator, Vol. vii. Numb. 519.

earth is peopled, to discover that they are perfect in their kind, and carry about them as strong marks of infinite wisdom, power, and beneficence as the greatest. It has been justly said, " that there is not a vegetable that grows, nor an insect that moves, but what is sufficient to confound the Atheist, and to afford the candid observer endless materials for devout adoration and praise."

If we examine insects with attention, we shall soon be convinced of their divine original, and survey with admiration the wonderful art and mechanism of their structure, wherein such a number of vessels, parts, and movements are collected in a single point; yet are they furnished with weapons to seize their prey, dexterity to escape their foes, every thing requisite to perform the business of their stations, and enjoy the pleasures of their conditions. What a profusion of the richest ornaments and the gayest colours are often bestowed on one little insect! and yet there are thousands of others that are as beautiful and wonderful in their kind; some are covered with shining coats of mail, others are adorned with plumes of feathers, all of them furnished with every thing that is proper to make them answer the purposes for which they were designed.

" After an attentive examination of the nature and fabric of both the least and largest animals, I cannot," says the great and excellent Swammerdam, " but allow the less an equal, perhaps a superior degree of dignity; whoever duly considers the conduct and instinct of the one, with the manners and actions of the other, must acknowledge, that they are all under the direction and controul of a supreme and particular intelligence; which, as in the largest it extends beyond the limits of our comprehension, escapes our researches in the smallest. If, while we dissect with care the larger animals, we are filled with wonder at the elegant disposition of their limbs, the inimitable order of their muscles, and the regular direction of their veins, arteries, and nerves, to what an height is our astonishment raised, when we discover all the parts arranged in the least, and in the same regular manner! How is it possible but we must stand amazed when we reflect, that those little animals, whose bodies are smaller than the point of the dissecting knife, have muscles, veins, arteries, and every other part common to the larger animals? Creatures so very diminutive, that our hands are not delicate enough to manage, or our eyes sufficiently acute to see them."

The subserviency of the several beings in the visible creation to one another; the order in which each of them appears in that appointed season, when only it can be conducive to the purposes of the rest; and the preservation of a sufficient number of every species, amidst the immense havoc that reigns throughout, are, among other things, proofs of the amazing and incomprehensible wisdom by which they were all formed. With what pleasure does the mind, accustomed to look up from effects to their causes, from created beings to the GREAT SOURCE OF BEING, view that unbounded beneficence, which leaves not the smallest space, capable of supporting existence of any kind, unplanted with them. There is hardly any portion of matter, or the least drop of fluid naturally found on the surface of the earth, that is not inhabited by multitudes of animals; the subterraneous regions are peopled with their minute inhabitants, and the abyss of the sea, where no human eye can penetrate, abounds with animated beings.

The air is usually considered as the great source of destruction to bodies, whether animal or vegetable; but we do not always understand by what means or in what manner it is performed. What we term destruction and decay of one substance, occasions the production and ripening a multitude of others; wherever the air is admitted, with it a thousand different things find their way; and what is usually attributed to the effects of that fluid, is in general occasioned by the multitudes of bodies with which it is fraught. Redi observed, that flesh preserved from the access of flies, would bread no maggots; and it is as constant an observation, that vegetable substances will keep a long time in whatever state they are, if the air be excluded; but as soon as it is admitted, they also produce or afford their several kinds either of animal, or minuter vegetable inhabitants. In the first of these cases, the parent flies make their way to the exposed flesh, and there deposit their eggs for the production of a new offspring; in the other, multitudes of the seeds of minute plants and ovula of animals are floating in the air, and accompany it wherever it enters; if they be thus deposited in a place proper for vegetation and accretion, they burst their inclosures, and attain their growth as regularly as the seeds of plants deposited in the earth, or the eggs of larger animals in the nest.

The same wisdom which placed the sun in the center of the system, and arranged the several planets around him in their order, has no less shewn itself in the provision made for the food and dwelling of every bird that roams in the air, and every beast that wanders in the desert; equally great in the smallest and in the most magnificent objects; in the star and in the insect; in the elephant and in the fly; in the beam that shines from heaven and in the grass that cloathes the ground. Nothing is overlooked, nothing is carelessly performed: every thing that exists is adapted with perfect symmetry to the end for which it was designed. This wisdom displayed by the Almighty in the creation, was not intended merely to gratify curiosity and to raise wonder; it ought to beget profound submission, and pious trust in every heart.

Histories of the providence and caution, the care and foresight of the most inconsiderable among animal beings, must surely ever be read with pleasure and attention, as conveying a most beautiful lesson to a reflecting mind; it is impossible for any one thus instructed to think that the Great Being, who has been so careful of those inferior creatures, can be regardless of him whom he has placed in a station infinitely more exalted. Throughout the whole system of things, we behold a manifest tendency to promote the benefit either of the rational or the animal creation. In some parts of nature, this tendency may be less obvious than in others. Objects, which to us seem useless or hurtful, may sometimes occur; and strange it were, if in so vast and complicated a system, difficulties of this kind should not occasionally present themselves to beings, whose views are so narrow and limited as ours. It is well known, that in proportion as the knowledge of nature has increased among men, these difficulties have diminished. Satisfactory accounts have been given of many perplexing appearances; useful and proper purposes have been found to be promoted by objects which were at first thought to be unprofitable or noxious.*

Malignant must be the mind of that person; with a distorted eye he must have contemplated creation, who can suspect that it is not the production of infinite benignity and goodness. How many clear marks of benevolent intention appear every where around us? What a profusion of beauty and ornament is poured forth on the face of nature? What a magnificent spectacle presented to the view of man? What a supply contrived for his

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* The great beauty of the dye produced by the cochineal insect, and the medical virtues of the cantharis, have occasioned them to be considered as very extensive and valuable articles of commerce. The benefits derived from the bee and the silk-worm are universally known; and spiders, could a method be devised to induce them to live in harmony, might also be productive of very essential advantages to the human race. EDIT.

wants? What a variety of objects set before him, to gratify his senses, to employ his understanding, to entertain his imagination, to cheer and gladden his heart? Indeed the very existence of the universe is a standing memorial of the goodness of the Creator; for nothing except goodness could originally prompt creation. No new accession of felicity or glory was to result to him from creatures whom he made: it was goodness communicating and pouring itself forth, goodness delighting to impart happiness in all its forms, which in the beginning created the heaven and the earth. Hence those innumerable orders of living creatures with which the earth is peopled, from the lowest class of sensitive being to the highest rank of reason and intelligence. Wherever there is life, there is some degree of happiness; there are enjoyments suited to the different powers of feeling; and earth, air, and water, are with magnificent liberality made to teem with life.*

Let us not then slight, or deem that unworthy our notice, in which immensity is so conspicuous; or that trivial, in which there is such a manifestation of infinite beneficence; but rather let those striking displays of creating goodness call forth, on our part, responsive love, gratitude, and veneration. To this Great Father of all existence and life, to Him who hath raised us up to behold the light of day, and to enjoy all the comforts which his world presents, let our hearts send forth a perpetual hymn of praise. Evening and morning let us celebrate Him who maketh the morning and the evening to rejoice over our heads; who "openeth his hand and satisfieth the desire of every living thing." Let us rejoice that we are brought into a world, which is the production of infinite goodness; over which a supreme intelligence presides; and where nothing happens but by his divine

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* Blair's Sermons.

permission for the wisest purposes. Convinced that he hateth not the works which he hath made, nor hath brought creatures into existence merely to suffer unnecessary pain, let us even in the midst of sorrow, receive with calm submission whatever he is pleased to send; thankful for what he bestows; and satisfied that, without good reason, he takes nothing away.

Such, in general, are the effects which meditation on the works of the creation ought to produce. It presents such an astonishing conjunction of power, wisdom, and goodness, as we cannot behold without religious veneration.

In short, the world around us is the mighty volume wherein GOD hath declared himself; a picture wherein his perfections are displayed. The book of nature is written in a character that every one may read; it consists not of words, but things; it is a school where GOD is the teacher. All the objects of sense are as the letters of an universal language, in which all people and nations have a common interest; the Creator himself has made this use of it, revealing his will by it, and referring man to it for instruction. Hence the universal agreement between nature and revelation; hence, also, he that can understand GOD as the Fountain of truth and the Saviour of men in the holy scriptures, will be better enabled to understand and adore him as the fountain of power and goodness in the natural creation. Thus will philosophy and divinity go hand in hand, and shew that the world was made, as the scriptures were written, for our instruction; and that the creation of GOD is a school for Christians, if they use it aright.*

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* It is a curious, though melancholy subject of contemplation, to observe how different have been the sentiments of learned and reputedly pious men in times less enlightened; a period when attention to, or compassion for, the animal creation could find no place in a breast that withheld and denied the mercy of GOD unto men; when mercy itself was deemed heresy! Even

A GENERAL DESCRIPTION OF INSECTS.

The subjects of that part of the creation we are now going to survey, merit our attention as exceeding the rest of animated nature in their numbers, the singularity of their appearance, and the variety of their forms. Earth, air, and water are filled with hosts of them. Being for the major part very small, and myriads so diminutive, as even to be imperceptible to the unassisted eye, our knowledge of them, and their component parts would be extremely circumscribed and imperfect, were it not for the advantages derived from the use of the microscope; but happily possessed of this valuable instrument, an inexhaustible source of entertainment and instruction is afforded to the curious inquirer into the wonders of nature. The beauties of the minuter parts of creation are not more hidden from our unassisted sight, than the ends and purposes of their œconomy from slight and superficial observation; the microscope does not more amaze and charm us with a discovery of the first, than the application of our faculties in investigating the latter.

The name of INSECT has been appropriated to these small animals on account of the sections or divisions that are observable in the bodies of the greatest part of them; though, perhaps, it is

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in prior and purer times it was affirmed that " It is absurd, and a disparagement to the majesty of GOD to suppose him to know how many insects there are in the world, or how many fishes in the sea; yea, that such an idea of the Omniscience of GOD would be foolish flattery to Him, and an injury to ourselves." For the satisfaction of the learned reader, I shall here quote the original. " Absurdum est ad hoc Dei deducere Majestatem, ut sciat per momenta singula quot nascantur culices, quotve moriantur; quæ cimicum et pulicum et muscarum sit in terra multitudo; quanti pisces in aqua natent, et qui de minoribus majorum prædæ cedere debeant. Non simus tam fatui Adulatores Dei, ut dum potentiam ejus ad ima detrahimus in nos ipsos injuriosi simus." HIERONYMI Comment. in Abac. Lib. 1. Edit. Basil. Tom. vi. p. 187.

EDIT.

impossible to find any precise term that shall embrace the whole genera, as many particulars must be described before we can attain an exact notion of these animals and their structure.

An insect is now generally defined to be, an animated being whose head is furnished with antennæ; that is destitute of bones, but which, instead thereof, is covered with a very hard skin; that has six or more feet; and that breathes through spiracula, or pores placed in the side of the body.

To be more particular, quadrupeds, birds, and fishes have an internal skeleton of bones, to which the muscles are affixed; but the whole interior body of insects is composed of soft flesh, and the muscles are attached to an external skeleton, serving the double purpose of skin and bone.

Insects are by most writers considered as divided into four principal parts: the caput, or head; the thorax, or trunk; the abdomen, or belly; and artus, or limbs. A perfect knowledge of these parts, and their several subdivisions, is requisite for those who are desirous of forming accurate ideas of these minute animals, or who wish to arrange them in their proper classes.

The head is affixed to the thorax by a species of articulation or joint; it is the principal seat of the senses, and contains the rudiments of the brain;* it is furnished with a mouth, eyes, antennæ, a forehead, a throat, and stemmata. In the greater part of insects the head is distinctly divided from the thorax, but in others it coalesces with it. The head of some insects is very large compared with the size of their bodies; the proportion between the head of the same insect is not always similar; in the

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* Fabricius Philos. Entomolog. p. 18.

caterpillars with horny heads it is generally small, before they moult or change their skin, but much larger after each moulting. The hardness of the exterior part of the head prevents its growth before the change; it is, consequently, in proportion to the body very small; but when the insect is disposing itself for the change, the internal substance of the head retires inwards to the first ring of the neck, where it has room to expand itself; so that when the animal quits the skin, we are surprized with a head twice the former size; and, as the insect neither eats nor grows while the head is forming, there is this further circumstance to be remarked, that the body and the head have each their particular time of growth: while the head expands and grows, the body does not grow at all; when the body increases, the head remains of the same size, without any change. The heads of all kinds of insects, and their several parts, form very pleasing, as well as most diversified objects for the opake microscope.

Os, the mouth, is a part of the insect to which the naturalist will find it necessary to pay a very particular attention; Fabricius goes so far as to assert that, without a thorough knowledge of the mouth, its form, and various appendages, it will be impossible ever to discriminate with accuracy one insect from another. In the structure of the mouth considerable art and wisdom is displayed; the diversity of the figure is almost as great as the variety of species. It is usually placed in the forepart of the head, extending somewhat downwards; in the chermes, coccus, and some other insects, it is placed under the breast. In some insects, the mouth is forcipated, to catch, hold, and tear the prey; in others, aculeated, to pierce and wound animals, and suck their blood; in others, strongly ridged with jaws and teeth, to gnaw and scrape out their food, carry burdens, perforate the earth, nay the hardest wood, and even stones themselves, for habitations and nests for their young. Others are furnished with a kind of tube or tongue, at one time moveable, at another fixed; with this they suck the juices of the flowers: in some again the tongue is so short, as to appear to us incapable of answering the purpose for which it was formed, and the oestri appear to have no mouth.

Maxillæ, the jaws, are generally two in number; in some, four; in others, more. They are sometimes placed in an horizontal, sometimes in a transverse direction; the inner edge is serrated, or furnished with small teeth, as in the cicada, nepa, notonecta, cimex, (bug,) aphis, and remarkably so in some curculiones.

The rostrum, or proboscis, is in general a very curious and complicated organ; it is the mouth drawn out to a rigid point. In many insects of the hemiptera class, it is bent down towards the breast and belly. It has by some writers been considered as serving at once the different purposes of mouth, nose, and windpipe, enabling the insect to extract the juices of plants, communicate the sensation of smelling, and convey air to the body.

Lingua, the tongue, is a taper and compact instrument, by which the insect obtains the juices of plants. Some can contract or expand it, others roll it up with dexterity; in some it is inclosed within a sheath. It is taper and spiral in the butterfly, tubular and fleshy in the fly; in all affording agreeable amusement for the microscope. To exemplify which in one or two instances, while it relieves the reader from the tediousness of narration, will, it is hoped, animate him to farther researches on the subject.

OF THE PROBOSCIS OF THE BEE.

Every day's experience shews that the more we penetrate into the hidden recesses and internal parts of natural bodies, the more we find them marked with perfection in form and design; of the truth of which observation the minute apparatus now to be described will, no doubt, ensure conviction. Swammerdam, when speaking thereof, breaks out into this pious and humble confession: " I cannot refrain," says he, " from confessing to the glory of the Immense and Incomprehensible Architect, that I have but imperfectly described and represented this small organ; for, to represent it to the life in its full perfection, as truly most perfect it is, far exceeds the utmost efforts of human knowledge."

From what has here been said, it will be easy to perceive, that the limits of these Essays will not permit our entering largely into a description of the minute parts of the proboscis of the bee; for an ample account of which recourse must be had to the works of Swammerdam and Reaumur. The last writer, like a skilful workman who takes to pieces a watch which he himself has made, exhibits to you the several parts of which it is composed, and explains their fitness, their adjustments, their uses, the play of the pivots, springs, and pillars; for all these parts, and many more, are to be found in the proboscis of a bee.

It is by this small instrument that the bee procures the food necessary for its subsistence. In a general view, it may be considered as consisting of seven pieces; one of these, i i, b c, Fig. 3. Plate XIII. is placed in the middle; this is supposed to be pervious, and to constitute what may be properly called the tongue; the other six smaller parts or sheaths, disposed in three pairs, are placed on each side of the former: they not only assist in extracting and gathering the honey from the flowers, but they also protect and strengthen the part. The proboscis itself is very curiously divided; the divisions are elegant and regular, and are beset all round with shaggy triangular fibres or villi, distributed in beautiful order: these divisions, though very numerous, appear at first sight as a number of different articulations. The tongue, considered with respect to its length, may be said to have three articulations; one with the head, then a kind of cylindrical horny substance, which forms as it were a base for the true tongue, which is not horny, but soft, fleshy, and pliable.*

The two pieces a a of the exterior sheath are of a substance partly between bone and horn, and partly membranaceous; they are set round with fibres, and are furnished with air vessels, which are distributed through their whole texture; the upper ends f f of this sheath appear to be a little bent, but can be straitened by the bee when they are applied to the proboscis. At d d are two articulations, by means of which the pieces a a may be occasionally bent. The joints contribute towards bending the proboscis downwards, or rather underneath, against the head. These sheaths, together with two interior ones e e, assist in defending, covering, and protecting it from injuries; it is also probable that they promote the descent of the honey, by pressing the proboscis. The parts k k of this sheath have been called by some writers the root.

The two parts e e of the interior sheath are placed higher than those of the exterior one; they originate at g g on the proboscis itself, and near that part or articulation, by which the bee can upon occasion bend the proboscis; this sheath, therefore, always moves with the middle part i i, and is carried forward by it, the exterior sheath being left behind, because its attachments and origin are below that of the proboscis. The pieces e e are very similar in structure to those of a a, only that each of them has on the upper part three joints, the lower one is much longer than the other two; they are all of them surrounded with short fibres.

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* Philos. Trans. for 1792, Part 1.

The smaller articulated pieces never lie close to the proboscis, nor cover it, but are only placed near it, the two upper joints projecting outwards, as in this figure, even when the whole apparatus is shut up as much as possible. Swammerdam thinks these joints are of essential use to the bee, acting as it were in the manner of fingers, and assisting the proboscis, by opening the leaves of the flowers, and removing other obstructions from it; or like the two fore feet of the mole, by the help of which it pushes the earth from the sides both ways, that it may be able with its sharp trunk to search for its food more conveniently. There are two smaller pieces or sheaths, m m, near the bottom af the proboscis; these cannot be well seen without removing the sheath e e.

The proboscis iſ partly membranaceous, and partly of a gristly nature; the lower part is formed in such a manner, that it will swell out considerably, by which means the internal cavity may be prodigiously enlarged, and rendered capable of receiving a very large quantity of native and undigested honey, and larger than might be expected from its size. When the proboscis is shut up and inactive, it is very much flattened, and is three or four times broader than it is thick. The edges are always round: it grows tapering, though very gradually, towards the extremity. The lower and membranaceous part of the trunk has no fibres or villi on it, but is covered with little protuberant transparent pimples, that are placed in regular order, and at equal distances from each other, resembling the little risings observable on the skin of birds when the feathers have been plucked off. They are probably glandules, and may have a considerable share in changing or preparing the honey that is swallowed or taken up by the proboscis. Down the middle of the proboscis there is a tube of a much harder nature than the sides, it grows gradually smaller towards the top; at this place the tongue itself is extremely villous, having some very long villi at the point; whether they are open tubes, or whether they only serve as so many claws, to keep it in its proper place while in action, has not been determined; Mr. John Hunter conceives them to act somewhat like capillary tubes.

The proboscis terminates in a small cylinder c, at the top of which there is a little globule or nipple; the bee can contract this cylindrical part, and the little membrane in which the villi are fixed, into a much smaller compass, and draw it inwards. The exterior sheaths lap over each other on the upper part, so that the outside of the proboscis is protected by a very strong double case, a covering that was unnecessary for the under part; because when this instrument is in use the sheaths are opened, but when it is inactive, it is so folded that the under part is protected by the body of the bee. Withinside the exterior sheath, and near the bottom q, are two levers, which are fixed to the end of the proboscis, and by which it is raised and lowered.

Swammerdam thinks that the honey is, as it were, pumped or sucked up by the bee through the hole at the end b of the tongue; he does not seem to have discovered the apertures which are on the cylindrical part, near the end b. But Reaumur is of opinion that it is used to lap up the fluid, which is then conveyed down between the sheath to the mouth of the bee. To ascertain this, he placed a bee in a glass tube, the inside of which was rubbed over with honey, and little pieces thereof placed in different parts; the bee placed the tongue on the honey; stretching the end beyond the piece thereof, she bent it into the form of a bow, and inserted the most convex part of the bow into the honey; by rubbing the glass backwards and forwards with this part, she soon cleaned that portion to which it was applied, conveying the honey afterwards to the throat by the vermicular motion of the tongue.

If you attentively observe a bee, when it has placed itself on a full-blown flower, the activity and address with which it uses this apparatus will be very conspicuous. It lengthens the end, and applies it to the bottom of the petals or leaves of the flower, moving it continually in a vast variety of different directions; lengthening and shortening, bending and turning it in every possible way, to adapt it to the form, &c. of the leaves of the flower. These various movements are executed with a promptitude that surpasses all description.

The whole of this curious apparatus can be folded up into a very small compass under the head and neck. The larynx, or that part next to the head, falls back into the neck, which brings the extreme end of the first portion of the proboscis within the upper lip, or behind the two teeth; then the whole of the second part is bent down upon and under the first part, and the two last sheaths or scales are also bent down over the whole; so that the true tongue is inclosed laterally by the two second horny sheaths, and over the whole lie the two first.

OF THE PROBOSCIS OF THE BUTTERFLY.

From the tongue of the bee, let us now direct our attention to that of the butterfly. This is a spiral substance, somewhat resembling the spring of a watch when wound up, consisting of eight rounds; by means of a pin you may gently pull it out to its full length; it grows gradually tapering from the base, at the end it divides or separates into two tubes, each furnished with little organs of suction; probably, it is by these that it extracts the juices on which it feeds, and not by the extreme ends of the tongue. As the butterfly has no mouth, the proboscis is the only alimentary organ; when separated from the insect, it will often unroll itself, then wind and coil itself up again, continuing these motions at intervals for a considerable time.

OF THE PROBOSCIS OF THE CULEX OR GNAT.

The proboscis of the gnat consists of a great number of extremely delicate pieces, all concurring to one purpose; this is the instrument with which it strikes the flesh, and sucks the blood of animal bodies. The only part exhibited to the naked eye is the sheath, which contains all the other pieces. This sheath is a cylindrical tube, which is slit in such a manner, that the insect can separate it from the dart, and bend it more or less in proportion as the dart is plunged into the wound. From this tube the sting is darted, which consists of five or six blades or lancets of exquisite minuteness, lying one over the other; some of these are sharpened like a two-edged sword, while others are dentated and barbed at their extremities like the head of an arrow. The instant the gnat lances this bundle of darts into the flesh, and penetrates a vein, a drop or two of fluid is by it insinuated into the wound, by which the blood is attenuated, and the blades acting as so many capillary tubes, the blood ascends in them, and is conveyed into the body of the gnat. The injected fluid also by its fermentation causes that disagreeable and teazing sensation of itching, to which most persons are subjected, after having sustained an attack from one or more of these little animals.*

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* To some persons the gnat (culex pipiens) is so truly formidable, that, during the Summer season, they constantly dread the approach of evening, that being the time when these blood-thirsty marauders sally forth in great numbers, pursue them wherever they go, and exempt no part of the face, hands, or even the legs from their depredations; the consequences of which are, violent, though happily only local and temporary inflammation, attended with insupportable itching, succeeded by tumors very similar to those occasioned by a scald; when these have discharged the pellucid fluid they contain, the symptoms subside. Instances have been known in the vicinity of London, where for several days the eyes of the sufferers have been closed, the nose and lips violently swelled, the fingers of both hands so affected as to prevent their motion, and

OF THE PROBOSCIS OF THE TABANUS OR OX-FLY.

Plate XVI. Fig. 1. is a microscopic view of the proboscis of a tabanus, with which it pierces the skins of horses and oxen, and nourishes itself with their blood; Fig. 2. the same of the natural size. The singular and compound structure, together with the wonderful form and exquisite beauty of this apparatus, discovers such a view of the wisdom, power, and greatness of its infinite composer, as must strike with admiration every contemplative observer, and lead him to reflect on the weakness, impotence, and nothingness of all human mechanism, when compared with the immense skill and inimitable finishing displayed in the subject before us. The whole of this formidable apparatus is composed of six parts, exclusive of the two guards or feelers a a, all of which are inclosed in a fleshy case, which in the figure is totally removed, as it contained nothing remarkably different from that

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the legs equally affected. It is remarkable, that in general those who thus suffer are not conscious of the moment when they receive the injury, but are soon made sensible of it by the effect it produces. The approach of the enemy is, however, always known by the singing or humming noise they make; the peculiar note of which, though rendered very familiar by daily repetition, is never esteemed sufficiently musical to render it pleasant or agreeable to the destined victims. Amongst the variety of remedies which have been recommended for the cure of this temporary evil, Barbut mentions the immediate application of volatile alkali, or scratching the part newly stung, and washing it with cold water; he likewise asserts, that rubbing the part at night with fuller's earth and water abates the inflammation. As preventatives are certainly more acceptable than curatives, I wish I were enabled to recommend such in the present case: in one instance, the application of vinegar every evening before sun-set produced a happy effect; possibly washing the parts exposed with extract of saturn properly diluted might prove effectual.

In the Philosophical Transactions for the year 1767, is an account of uncommonly numerous swarms of gnats which made their appearance at Oxford, during the months of July, August, and September of the preceding year. So many myriads sometimes occupied the same part of the atmosphere in contiguous bodies, that they resembled a very black cloud, greatly darkened the air, and almost totally interrupted the solar rays. The repeated bites of these malignant insects were so severe, that the legs, arms, heads, and other parts of many persons were swelled to an enormous size. The colour of the parts was red and fiery, perfectly similar to that of some of other insects with two wings. The guards or feelers a a, are of a spungy or fleshy substance, and are grey, covered with short hairs or villi; they are united to the head by a little joint of the same texture, which in this view of the object could not be shewn. These guards are a defence to the other parts of the apparatus, as they are laid upon it side by side, whenever the animal stings, and by that means preserve it from external injury. The two lancets b b and B, evidently open the wound, and are of a delicate and tender structure, formed like the dissecting knife of the anatomist, with a sharp point and slender edge, but gradually increasing to the back. The two instruments, c c and C, appear as if intended to enlarge the wound, by irritating the parts round it; to accomplish which, they are jagged or serrated; they may also serve, from their hard and horny texture, to defend the tube e E, which is of a softer nature and tubular to admit the blood, and convey it to the stomach; this delicate part is inclosed in a

of the most alarming inflammations. Some of these gnats had their bodies greatly distended by the uncommon quantities of blood which they had imbibed.

In short, there is no species of insects more troublesome to mankind than the gnat; others give more pain with their stings, but it is only when they are attacked, or by accident, that we are stung by them; but the gnats thirst for our blood, and follow us in whole companies to attack us. In marshy places of this country the limbs of the inhabitants are kept swelled during the whole season. In warmer climates, particularly the West Indies, they are, under the denomination of musquetoes, still more formidable.

Hooke, in his Micrographia, pleads in justification of these terrible little insects, that they do not wound the skin and suck the blood out of enmity or revenge, but through mere necessity, and to satisfy their hunger:—it may be so; and on this account we cannot annex the criminality to them which appertains to such of the highest rank in the scale of the animal creation, who, though not urged by the same powerful motive, pursue a somewhat similar conduct; but those who have experienced their assaults, will scarcely admit this plea as a sufficient apology, or feel themselves amicably disposed towards them; as, from whatever cause their attacks may proceed, the effect is so very unpleasant, as almost to justify the sufferers in addressing them in the language of the frogs in the fable to the boys, "Consider, I beseech ye, that though this may be sport to you, it is death to us," and ejaculating a wish, that they might be enabled to gratify their rapacious appetites by some other means. Edit.

case d D, which entirely covers it. These parts are drawn separately at B, C, D, E. De Geer observes, that it is only the female that sucks the blood of animals; and Reaumur declares, that having made one disgorge itself, the blood it threw up, appeared to him to be more than the whole body of the insect could have contained.

Many other instances of the variety and curious fabrication of this little organ in different insects, may be found in the works of Reaumur and De Geer; enough has been said to shew that its mechanism not only eludes the human eye, but far surpasses every work of man; I shall therefore proceed, in the next place, to notice

THE ANTENNÆ OF INSECTS.

The antennæ are fine slender horns consisting of several articulations, moveable in various directions, and constituting one of the discriminating characteristics of insects. They are beautiful in form, and of a very delicate structure, so finely articulated, and so minutely jointed, as to be instantaneously moveable in every direction. They are situated on the fore part of the head.

The shape, the length, the number, and kind of articulations, not only vary in different species, but the antennæ of the male generally differ from those of the female. The greater number of insects have only two antennæ, but the oniscus, the pagurus, and astacus have four. Regular rows of minute holes are said to have been discovered in the antennæ. Several insects cover their eyes with them while they sleep.

We are far from being certain of the use of this organ; some writers have conjectured that they were the organs of smell and hearing, others have supposed them appropriated to a delicate species of feeling, sensible to the least motion or disturbance in the circumambient fluid in which they move.* The following observations throw some light on this obscure subject. When a wingless insect is placed at the end of a twig, or in any other situation where it meets with a vacuity, it moves the antennæ backward and forward, elevates and depresses them from side to side, and will not advance further lest it should fall. Place a stick or any other substance near the antennæ, and the insect immediately applies them to this new object, seems to examine whether it be sufficient to support its weight, and then proceeds on its journey. From these observations it would appear that the antennæ assist the insect in judging of the vicinity of objects, and probably enable them to walk with safety in the dark.

That these observations are not, however conclusive, appears from an experiment of a very ingenious naturalist: being desirous of ascertaining the nature and use of the antennæ and proboscis of a butterfly, he gently approached one that was flying about in search of food; he observed that it turned the antennæ about every way, till coming within scent of a flower, it kept them fixedly bent toward that object, directing its course by their guidance, till it arrived at the flower; there they appeared to act as an organ of smell, and that the minute holes with which it is furnished assisted in promoting this operation. When the creature had reached the flower, it hovered over it as with rapture,

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* Some have thought them intended to defend the eyes, but though this might seem probable in regard to the short plumose ones, it can never hold good in those that are slender and smooth, which can be of no such service. Others have thought them made for wiping and cleaning the eyes, but for this purpose they are totally unfit; the fore legs of the insect are much better calculated for this use by the hairs or fibrilla with which they are covered. Possibly they may be the organs of smelling, since we evidently find that many insects possess this sense in a very exquisite degree, and yet we see no external organs except these to serve that purpose.

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poising itself quietly upon its wing, like a kite or hawk in the air; it then dropped suddenly, till it was on a level with the flower, when it began to agitate its wings briskly and to unroll its spiral trunk, thrusting it to the bottom of the flower; in a little time the trunk was rolled up, and again in a moment unrolled; these operations it repeated till the flower yielded no more juices, the butterfly then sought for and alighted on another.*

The differences in the form, &c. of the antennæ are characterized by naturalists under the following names:

Setaceæ; are those that, like a bristle, grow gradually taper towards the point or extremity, as in many of the phalenæ. Filiformes; thread-shaped, and of an uniform thickness. Moniliformes; these are filiform like the preceding, and of a regular thickness, but consist of a series of round knobs, like a necklace of beads, as in the chrysomela. Clavatæ; formed like a club, increasing gradually from the base to the extremity, as in the papilio, butterfly. Capitatæ; these are also formed like a club, but the last articulation is larger than the rest, finishing with a kind of capital or head. Fissiles; these are like the former, only that the capitulum or head is divided longitudinally into three or four parts or laminæ, as in the scarabæi. Perfoliatæ; are also capitated, but have the capitulum divided horizontally, and the laminæ connected by a kind of thread passing through their center, as in the dermestes and dytiscus. Pectinatæ; so called from their similitude to a comb, though they more properly resemble a feather, as in the phalenæ and elateres; this is most

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* After all, this subject must for the present remain undecided. Indeed, the bodies of insects are throughout formed of parts so different from ours, that we can probably conceive no more idea of the use of some of their organs, than a man born blind or deaf can of the senses of vision or hearing. They may have senses different from ours, and these may be the organs of them.
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obvious in the male. Aristatæ; such as have a lateral hair, which is either naked, or furnished with smaller hairs, as in the fly.

Besides the foregoing terms, the antennæ are called breviores, or short, when they are shorter than the body; mediocres, or middling, when they are of the same length; and longiores, when they are longer.

Near the mouth there is also a species of small filiform articulated antennæ, called the palpi, or feelers; they are generally four in number, sometimes six; they are placed under and at the sides of the mouth, which situation, together with their size, sufficiently distinguish them from the antennæ; they are in continual motion, the animal thrusting them in every matter, as a hog would its nose, when in search of food. Some have supposed them to be a kind of hand to assist in holding the food when it is near the mouth.

OF THE EYES OF INSECTS.

The structure of the eye has always been considered as a wonderful piece of mechanism; the admirable manner in which those of the human species are formed, and the nature of vision, are speculations which cannot but excite the attention of every inquisitive mind. The eyes of insects, though they differ considerably in their construction from those of other animals, are no less objects of our admiration. Indeed, among the exterior parts of insects, none are more worthy of minute investigation, and very few persons are to be found, who can be insensible to the beauties of this organ when exhibited under the microscope, as that instrument alone points out to us the prodigious art employed in their organization, and evidently shews how many wonders escape the unassisted sight.

The construction of the eye in insects is not only distinct from that of other animals, but also differs in different species. They vary in number, situation, connection, and figure. In other creatures the eyes are moveable, and two in number, one on each side of the head: in insects, the genus of cancri excepted, the eyes are fixed; they have no eye-brows, but the outer coating is hard and transparent.

The greater part of insects have two eyes; in the monoculus they approach so near to each other, as to appear like one; the gyrinus has four eyes, the scorpion six, the spider eight, and the scolopendra three.

Of the eyes of insects, some have them single, that is, placed at a small distance from each other; while others are furnished with an indefinite number, all placed in one common case or socket; the latter are generally termed the reticulated eyes,

OF THE RETICULATED EYES OF INSECTS.

The microscope does not disclose greater wonders, when it exhibits to us millions of animals invisible to the naked eye, where we should suppose nothing living existed, than when it discovers to us hidden beauties in those, which, though they are large enough to be seen by our natural eye, yet in their several minute parts are no ways discernible, but by the assistance of glasses.

Thus we readily discern those protuberances on the heads of insects, which are formed by a congeries of eyes; we can even perceive that they consist of a number of lines crossing each other with great regularity and exactness at some little distance, like the meshes of a net. By this we know that they are reti-

Y The [illegible]

culated substances; but in what manner they are so, can only be shewn by the microscope.

The eyes of the libellula, on account of their size, are peculiarly well adapted for microscopical examination; and, by the assistance of the instrument, you will find that they are divided into h/ a number of exagonal cells, each of which forms a complete eye. The external parts of these eyes are so perfectly smooth, and so well polished, that, when viewed as opake objects, they will, like so many mirrors, reflect the images of all the surrounding objects. The figure of a candle may be seen on their surface multiplied almost to infinity, shifting its beam to each eye, according to the motion given to it by the hands of the observer. Other creatures are obliged to turn their eyes towards the object; but insects have eyes directed thereto, on whatsoever side it may appear: they more than realize the wonderful accounts of fabulous history: poets gave to Argus an hundred eyes; insects are furnished with thousands, having the benefit of vision on every side with the utmost ease and speed, though without any motion of the eye or flexion of the neck.

Each of these protuberances, in its natural state, is a body cut into a number of faces, like an artificial multiplying glass; but with this superiority in the workmanship, that as there, every face is plane, here, every one is convex, immensely more numerous, and contained in a much smaller space. If one of these protuberant substances be nicely taken from the head of the insect, washed clean, and placed before the microscope, its structure is elegantly seen, and it becomes an object worthy of the highest admiration. You will find that each of the eyes is an hexagon, varying in its size according to its situation in the head, and that each of them is a distinct convex lens, and has the same effect in forming the image of an object placed before it. Of this you will be convinced, by turning the mirror of the microscope so as to bring the picture of some well-defined object under the eye; thus, turn it towards a house, and in the eye of the insect you will perceive the house diminished to a box, but multiplied into a city; turn it towards a soldier, and you will have an army of pigmies performing every motion at the same instant of time; again, turn the mirror towards a candle, and you will have a beautiful and resplendent blaze from multitudes of regular flames.

Hooke, Catalan, &c. have shewn that these small eyes are furnished with every requisite of vision, and that each of them has the use, the power, and properties of an eye. But we must have recourse to the works of Swammerdam for a full account of the astonishing organization of the eyes of insects. Among other things, he has shewn, that under each facet there is a pyramid of fibres broad at the base, and growing smaller as it proceeds inwards; the pyramid has the same number of sides as the eye, and there are as many hexagonal pyramids, as there are small facets or eyes in the insect. An innumerable number of pulmonary tubes ascend these fibres, terminating in a white fibrous convex membrane; under these membranes there is another, still more delicate and transparent; beneath this, a second species of fibres is transversely applied, like so many beams to support the pyramids that are laid upon them. Still we cannot determine with certainty, how these numerous inlets to sight operate for the service of the animal; they may increase the field of view, augment the intensity of light, and be productive of advantages of which we can have no conception.

Hooke computed 14000 of these facets in the two eyes of a drone; Leeuwenhoek reckoned 6036 in the two eyes of a silkworm, when in its fly state; in the eyes of the libellula he reckoned 12544 hexangular lenses.

Swammerdam covered the reticulated eyes of certain insects with black paint; in this state they flew at random, and seemed to be deprived of their strength; when they settled, they did not avoid the hand that was going to take hold of them. Reaumur made similar experiments on the eyes of bees, which concurred with those of Swammerdam.

Some ephemera flies have four reticulated eyes, two of which are placed as in the common fly; the other two are placed, one beside the other, upon the upper part of the head, and have the appearance of a kind of mushroom, the head extended somewhat beyond the stalk. The first pair are of a brown colour, those of the mushroom form are of a very beautiful citron colour.

In some of the fly class, these reticulated eyes are little inferior in colour and brilliance to the brightest gem. The colour varies in different species; in some you find it green, in others red, &c. some have a most elegant changeable colour thrown over them, partly purple, partly green, and partly of that brassy hue, which is seen on the backs of some of our beetles, and which is not equalled by any other production of art or nature.

Fig. 3. Plate XVI. is a representation of a small part of the cornea of a libellula, as seen by the microscope; the sides of the hexagons in some positions of the light, appear of a fine gold colour, and divided into three parallel borders. Fig. 4. the same object of its natural size.

Fig. 5. Plate XVI. represents a small portion of the cornea of a lobster; here each of the eyes are small squares, not hexagons; a conformation which admits a smaller number in the same surface; so great a number was not necessary in this instance, as the eyes of the lobster are moveable. Fig. 6. the same of its natural size.

OF THE EYES OF THE MONOCULUS POLYPHEMUS.

The monoculus polyphemus, or king crab, has four eyes, two large and two small ones; the large eyes are formed of a great number of transparent amber-like cones, the small ones of a single cone,

"The internal surface of the large eyes, examined with the microscope, is found to be thick set with a great number of small transparent cones, of an amber colour, the bases of which stand downward, and their points upward next the eye of the observer. The cones in general have an oblique direction, except some in the middle of the cornea, about thirty in number, the direction of which is perpendicular. The center of every cone being the most transparent part, and that through which the light passes, on that account the perpendicular or central cones always appear beautifully illuminated at their points. In a word, they are all so disposed, as that a certain number of them receive the light from whatever point it may issue, and transmit it to the immediate organ of sight, which we may reasonably suppose is placed underneath them. The cones are not all of the same length; those on the edges of the cornea are the longest, from whence they gradually diminish as they approach the center, where they are not above half the length of those on the edges.

"The structure of the small eyes being less elaborate, their internal appearance, when placed in the microscope, will be described in a few words. They consist of an oval transparent horny plate, of an amber colour, in the center of which stands a single cone, through which and the oval plate the light passes."*

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* See Mr. André's paper with a plate, in the Phil. Trans. for 1782, page 440.

OF THE EYES OF A SPIDER.

Though the form of this insect is naturally disgusting, yet the eyes make a beautiful object for the microscope. They have generally eight; two on the top of the head, that look directly upwards; two in the front, a little below the foregoing, to discover what passes before it; on each side a couple more, whereof one points sideways forward, the other sideways backward; so that the spider can nearly see all around. These eyes are immoveable, and seem to be formed of a hard transparent horny substance. A portion of each sphere projects externally beyond the socket, the largest part is sunk within it. There is round each eye a circular transparent membrane. Mr. Baker placed the eye of a spider over a pin-hole made through a piece of card, and then applied it as a lens to examine objects; he found it magnified the objects greatly, but that it did not exhibit them distinctly; this he however attributed to the length of time the spider had been dead whose eye he used. The number of eyes is not the same in all species of the spider.

OF THE STEMMATA.

It might be imagined, that as every fly has two reticulated eyes, they could not have occasion for more; but so it has not appeared to that GREAT BEING who formed them, for many are furnished besides with other eyes, differing in form and construction from those that are reticulated.

These were first noticed by M. de la Hire; they are three lucid protuberances placed on the back part of the head of many insects: their surface is glossy, of an hemispheric figure, and a coal black colour. They are transparent, and disposed in a triangular form; by modern naturalists they are termed stemmata.

Reaumur made experiments on these eyes, similar to those he had made on the reticulated ones, and found that when the stemmata were covered with dark varnish, the insects flew but to a small distance, and always at random.

No insect is, I believe, found with both kind of eyes, unless in its perfect state: there are many species which are not furnished with stemmata, gnats and tipulæ are without them.

We are apt to suppose that nature has lavished all her bounty upon her larger creatures, and left her minims of existence, as Shakspeare phrases it, unfinished; with what different ideas must those be impressed, who find the apparatus for vision in these small creatures so various and so wonderful in their structure, and who must perceive so much design and order manifested in the position, construction, and number of these delicate and useful organs.

OF THE BODY OF INSECTS.

The trunk or body of the insect is situated between the head and abdomen. Naturalists divide it into three parts; the thorax, scutellum, and sternum.

The thorax is the upper part of the body, it is of various shapes and proportions; the sides and back of it are often armed with points.

The scutellum, or escutcheon, is the lower part of the body, and is generally of a triangular form; though it adheres to the thorax, it is easily distinguished therefrom by its figure, and often by an intervening suture. It seems intended to assist in expanding the wings.

The sternum is situated on the under part of the thorax; in some species it is pointed behind, as in the elateres; in others, bifid, as in some of the dytisci.

OF THE ABDOMEN OF INSECTS.

The abdomen, or under part of the body, contains the stomach, the intestines, the air vessels, &c. It is composed of several rings or segments, so that it may be moved in various directions, or lengthened and shortened at pleasure; in some it is formed of one piece only. It is perforated with spiracula, or breathing holes, and is terminated by the tail.

The spiracula are small oblong holes or pores placed singly one on each side of every ring of the abdomen; these are the means or instruments of respiration, supply the want of lungs, and form a peculiar characteristic of insects.

OF THE LIMBS OF INSECTS.

By the limbs are here meant the instruments used by the insect both for motion and defence. They are, alæ, the wings; halteres, the poisers; pedes, the legs; cauda, the tail; and aculeus, the sting.

OF THE WINGS OF INSECTS.

The wings are those organs by which the insect is enabled to fly; some have only two, others are furnished with four, two on each side; these are, in some, of the same size; in others, the superior ones are much larger than the inferior: Linnæus has made them the foundation of the order into which he has divided this numerous class of beings. The variety in the form and structure of the wings is almost infinite; the beauty of their colouring, the art with which they are connected to the body, the curious manner in which some are folded up, the fine articulations provided for this purpose, by which they are laid up in their cases when out of use, and yet are ready to be extended in a moment for flight; together with the various ramifications, by which the nourishing juices are circulated, and the wing strengthened, afford a fund of rational investigation highly entertaining; exhibiting, particularly when examined by the microscope, a most wonderful display of divine wisdom and power. The more delicate and transparent wings are covered and protected by elytra, or cases, which are generally hard and opake. The wings of moths and butterflies are mostly farinaceous, covered with a fine dust; by the assistance of the microscope, we discover that this dust is a regular assemblage of organized scales, which will be more particularly noticed hereafter.

The following names are made use of to describe the different kinds of wings. They are first distinguished, with respect to their surfaces, into superior and inferior. The part next the head is called the anterior part; that nearer the tail, the posterior part. The interior part is that next the abdomen; the exterior part is the outermost edge.

Those wings are termed plicatiles, which are folded when the insect is at rest, as in the wasp. Planæ; those which are incapable of being folded. Erectæ; whose superior surfaces are brought in contact when the insect is at rest, as in the ephemera, papiliones, &c. Patentes; if they are extended horizontally when the insect is at rest, as in the phalænæ geometræ. Incumbentes; those insects which, when they are not in motion, cover horizontally with their wings the superior part of the abdomen. Deflexæ; those are also incumbentes, but not horizontally, the outer edges declining towards the sides. Reversæ, are also deflexæ, with this addition, that the edges of the inferior wings project from under the anterior part of the superior ones. Dentatæ; with serrated or scolloped edges. Caudatæ; in these some of the fibres of the wings are extended beyond the margin into a kind of tail. Reticulatæ; when the veins or membranes of the wings put on the appearance of net-work.

The wings are further distinguished by their ornaments, being painted with spots, maculæ; bands, fasciæ; streaks, strigæ: when these are extended lengthways, they are called lines, linæ; and if with dots, punctæ; one or more rings are termed eyes, ocelli; if the spots are shaped like a kidney, they are termed stigmata.

The elytra, or crustaceous cases of the wings are extended when the insect flies, and shut when it rests, forming a longitudinal suture down the middle of the back; they are of various shapes, and distinguished by the following names:

Abbreviata; when they are shorter than the abdomen. Truncata; when their extremities terminate in a transverse direct line. Fastigiata, when of equal or greater length than the abdomen, and terminating in a transverse line. Serrata; having their external margins edged with teeth or notches. Spinosa; when their exterior surfaces are covered with small sharp points. Scabra; when they are very rough. Striata; marked with slender longitudinal furrows. Porcata; having sharp longitudinal ridges. Sulcata; with deep furrows. They are likewise distinguished by the denomination of Hemelytra, when their cases are neither so hard as the elytra, nor so delicate as the transparent wings.

OF THE HALTERES OR POISERS OF INSECTS.

Under the wings of most insects which have only two, there is a small head placed on a stalk, frequently under a little arched scale; these are called halteres, poisers; they appear to be rudiments of the hinder wings: it has been supposed that they serve to keep the body in equilibrio when the insect is flying.

OF THE ELYTRA, AND WINGS UNDER THE ELYTRA.

I have already observed, that the delicate and transparent wings of many insects are covered and protected by elytra, or cases, which also in some measure act as wings.

These exterior cases are harder and more opake than the wings under them; they are generally highly polished, and often enriched with various colours, adorned with ornamental flutings, and studded with brilliants, whose beauties are beyond description. All these ornaments are united in the curculio imperialis,* or diamond beetle, one of the richest and most magnificent creatures in nature; the head, the wings, the legs, &c. are curiously beset with scales of a most splendid appearance, outvying the ruby, saphire, and emerald, forming in miniature one of the most noble phenomena that the colours of light can exhibit. It is said, that in the Brazils, from whence they come, it is almost impossible to look at them on a sunny day, when they are flying in little swarms, so great is the glowing splendor of their heightened colours.

The strength and hardness of the elytra are admirably adapted to the various purposes of the insects to which they are appropriated; at the same time that they protect the tender wings be-

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* Fabricius Spec. Ins. 184. 129.—Drury. Ins. 2 Tab. 33, Fig. 1.

neath them, they serve as a shield to the body; while the ribs, and other prominences, contribute to lessen the friction and diminish the pressure to which they are often exposed. In most of these insects, the under wing is longer and larger than the exterior one, so that it is obliged to be bent and folded up, in order to lye under the elytra; for this purpose they are furnished with strong muscles, and proper articulations to display or conceal them at pleasure.

OF THE WINGS OF THE FORFICULA AURICULARIA, OR EARWIG.

Fig. 1. Plate XIV. is a magnified view of the wing of an earwig. Fig. 2. the natural size. Though the insect is so very common, yet few people know that it has wings, and fewer yet have seen them; they are of a curious and elegant texture, and wonderful structure. The upper part is crustaceous and opake, while the other part is beautifully transparent. They fold up into a very small compass, and lie neatly concealed under the elytra, which are not more than a sixth part of the wing in size. They first fold back the parts A B, and then shut up the ribs like a fan; the strong muscles used for this purpose are seen at the upper part of the figure. The ribs are extended from the center to the outer edge, others are extended only from the edge about halfway; but they are all united by a kind of band, at a small, but equal distance from the edge; the whole evidently contrived to strengthen the wing, and facilitate the various motions thereof; so that, in these wings you find all the motions that are in the most elaborate and portable umbrellas, executed with a neatness and elegance surpassing description. The earwig is a very destructive animal, doing considerable injury to most kinds of wall fruit, to carnations, and other fine flowers, &c. and as they only

feed in the night, they escape the search of the gardener. Reeds open at both ends, and placed among fruit trees, are a good trap for them, as they croud into these open channels, and may be blown out into a tub of water. As they conceal themselves in the day-time, those that are curious in flowers place tobacco pipes, lobster claws, &c. on the top of their garden sticks, in order to catch them. This insect differs very little in appearance in its three different states. De Geer asserts, that the female sits on her eggs, and broods over the young ones, as a hen does over her chickens.

OF THE WINGS OF THE HEMEROBIUS PERLA.

So infinite is the variety displayed in the disposition, structure, and ornaments of the wings of insects, that only to enumerate them would fill many pages; I must leave this subject to be further pursued by the reader, contenting myself with presenting him with the view of a wing of the hemerobius perla, as it appears under the microscope. The insect to which it belongs, has acquired the name of hemerobius, from the shortness of its life, as it seldom lives more than two or three days in the fly state. Linnæus has placed it in his fourth class, among those insects which have four transparent wings and no sting. The body of the insect is of a fine green colour; the eyes appear like two delicate beads of burnished gold, whence it is by many called the golden eye. The wings are delicate and elegant, nearly of a length, and exactly similar; they are composed of a beautiful thin transparent membrane, furnished with slender fine ribs, regularly and elegantly disposed, adorned with hairs, and slightly tinged with green. Fig. 1. Plate XV. exhibits its magnified appearance; Fig. 2. the natural size.

OF THE WINGS OF MOTHS AND BUTTERFLIES.

The wings of these insects are mostly farinaceous, being covered with a fine dust, which renders them opake, and produces those beautiful and variegated colours by which they are so richly adorned, and so profusely decked. If this be wiped off, you find the remaining part, or naked wing, to consist of a number of ribs, like those in the leaves of plants, but of a crustaceous or talcy nature; the largest rib runs along and fortifies the exterior edge of the wing; the interior edge is strengthened by a smaller vessel or rib. The ribs are all hollow, by which means the wing, though comparitively large, is very light. The substance between the ribs, and which constitutes the body of the wing, resembles talc,* surprizingly thin and transparent; as this is extremely tender, one use of the scales may be to protect it from injuries. When the moth emerges from the chrysalis, the wings are soft and thick, and if they be examined in that state, will be found to consist of two membranes, that may be raised up and separated, by blowing between them with a small tube: the ribs

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* As the author's idea of this substance being of the nature of talc, does not appear correct, and I cannot find that entomologists are agreed in the definition of it, I shall just give the following extract on the subject from the Cyclopœdia by Rees, and submit the decision to the reader.

"The substance which connects and fills up the spaces between these ribs, is of so peculiar a nature, that it is not easy to find any name to design it by, at least there is no substance that enters the composition of the bodies of the larger animals, that is at all analogous to it. It is a white substance, transparent and friable, and seems indeed to differ in nothing from that of the large and thick ribs, but in that it is extended into thin plates; but this is saying little toward the determining what it really is, since we are as much at a loss to know by what name to call the substance they are composed of. Malpighi indeed calls them bones; but though they do serve in the place of bones, rendering the wing firm and strong, &c. yet, when strictly examined, they do not appear to have any thing of the structure of bones, but appear rather of the substance of scales, or of that sort of imperfect scales, of which the covering of crustaceous insects is composed." Edit.

lie between these membranes. You may with the assistance of glasses discover certain strait and circular rows of extremely minute holes, running from rib to rib, or forming figures in the intermediate spaces, which seem to answer to the figures and variegations on the complete wing, and are probably the sockets for the stalks or stems of the small scales.

Ever since the microscope was invented, the dust that covers these wings has engaged the attention of microscopic observers; as by this instrument it is found to be a regular collection of organized scales of various shapes, and in whose construction there is as much symmetry, as there is beauty in their colours. A view of some of these scales, as they appear in the microscope, is exhibited at F E H I, in Fig. 7. Plate XVI. and in Fig. 8. of the natural size. Their shapes are not only very different in moths of various species, but those on the same moth are also found to differ. Of the scales, some are so long and slender that they resemble hairs, except that they are a little flattened and divided at the ends; some are short and broad; some are notched at the edges, others smooth; some are nearly oval, while others are triangular: they are mostly furnished with a short stalk or stem to fix them to the wing. With the microscope, a variety of large stripes or ribs are to be discovered; between these larger lines, minuter ones may be seen with a deep magnifier. The larger stripes rise in general from the exterior notches; some have a rib running down the middle, through their whole length. The upper and under parts of the wing are equally supplied with them.

The regular arrangement of these plates, one beside and partly covering the other, as in the tiling of an house, is best seen by examining a wing in the opake microscope. The prodigious number of small scales which cover the wings of these beautiful insects, is a sure proof of their utility to them, because they are given by HIM who makes nothing in vain.

That the lively and variegated colours, which adorn the wings of the moth and butterfly, arise from the small scales or plates that are planted therein, is very evident from this, that if they be brushed off from it, the wing is perfectly transparent: but whence this profusion and difference of colour on the same wing? is a question as difficult to resolve, as that of Prior, when he asks.

"Why does one climate and one soil endue
The blushing poppy with a crimson hue,
Yet leave the lilly pale, and tinge the violet blue?"

As the wings of the moths and butterflies are very light, they can support themselves for a long time in the air; their manner of flying is ungraceful, generally moving in a zigzag line, to the right and to the left, alternately ascending and descending; this undulating motion however has its uses, as it disappoints the birds who chase them in taking aim; by which means they frequently elude their pursuit, though continued for a considerable time.

Dr. Hooke* endeavoured to investigate the nature of the motions of the wings of insects; and, although he was not able, from the experiments he made, to give a satisfactory account of them, yet as they may be useful to some future inquirer, and lead him more readily into the path of truth, I hope an extract therefrom will not prove unacceptable to the reader. To investigate the mode or manner of moving their wings, he considered with attention those spinning insects that suspend, or as it were poise

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* Hooke's Micrographia, p. 172.

themselves in one place in the air, without rising or falling, or even moving backwards or forwards; by looking down on these, he could, by a kind of faint shadow, perceive the utmost extremes of the vibratory motion of their wings; the shadow, while they were thus suspended, was not very long, but was lengthened when they endeavoured to fly forwards. He next tried by fixing the legs of a fly upon the top of the stalk of a feather with glue, wax, &c. and then making it endeavour to fly away; he was thereby able to view it in any posture. From hence he collected, that the extreme limits of the vibrations were usually somewhat about the length of the body distant from each other, often shorter, and sometimes longer. The foremost limit was generally a little above the back, and the hinder one somewhat beneath the belly; between these, to judge by the sound, they seemed to move with an equal velocity. The manner of their moving them, if a just idea can be formed by the shadow of the wing, and a consideration of its nature and structure, seemed to be this: the wing being supposed to be in the extreme limit, it is then nearly horizontal, the forepart only being a little depressed; in this situation the wing moves to the lower limit; before it arrives at this, the hinder part begins to move fastest; the area of the wing begins to dip behind, and in that posture it seems to be moved to the upper limit back again. These vibrations, judging by the sound, and comparing them with a string tuned in unison thereto, consist of many hundreds, if not thousands, in a second of time. The powers of the governing faculty of the insect, and the vivacity of its sensations, whereby every organ is stimulated to act with so much velocity and regularity, surpass our present comprehension.

PEDES THE FEET, AND LEGS OF INSECTS.

These are admirably adapted for their intended service, to give the most convenient and proper motion, and, from the variety in their construction, their various articulations, &c. furnish the microscopic observer with an abundance of curious and interesting objects: the most general number is six; many of the class aptera have eight, as the spider; the crab has ten; the oniscus fourteen; the julus has from seventy to one-hundred and twenty on each side. The legs of those insects that have not more than ten, are affixed to the trunk; while those that exceed that number, have part fixed to the trunk, the rest to the abdomen.

The legs of insects are generally divided into four parts. The first, which is usually the largest, is called the femur; the second, or tibia, is joined to the former, and is commonly of the same size throughout, and longer than the femur; this is followed by the third part, which is distinguished by the name of tarsus, or foot; it is composed of several joints, the one articulated to the other, the number of rings varying in different insects; the tarsus is terminated by the unguis, or claw.

The writers on natural history, in order to render their descriptions clear and accurate, have given several names to the legs of insects, from the nature of the motions produced by them. Thus cursorii, from that of running; these are the most numerous. The saltatorii, those that are used for leaping; the thighs of these are remarkably large, by which means they possess considerable strength and power to leap to great distances. The natatorii, those that serve as oars for swimming; the feet of these are flat and edged with hairs, possessing a proper surface to strike against the water, as in the dytiscus, notonecta, &c. Such feet as have no claws are termed mutici. The chelæ, or claws, are an enlargement of the extremity of the fore feet, each of which is furnished with two lesser claws, which act like a thumb and finger, as in the crab. The under part of the feet in some insects is covered with a kind of brush or sponge, by which they are enabled to walk with ease, on the most polished substances, and in situations from which it would seem they must necessarily fall,

Motion is one of the principal phenomena of nature; it is as it were the soul of our system, and is as admirable in the smallest animal, as in the universe at large. It is the principal agent in producing all that diversity and change which perpetually affect every object in the creation. The motions of animals are proportioned to their weight and structure, a flea can leap to the distance of at least two hundred times its own length; were an elephant, a camel, or an horse to leap in the same proportion, their weight would crush them to atoms. The same remark is applicable to spiders, worms, and other insects; the softness of their texture, and the comparative smallness of their specific gravity, enable them to fall without injury from heights that would prove fatal to larger and heavier animals.*

Many insects can only move the thigh in a vertical direction, while others can move it in a variety of ways. The progressive motion of insects, and the various methods employed to effect it, will be found a very curious and important subject, and well worthy the attention of the naturalist. The intelligent mechanic will not find it lost labour if he bestow some time on the same subject. Very little has been done on this head, and that princi-

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* The parts of some of the larger animals are, however, so admirably constructed for swiftness, as to enable them to perform surprizing acts of agility; for instance, the Siberian jerboa, mus saliens, Pennant; this animal springs forward by successive leaping so very nimbly, that it is said to be very difficult for a man well mounted to overtake it; it is about the size of a large rat. The kanguroo, opossum of Pennant, macropus giganteus, Shaw, leaps to so uncommon a height, and to so great a distance, as to outstrip the swiftest greyhound; its size is that of a full-grown sheep. Accurate coloured figures of both these extraordinary animals are given in that elegant work, the Naturalist's Miscellany. EDIT.

pally by Reaumur, in his excellent Memoires; and by M. Weiss, in a Memoir published in the Journal de Physique for 1771. The reader may also consult Borelli de Motu Animalium.

OF THE TAIL AND STING OF INSECTS.

Cauda, the tail, terminates the abdomen, and is constructed in a wonderful manner for answering the purposes for which it is formed, namely, to direct the motion of the insect, to serve as an instrument of defence, or for depositing the eggs; the figure and size thereof varying in each genus and its families. In most insects it is simple, simplex, and yet capable of being extended or drawn back at pleasure; in others, elongata, elongated, as in the crab and scorpion; setacea, shaped like a bristle, as in the raphidia; triseta, with three appendages like bristles, as in the ephemera; in some it is forked, furcata, as in the podura; and in others it is furnished with a pair of forceps, forcipata, as in the forficula; in the blatta, grylli, and others, it is foliosa, or like a leaf; in the scorpion and panorpa it is telifera, furnished with a dart or sting. Further particulars may be obtained from the Philosophia Entomologica of Fabricius.

Aculeus, or the sting, is an instrument with which insects wound and instil a poison; the sting generally proceeds from the under part of the last ring of the belly: in some it is sharp and pointed, in others serrated or formed like a saw. It is used by many insects both as an offensive and defensive weapon; by others it is only used to pierce the substances where they mean to deposit their eggs. This instrument cannot be properly seen or known, but with the assistance of a microscope.

OF THE STING OF A BEE.

Of bees, it is only the labourers and the queen that have stings. The apparatus is of a very curious construction, fitted for inflicting a wound, and at the same time conveying poison into that wound.

The apparatus consists of two piercers conducted in a sheath, groove, or director.

This groove is rather large at the base, but terminates in a point; it is affixed to the last scale of the upper side of the abdomen by thirteen thin scales, six on each side, and one behind the rectum. These scales inclose the rectum all round, and are attached to each other by thin membranes which allow of a variety of motions; three of them are however attached more closely to a round and curved process, which comes from the basis of the groove in which the sting lies, as also to the curved arms of the sting which spread out externally. The two stings may be said to begin by those two curved processes at their union with the scales, and converging towards the groove at its base, which they enter, and then pass along to its point.

The two stings are serrated or notched towards the points; they can be thrust out a little way, and drawn within it. These parts are all moved by very strong muscles, which give motions in almost all directions, but most particularly outwards. It is wonderful how deep they will pierce solid bodies with this sting.

To perform this by mere force, two things are necessary, power of muscles, and strength of sting; neither of which they seem to possess in a sufficient degree. Mr. J. Hunter thinks that it cannot be by simple force, because the least pressure bends the sting in any direction. It is probable that the serrated edges may assist, by cutting their way like a saw.

The apparatus for the poison consists of two small ducts, which are the glands that secrete the poison; these lie in the abdomen among the air cells, they soon however unite into one oblong bag; at the opposite end of which a duct passes out, which runs towards the angle where the two stings meet, and, entering between them, forms a canal by the union of the two stings at this point. From the serrated construction of the stings the bee can seldom disengage them, and hence, when they pass into materials of too strong a nature, the bee generally leaves them behind, and often a part of the bowels therewith.*

DISTINGUISHING CRITERIA OF INSECTS.

It has already been observed, that the bodies of insects are covered with a hard skin, answering the purpose of an internal skeleton, and forming one of the characters by which they are distinguished from other animals. This external covering is very strong in those insects which, from their manner of life, are particularly liable to great friction, or violent compression; but is more tender and delicate in such as are not so exposed. The skin of insects, like that of larger animals, is porous; the pores in some species are very large; many insects often change or cast off their skin; this exuvia forms an excellent object for the microscope.

Another distinguishing criterion of insects is the colour of their circulating fluid or blood, which is never red; this, at first sight, seems liable to some objections, on account of the drop of red

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* Phil. Trans. for 1792, page 189.

liquor which is often procured from small insects when squeezed or pressed to pieces. It does not appear, however, that this is the blood of the little animal; when it existed as a worm there was no such appearance, and when transformed to the perfect, or fly state, it is only found in the eye, and not in the body, which would be the case if it circulated in the veins of the insect. It is probable there is a circulation of some fluid analogous to the blood in most insects: with the assistance of the microscope this circulation may be perceived in many; but the circulating liquor is not red.

To these discriminating characteristics we may also add the following particulars:

1. That the body of insects is divided by incisuræ, or transversal divisions, from whence they take their name.

2. That they are furnished with antennæ, which are placed upon the fore part of the head; these are jointed and moveable in various directions.

3. That no insect in its perfect state, or after it has gone through all its transformations, has less than six legs, though many have more. There are some moths, whose two fore feet are so small, as scarcely to entitle them to that name.

4. That insects have neither the organs of smell nor hearing; at least they have not as yet been discovered, though it is reported that Fabricius has lately found and described the organs of hearing in a lobster.*

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* That many insects are susceptible of a shrill or loud noise, is a fact so well ascertained, as to be indisputable; but in what manner, or by what organs the sensation is conveyed, is

5. That they do not respire air by the mouth, but that they inspire and exhale it by means of organs which are placed on the body.

6. That they move the jaws from right to left, not up and down.

7. That they have neither eye-lid nor pupil.

To these we may also add, that the mechanism resulting from the LIFE of insects is not of so compound a nature as in animals of a larger size. They have less variety of organs, though some of them are more multiplied; and it is by the number and situation of these that their rank in the great scale of beings is to be determined.

These characters are often united in the same insect; there are, however, some species in which one or two of them are wanting.

The student in entomology, who wishes to attain a proper knowledge of the science, and indeed every microscopic observer,

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not so evident; Barbut, however, supposes them to possess the sense of hearing in a very distinct manner. Many insects, he observes, are well known to be endued with the power of uttering sounds, viz. large beetles, bees, wasps, common flies, gnats, &c. the sphinx atropos squeaks, when hurt, nearly as loud as a mouse: this faculty certainly must be intended for some purpose, and as they vary their cry occasionally, it appears designed to give notice of pleasure or pain, or some affection in the creature which possesses it. "The knowledge of their sounds," says he, "is undoubtedly confined to their tribe, and is a language intelligible to them only; saving when violence obliges the animal to exert the voice of nature in distress, craving compassion; then all animals understand the doleful cry; for instance, attack a bee or wasp near the hive or nest, or a few of them; the consequence will be, the animal or animals, by a different tone of voice will express his or their disapprobation or pain; that sound is known to the hive to be plaintive, and that their brother or brethren require their assistance, and the offending party seldom escapes desirous of availing himself of the discoveries of others, and of communicating intelligibly his own, will find it necessary to make himself conversant with the various classes, genera, &c. into which insects have been divided by Linnæus. Every system has its defects, and probably some may be found in that of this truly celebrated naturalist, but the purpose of science is answered by using those discriminations which are generally adopted.

The following general idea of the Linnæan classes may serve as a foundation for this knowledge: a more particular account may be obtained by consulting the under-mentioned works.

Institutions of Entomology, a translation of Linnæus's Ordines et Genera Insectorum, or systematic arrangement of insects, &c. by Thomas Pattinson Yeats.

Fundamenta Entomologiæ, or an Introduction to the Knowledge of Insects, translated from Linnæus by W. Curtis, the ingenious author of Flora Londinensis, the Botanical Magazine, &c.

The Genera Insectorum of Linnæus, exemplified by various

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with impunity. Now, if they had not the sense of hearing, they could not have known the danger their brother or brethren were in, by the alteration of their tone." Another proof, which he reckons still more decisive, was taken from his observation on a spider, which had made a very large web on a wooden railing, and was at the time in a cavity behind one of the rails, at a considerable distance from the part where a fly had entangled himself; the spider became immediately sensible of it, though, from the situation of the rail, he could not possibly have seen the fly. This observation, however, cannot be considered as conclusive, as it is very probable that the spider was alarmed by the tremulous motion of the threads of the web occasioned by the fluttering of the fly, which he might well know how to distinguish from their vibration by the wind. It is this author's opinion, that the organ of hearing is situated in the antennæ; he likewise supposes that the organs of smell reside in the palpi or feelers. For his reasoning on these subjects, see the Genera Insectorum, Preface, p. vii. & seq. EDIT.

Specimens of English Insects, drawn from Nature, by James Barbut.*

Class the first. COLEOPTERA. The insects of this class have four wings; the upper ones, called the elytra, are crustaceous, being of a hard horny substance; these, when shut, form a longitudinal suture down the back, as in the scarabæus, melolontha, or cockchaffer, &c.

2. HEMIPTERA. These have also four wings; but the elytra are different, being half crustaceous, half membranaceous: the wings do not form a longitudinal suture, but extend the one over the other, as in the gryllus, grasshopper, &c.

3. LEPIDOPTERA. Those which have four membranaceous wings covered with fine scales, appearing to the naked eye like powder or meal, as in the butterfly and moth.

4. NEUROPTERA. These have four membranaceous transparent wings, which are generally reticulated, the tail without a sting, as in the libellula, or dragon fly.

5. HYMENOPTERA. These, like the preceding class, have four membranaceous naked wings; but the abdomen is furnished with a sting, as in the bee, wasp, ichneumon, &c.

6. DIPTERA. These have only two wings, and are furnished with halteres, or poisers, instead of under wings, as in the common house fly, gnat, &c.

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* This work contains two excellent plates, illustrative of the Distinctions of the Ordines and Genera Insectorum, by their antennæ, tarsi of the feet, &c. EDIT.

7. APTERA. These are distinguished by having no wings, as in the spider, louse, acarus, &c.

OF THE TRANSFORMATION OF INSECTS.

Insects are further distinguished from other animals by the wonderful changes that all those of the winged species without exception, and some which are destitute of wings, must pass through, before they arrive at the perfection of their nature. Most animals retain, during their whole life, the same form which they receive at their birth; but insects go through wonderful exterior and interior changes, insomuch that the same individual, at its birth and middle state, differs essentially from that under which it appears when arrived at a state of maturity; and this difference is not confined to marks, colour, or texture, but is extended to their form, proportion, motion, organs, and habits of life.

The ancient writers on natural history were not unacquainted with these transformations, but the ideas they entertained of them were very imperfect and often erroneous. The changes are produced in so sudden a manner, that they seem like the metamorphoses recorded in the fables of the ancients, and it is not improbable that those fables owe their origin to the transformation of insects. It was not till towards the latter end of the last century that any just conception of this subject was formed; the mystery was then unveiled by those two great anatomists Malpighi and Swammerdam, who observed these insects under every appearance, and traced them through all their forms; by dissecting them at the time just preceding their changes, they were enabled to prove that the moth and butterfly grow and strengthen themselves, that their members are formed and unfolded under the figure of the insect we call a caterpillar, and that the growth was effected by a developement of parts; they also shewed that it is not difficult to exhibit in these all the parts of the future moth, as its wings, legs, antennæ, &c. and consequently that the changes which are apparently sudden to our eyes, are gradually formed under the skin of the animal, and only appear sudden to us, because the insect then gets rid of a case which had before concealed its real members. By this case it is preserved from injuries, till its wings, and every other part of its delicate frame are in a condition to bear the impulse of the sun, and the action of the air naked; when all the parts are grown firm, and ready to perform their several offices, the perfect animal appears in the form of its parent. Though these discoveries dissipated the false wonders of the metamorphoses that the world before believed, they created a fund of real admiration by the discovery of the truth. These transformations clearly prove, that without experience every thing in nature would appear a mystery; so much so, that a person unacquainted with the transformation of the caterpillar to the chrysalis, and of this to the fly, would consider them as three distinct species; for who, by the mere light of nature, or the powers of reason unaided by experience, could believe that a butterfly, adorned with four beautiful wings, furnished with a long spiral proboscis or tongue, instead of a mouth, and with six legs, proceeded from a disgusting hairy caterpillar, provided with jaws and teeth, and fourteen feet? Without experience, who could imagine that a long white smooth soft worm hid under the earth, should be transformed into a black crustaceous beetle? Nor could any one, from considering them in their perfect state, have discovered the relation which they bear to the several changes of state, and their corresponding forms, through which they have passed, and which are to appearance as distinct as difference can make them.

The life of those insects which pass through these various changes, may be divided into four principal parts, each of which will be found truly worthy of the utmost attention of the microscopic observer.

The first change is from the EGG into the LARVA, or, as it is more generally called, into the worm or caterpillar. From the LARVA, it passes into the PUPA, or chrysalis state. From the PUPA, into the IMAGO, or fly state.

Few subjects can be found that are more expressive of the extensive goodness of Divine Providence, than these transformations, in which we find the occasional and temporary parts and organs of these little animals suited and adapted with the most minute exactness to the immediate manner and convenience of their existence; which again are shifted and changed, upon the insects commencing a new scene and state of action. In its larva state the insect appears groveling, heavy, and voracious, in the form of a worm, with a long body composed of successive rings; crawling along by the assistance of these, or small little hooks, which are placed on the side of the body. Its head is armed with strong jaws, its eyes smooth, entirely deprived of sex, the blood circulating from the hind part towards the head. It breathes through small apertures, which are situated on each side of the body, or through one or more tubes placed in the hinder part thereof. While it is in the larva state, the insect is as it were masked, and its true appearance concealed; for under this mask the more perfect form is hidden from the human eye. In the pupa, or chrysalis state, the insect may be compared to a child in swaddling cloathes; its members are all folded together under the breast, and inclosed within one or more coverings, remaining there without motion. While in this state, no insects but those of the hemiptera class, take any nourishment. The change is effected various ways; in some insects the skin of the larva opens, and leaves a passage, with all its integuments; in others, the skin hardens and becomes a species of cone, which entirely conceals the insect; others form or spin cones for themselves, and in this state they remain till the parts have acquired sufficient firmness, and are ready to perform their several offices.

The insect then casts off the spoils of its former state, wakes from a death-like inactivity, breaks as it were the inclosures of the tomb, throws off the dusky shroud, and appears in its imago or perfect form; for it has now attained the state of organical perfection, which answers to the rank it is to hold in the corporeal world: the structure of the body, the alimentary organs, and those of motion, are materially changed. It is now furnished with wings magnificently adorned, soars above and despises its former pursuits, wafts the soft air, chooses its mate, and transmits its nature to a succeeding race. Those members, which in the preceding state were wrapped up, soft, and motionless, now display themselves, grow strong, and are put in exercise. The interior changes are as considerable as those of the exterior form, and that in proportion as the first state differs from the last; some organs acquire greater strength and firmness, others are rendered more delicate; some are suppressed, and some unfolded, which did not seem to exist in the former stages of its life.

OF THE LARVA STATE OF INSECTS.

As the larvæ or caterpillars of the moth and butterfly* form the most numerous family among the tribe of insects, I shall first

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* Butterflies are distinguished from moths by the time of their flying abroad, and by their antennæ; the butterflies appear by day, their antennæ are generally terminated by a little knob; the moths fly mostly in the evening, and their antennæ are either setaceous or pectinated.

describe them, and their various changes from this state to their last and perfect form, and then proceed to those insects which differ most from the caterpillar in one or all of their various changes.

The greater part of those insects which come forth in spring or summer, perish or disappear at the approach of winter; there are very few, the period of whose life exceeds that of a year; some survive the rigours of winter, being concealed and buried under ground; many are hid in the bark of trees, and others in the chinks of old walls; some, like the caterpillar of the brown-tailed moth,* at the approach of winter not only secure and strengthen the web in which the society inhabit, and thus protect themselves from impertinent intruders, but each individual also spins a case for itself, where it rests in torpid security, notwithstanding the inclemency of the season, till the spring animates it afresh, and informs it, that the all-bountiful Author of nature has provided food convenient for it. Many that are hatched in the autumn retire and live under the earth during the winter months, but in the spring come out, feed, and proceed onward to their several changes; while no small part pass the colder months in their chrysalis or pupa state: but the greater number of the caterpillar race remain in the egg, being carefully deposited by the parent fly in those places where they will be hatched with the greatest safety and success; in this state the latent principle of life is preserved till the genial influences of the spring call it into action, and bring forth the young insect to share the banquet that nature has provided.

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* This moth was uncommonly numerous and destructive near London in the year 1782, and, aided by the predictions of an empirical imposter, occasioned a considerable alarm in the minds of the ignorant and superstitious. The judicious publication of a short history of the insect, by Mr. Curtis, in some measure contributed to dissipate their fears. EDIT.

All caterpillars are hatched from the egg, and when they first proceed from it are generally small and feeble, but grow in strength as they increase in size. The body is divided into twelve rings; the head is connected with the first, and is hard and crustaceous. No caterpillar of the moth or butterfly has less than eight, or more than sixteen feet; the six first are crustaceous, pointed, and fixed to the three first rings of the body; these feet are the covering to the six future feet of the moth; the other six feet are soft and flexible or membranaceous; they vary both in figure and number, and are proper only to the larva state; with respect to their external figure, they are either smooth or hairy, soft to the touch, or hard like shagreen, beautifully adorned with a great variety of the most lively teints; on each side of the body nine little oval holes are placed, which are generally considered as the organs of respiration. There are on each side of the head of the caterpillar five or six little black spots, which are supposed to be its eyes. These creatures vary in size, from half an inch long to four and five inches.

The caterpillar, whose life is one continued succession of changes, often moults its skin before it attains its full growth; not one of them arrives at perfection, without having cast its skin at least once or twice. These changes are the more remarkable, because when the caterpillar moults, it is not simply the skin that is changed; for we find in the exuvia, the skull, the jaws, and all the exterior parts, both scaly and membranaceous, which compose its upper and under lip, its antennæ, palpi, and even those crustaceous pieces within the head, which serve as a fixed basis to a number of muscles; we further find in the exuvia, the spiracula, the claws, and sheaths of the anterior limbs, and in general all that is visible of the caterpillar.

The new organs were under the old ones as in a sheath, so that the caterpillar effects the changes by withdrawing itself from the old skin, when it finds itself lodged in too narrow a compass. But to produce this change, to push off the old covering, and bring forward the new, is a work of labour and time. Those caterpillars who live in society, and have a kind of nest or habitation, retire there to change their skins, fixing the hooks of the feet, during the operation, firmly in the web of their nest. Some of the solitary species spin at this time a slender web, to which they affix themselves. A day or two before the critical moment approaches, the insect ceases to eat, and loses its usual activity; in proportion as the time of change advances, the colour of the caterpillar becómes more feeble, the skin hardens and withers, and is soon incapable of receiving those juices by which it was heretofore nourished and supported. The insect may now be seen, at distant intervals, to elevate its back, and stretch itself to its utmost extent; sometimes to lift up the head, move it a little from side to side, and then let it fall again; near the change, the second and third rings are seen to swell considerably; by these internal efforts the old parts are stretched and distended as much as possible, an operation which is attended with great difficulty, as the new parts are all weak and tender. However, by repeated exertions, all the vessels which conveyed the nourishment to the exterior skin are disengaged, and cease to act, and a slit is made on the back, generally beginning at the second or third ring; the new skin may now be just perceived, being distinguished by the freshness and brightness of its colour; the caterpillar then presses the body like a wedge into this slit, by which means it is soon opened from the first down to the fourth ring; this renders it large enough to afford the insect a passage, which it soon effects in a very curious manner. Thec aterpillar generally fasts a whole day after each moulting, for it is necessary that the parts should acquire a certain degree of consistency, before it can live and act in its usual manner; many also perish under the operation. The body having grown under the old skin, till the insect was become too large for it, it always appears much larger after it has quitted the exuvia: now as the growth was gradual, and the parts soft, the skin pressed them together, so that they lay in a small space; but as soon as the skin is cast off, they are as it were liberated from their bonds, and distend themselves considerably. Some caterpillars, in changing their skin, from smooth, become covered with fine hair; while others, that were covered with this fine hair, have the last skin smooth.* The silk-worm, previous to its chrysalis or pupa state, casts its skin four times; the first is cast on the tenth, eleventh, or twelfth day, according to the nature of the season; the second, in five or six days after; the third in five or six days more, and the fourth and last in six or seven days after the third.

Before we describe the change of the larva into the pupa state, it will be necessary to give the reader an account of those names by which entomologists distinguish the different appearances of the insect in its pupa state. It it called Coarctata, when it is straitened or confined to a case of a globular form, without the smallest resemblance to the structure of the insect it contains, as in the diptera. It is called Obtecta, disguised or shrouded, when the insect is inveloped in a crustaceous covering, consisting of two parts, one of which surrounds the head and thorax, the other the abdomen. It is termed Incompleta, when the pupa has perceptible wings and feet, but cannot move them, as in most of the hymenoptera. Semicompleta; these can walk or run, but have only the rudi-

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* Valmont de Bomare Dictionnaire Universel d'Histoire Naturelle, vol. ii. 2d edit. 12mo. p. 394.

ments of wings. The difference between the pupa and the larva of this class is very inconsiderable, as they eat, walk, and act, just as they did in their primitive state; the only remarkable difference is a kind of case which contains the wings that are to be developed in their fly state. Completa; those designed by this name take their perfect form at their birth, and do not pass, like other insects, through a variety of states, though they often change their skin.

It is a general rule, that all winged insects pass through the larva and pupa state, before they assume their perfect form: there are also insects which have no wings, and yet undergo similar transformations, as the bed bug, the flea, &c. Other insects, which have no wings, and which always remain without them, never pass through the pupa state, but are subject to considerable changes, as well with respect to the number, as the figure of their parts; thus mites have four pair of feet, and two smaller ones at the fore part of the body, near the head; yet some of these are born with only three pair of feet, the fourth is not perceived till some time after their birth.* The figure of the monoculus quadricornis of Linnæus (Fauna Suecica, edit. Stockholm, 1761, No. 2049) changes considerably after its birth.† The julus is an insect with a great number of feet, some species having an hundred pair and upwards. M. De Geer has given a description of one with more than two-hundred pair,‡ and yet these at their birth have only three pair, the rest are not perceived till some time after.

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* De Geer Memoires pour servir a l'Histoire des Insectes, tom. 1. p. 154.

† Ibid.

‡ Memoires des Scavans etrangers, tom. 3, p. 61.

OF THE CHANGE FROM THE LARVA TO THE PUPA STATE.

I shall now return to the caterpillar, and take notice of the care and provision it makes to pass from the larva state into that of the pupa or chrysalis; which is, in general, a state of imperfection, inactivity, and weakness, through which the insect, when it has obtained a proper size, must pass; and in which it remains often for months, sometimes for a whole year, exposed, without any means of escaping, to every event; and in which it receives the necessary preparations for its perfect state, and is enabled once more to appear upon the transitory scene of time. During its passage from one state to the other, as well as when it is in the pupa form, the microscopical observer will find many opportunities of exercising his instrument.

The transitions of the caterpillar from one state to another, are to it a subject of the most interesting nature; for in passing through them, it often runs the risk of losing its life, that precious boon of heaven, which is ever accompanied with a degree of delight, proportioned to the state in which the creature exists, and the use it makes of the gift it has received. If the caterpillar could therefore foresee the efforts and exertions it must make to put off its present form, and the state of weakness and impotence under which it must exist while in the pupa state, it would undoubtedly choose the most convenient place, and the most advantageous situation, for the performance of this arduous operation; one where it would be the least exposed to danger, at a time when it had neither strength to resist, nor swiftness to avoid the attack of an enemy. All these necessary instructions the caterpillar receives from the influence of an all-regulating Providence, which conveys the proper information to it by its own sensations: hence, when the critical period approaches, it proceeds as if it knew what would be the result of its operations. Different species prepare themselves for the change different ways, suited to their nature and the length of time they are to remain in this state.

When the caterpillar has attained to its full growth, and the parts of the future butterfly are sufficiently formed beneath its skin, it prepares for its change into the pupa state; it seeks for a proper place in which to perform the important business: the different methods employed by these little animals to secure this state of rest, may be reduced to four: 1. Some spin webs or cones, in which they inclose themselves. 2. Others conceal themselves in little cells, which they form under ground. 3. Some suspend themselves by their posterior extremity; 4. While others are suspended by a girdle that goes round their body. I shall describe the variety in these, as well as the industry used in constructing them, after we have gone through the manner in which the caterpillar prepares itself for, and passes through the pupa state.

Preparatory to the change, it ceases to take any food, empties itself of all the excrementitious matter that is contained in the intestines, voiding at the same time the membrane which served as a lining to these and the stomach. The intestinal canal is composed of two principal tubes, the one inserted into the other; the external tube is compact and fleshy, the internal one is thin and transparent; it is the inner tube, which lines the stomach and intestines, that is voided with the excrement before the change. It generally perseveres in a state of rest and inactivity for several days, which affords the external and internal organs that are under the skin an opportunity of gradually unfolding themselves. In proportion as the change into the pupa form approaches, the body is observed often to extend and contract itself; the hinder part is that which is first disengaged from the caterpillar skin; when this part of the body is free, the animal contracts and draws it up towards the head; it then liberates itself in the same manner from the two succeeding rings, consequently the insect is now lodged in the fore part of its caterpillar covering; the half which is abandoned remains flaccid and empty, while the fore part is swoln and distended. The animal, by strong efforts, still forcing itself against the fore part of the skin, bursts the skull into three pieces, and forms a longitudinal opening in the three first rings of the body; through this it proceeds, drawing one part after the other, by alternately lengthening and shortening, swelling and contracting the body and different rings; or else, by pushing back the exuvia, gets rid of its odious reptile form.

The caterpillar, thus stripped from its skin, is what we call the pupa, chrysalis, or aurelia, in which the parts of the future moth are inclosed in a crustaceous covering, but are so soft, that the slightest touch will discompose them. The exterior part of the chrysalis is at first exceedingly tender, soft, and partly transparent, being covered with a viscous fluid; this soon dries up, thickens, and forms a new covering for the animal, capable of resisting external injuries; a case, which is at the same time the sepulchre of the caterpillar, and the cradle of the moth; where, as under a veil, this wonderful transformation is carried on.

The pupa has been called a chrysalis, or creature made of gold, from the resplendent yellow colour with which some kinds are adorned. Reaumur has shewn us whence they derive this rich colour; that it proceeds from two skins, the upper one a beautiful brown, which lies upon or covers a highly polished and smooth white skin: the light reflected from the last, in passing through, gives it the golden yellow, in the same manner as this colour is often given to leather; so that the whole appears gilt, although no gold enters into the tincture. The chrysalis of the common white butterfly furnishes a most beautiful object for the lucernal opake microscope.

Those who are desirous to discover distinctly the various members of the moth in the pupa, should examine it before the forementioned fluid is dried up, when it will be found to be only the moth with the members glued together; these, by degrees, acquire sufficient force to break their covering, and disengage themselves from the bands which confine them. While in this state, all the parts of the moth may be traced out, though so folded and laid together, that it cannot make any use of them; nor is it expedient that it should, as they are too soft and tender to be used, and pass through this state merely to be hardened and strengthened.

To examine the moth concealed under the skin of a caterpillar, one of them should be taken at the last change; when the skin begins to open, it should be drowned in spirit of wine, or some strong liquor, and be left therein for some days, that it may take more consistency and harden itself; the skin of the caterpillar may then be easily removed: the chrysalis, or feeble moth, will be first discovered, after which the tender moth may be traced out, and its wings, legs, antennæ, &c. may be opened and displayed by an accurate observer.

The parts of the moth or butterfly are not disposed exactly in the same manner in the body of the caterpillar, as when left naked in the chrysalis. The wings are longer and narrower, being wound up into the form of a cord, and the antennæ are rolled up on the head; the tongue is also twisted up and laid upon the head, but in a very different manner from what it is in the perfect animal, and different from that which it lies in within the chrysalis; so that it is by a progressive and gradual change, that the interior parts are prepared for the pupa and moth state. The eggs, hereafter to be deposited by the moth, are also to be found, not only in the chrysalis, but in the caterpillar itself, arranged in their natural and regular order.

While in this state, the creature generally remains immoveable, and seems to have no other business but patiently to attend the time of its change, which depends on the parts becoming hard and firm, and the transpiration of that humidity which keeps them soft; the powers of life are as it were absorbed in a deep sleep; the organs of sensation seem obliterated, being imprisoned by coverings more or less strong, the greater part remains fixed in those situations which the caterpillar had selected for them till their final metamorphosis; some, however, are capable of changing place, but their movements are slow and painful.

The time, therefore, which the moth or butterfly remains in the pupa state is not always the same, varying in different species, and depending also upon the warmth of the weather, and other adventitious circumstances; some remain in that situation for a few weeks; others do not attain their perfect form for eight, nine, or eleven months: this often depends on the season in which they assume the pupa form, or rather on the time of their birth. Some irregularities are also occasioned by the different temperature of the air, by which they are retarded or accelerated, so as to be brought forward in the season best suited to their nature and the ends of their existence. I have heard of an instance, where the pupa, produced from caterpillars of the same eggs, nourished in the same manner, and which all spun up within a few days of each other in the autumn, came into the fly state at three different and distant periods; viz. one-third of them the spring following their change, one-third more the succeeding spring, and the remainder the spring after, making three years from their first hatching; a further and manifest proof of the beauty and wisdom of the laws of Divine order, which are continually operating for the best interests of all created beings. As the transformation of insects is retarded by cold, and accelerated by heat, the ordinary period of these changes may sometimes be altered, by placing them in different degrees of heat or cold; by these they may be awakened sooner to a new state of existence, or kept in one of profound sleep.*

There are some caterpillars which remain in their cone eight or nine months before they acquire the complete pupa state; so that their duration in that form is much shorter than it naturally appears to be.

OF THE PREPARATION OF THE CATERPILLAR FOR THE METAMORPHOSES.

The industry of the caterpillar, in securing itself for its change into the chrysalis, must not be passed by; not only because it naturally leads the reader to consider and admire that divine agency, by which the insect is informed, but because the different modes it makes use of cannot be properly investigated, without the assistance of glasses, it therefore consequently becomes a proper subject for the microscope; we shall select from a great variety, a few instances, to animate the reader in these researches.

Some caterpillars, towards the time of their change, suspend themselves from the branch of a tree, with the head downwards; in this position they assume the pupa form, and from thence im-

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* Reaumur Memoires sur les Insectes, tom. 2, mem. 1.

merge a butterfly or moth. In order to secure itself in this position, the insect covers with threads that part of the branch from which it means to suspend itself; it places these in different directions, and then covers them with other threads, laying on several successive thicknesses, each new layer being smaller in size than that which preceded it; forming, when finished, a little cone or hillock of silk, as will be found when examined by the microscope. The caterpillar hooks itself by the hinder feet to this hillock, and when it has found by several trials that it is strongly fixed thereto, throws itself forward, letting the body fall with the head downwards. Soon after it is thus suspended, it bends the fore part of the body, keeping this bent posture for some time, then straitening the body, again in a little time bending it, and so on, repeating this operation till it has formed a slit in the skin upon the back; part of the pupa soon forces itself through this, and extends the slit as far as the last crustaceous feet; the pupa then forces upwards the skin, as we would push down a stocking, by means of its little hooks and the motion of the body, till it has slipped it off to that part from which the caterpillar had suspended itself. But the pupa has still to disengage itself from this small packet, to which the exuvia is now reduced: here the observer will find himself interested for the little animal, anxious to learn how the pupa will quit this skin, and how it will be enabled to fix itself to the hillock, as it has neither arms nor legs. A little attention soon explains the operation, and extricates the observer from his embarrassment. It seizes the exuvia by the rings of the body, and thus holds itself as it were by a pair of pincers; then, by bending the tail, it frees itself from the old skin, and by the same method soon suspends itself to the silken mount; it lengthens out the hinder part of the body, and clasps, by means of its rings, the various foldings of the exuvia, one after another; thus creeping backward on the spoils, till it can reach the hillock with the tail; which, when examined by the microscope, will be found to be furnished with hooks to fix itself by. It is surprizing to see with what exactness and ease these insects perform an operation so delicate and dangerous, which is only executed once in their lives; and nought else can account for it, but the consideration that HE, who designed that the caterpillar should pass through these changes, had provided means for that end, regularly connecting the greater steps by intermediate ones, the desire of extending their species forming and acting upon the organization, till the purposes of their life are completed. Different kinds of these insects require variety in the mode of suspension; some fix themselves in an horizontal position, by a girdle which they tie round their body; this girdle appears to the naked eye as a single thread; when examined with the microscope, it will be found to be an assemblage of fine threads, lying close to each other, so fixed as to support the caterpillar, and yet leave it in full freedom to effect the changes. Like the preceding kind, it fixes the girdle to the branch of a tree; in this situation it remains for some time motionless, and then begins to bend, move, and agitate its body in a very singular manner, till it has opened the exterior covering, which it pushes off and removes much in the same manner as we have described in the preceding article, and yet with such dexterity, that the pupa remains suspended by the same girdle.

OF THE IMAGO OR FLY STATE OF INSECTS.

As soon as the moth acquires sufficient strength to break the bonds which surround it, and of which it is informed by its internal sensations, it makes a powerful effort to escape from its prison, and view the world with new-formed eyes. The moth frees itself from the pupa with much greater ease than the pupa from the caterpillar; for the case of the pupa becomes so dry, when the moth is near the time of throwing off its covering, that it will break to pieces if it be only gently pressed between the fingers; and very few of the parts will be found, on examination, to adhere to the body. Hence, when the insect has acquired a proper degree of solidity, it does not require any great exertion to split the membrane which covers it. A small degree of motion, or a little inflation of the body, is sufficient for this purpose; these motions reiterated a few times, enlarge the hole, and afford the moth room to escape from its confinement. The opening through which they pass is always at the same part of the skin; a little above the trunk, between the wings, and a small piece which covers the head; the different fissures are generally made in the same direction. If the outer case be opened, it is easy to discover the efforts the insect makes to emancipate itself from its shell; when the operation begins, there seems to be a violent agitation in the humours contained in the little animal; the fluids seem to be driven with rapidity through all the vessels, and it is seen to agitate its legs, &c. as it were struggling to get free; these efforts soon break its brittle skin. The loosening the exterior bands of the pupa is not the only difficulty, many moths have to encounter with; it has often also to pierce the cone or case in which it has been inclosed, and that at a time when its members are very feeble, when it is no longer furnished with strong jaws to pierce and cut its way through; but by the regular laws of divine order, means are furnished to every creature of attaining the end for which it was produced: thus, in the present case, some of these insects are provided with a liquor with which they soften and weaken the end of the cone; some leave one end feeble, and close it only with a few threads, so that a slight effort of the head enables the moth to burst the prison doors, and immerge into day.

When the moth first sees the day, it is humid and moist; but this humidity soon evaporates, the interior parts dry and harden, as well as the exterior; the wings, which are wrinkled, being thick and small, then extend themselves, strengthen and harden insensibly, and the fibres which were at first flexible, become hard and stiff; so much so, that Malpighi considered them as bones: in proportion as these fibres harden, the fluid which circulates within them, and extends the wings, loses its force; so that if any extraneous circumstance prevent the motion of this fluid, at the first instant of the moth's escape from its former state, the wings will then become ill-shaped; often expanding with such rapidity, that the naked eye cannot trace their unfolding. The wings, which were scarce half the length of the body, acquire in a few minutes their full size, so as to be nearly five times as large as they were before: nor is it the wings only which are thus increased; all their spots and colours, heretofore so minute as to be scarce discernible, are proportionably extended, so that what before appeared as only so many unmeaning and confused points, become distinct and beautiful ornaments; and those that are furnished with a tongue or trunk, curl and coil it up. When the wings are unfolded, the tongue rolled up, the moth sufficiently dried, and the different members strengthened, it takes its flight. Most of them, soon after they have attained their perfect state, void an excrementitious substance; Reaumur thinks that they eject very little, if any, during the rest of their lives.

In the progress of these insects, such changes take place, as we could have formed no conception of, if the great Author of these wonders had not been pleased to reward the industrious naturalist with the discovery.

If the moth be opened down the belly, and the unctuous parts which fill it, be removed, the gross artery, which has been called the heart, will be visible, and the contractions and dilatations, by which it pushes forward the liquor it contains, may be easily observed. One of the most remarkable circumstances is, that the circulation of this fluid in the moth is directly contrary to that which took place in the caterpillar; in this, the liquor moved from the tail to the head, whereas in the moth, it moves from the head to the tail; so that the fluid which answers the purposes of the blood in the moth, goes from the superior, towards the inferior parts, but in the voracious sensual caterpillar, the order is inverted, it proceeds from the inferior towards the superior parts; all its members, formerly soft, inactive, and folded up under an envelope, are expanded, strengthened, and exposed to observation.

The food of the caterpillar is gross and solid, and even this it is obliged to earn with much labour and danger; but, when freed as it were from the jaws of death, and arrived at its perfect form, the purest nectar is its potion, and the air its element. It was supplied with coarse food, in the first state, by the painful operation of its teeth, which was afterwards digested by a violent trituration of the stomach. The intestines are now formed in a more delicate manner, and suited to a more pure and elegant aliment, which nature has prepared for its use from the most fragrant and beautiful flowers. Many internal parts of the caterpillar disappear in the chrysalis, and many that could not be perceived before, are now rendered visible: the interior changes are not less surprizing than those of the exterior form, and are, properly speaking, creative of them; for it is from these the exterior form originates, and with these it always corresponds. In a word, the creature that heretofore crept upon the earth, now flies freely through the air; and far from creating our aversion by its frightful prickles and foul appearance, it attracts our notice by the most elegant shape and apparel, and, from being scarce able to move from one shrub to another, acquires strength and agility to tower far above the tallest inhabitant of the forest.

OF THE SILK-WORM.

The industry of those that spin cones or cases, in which they inclose themselves, in order to prepare for their transformation in security, is more generally known, as it is from one species of these that we derive so many benefits, namely from the silkworm, whose works afford an ornament for greatness, and add magnificence to royalty. All caterpillars undergo similar changes with it, and many in the butterfly state greatly exceed it in beauty: but the golden tissue, in which the silk-worm wraps itself, far surpasses the silky threads of all the other kinds; they may indeed come forth with a variety of colours, and wings bedecked with gold and scarlet, yet they are but the beings of a summer's day; both their life and beauty quickly vanish, and leave no remembrance after them; but the silk-worm leaves behind it such beneficial monuments, as at once record the wisdom of its Creator, and his bounty to man.*

The substance of which the silk is formed, is a fine yellow transparent gum, contained in two reservoirs that wind about the intestines, and which, when they are unfolded, are about ten inches long; they terminate in two exceeding small orifices near the mouth, through which the silk is drawn, or spun to the degree of fineness which its occasions may require. This apparatus has been compared to the instrument used by wire-drawers, and by which gold and silver is drawn to any degree of minuteness. From each of these reservoirs proceeds a thread, which are united afterwards; so that if it be examined by the microscope, it will be found to consist of two cylinders or threads glued together, with a groove in the middle; a separation may sometimes be perceived.

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* Pullein on the Culture of Silk.

When the silk-worm has found a convenient situation, it sets to work, first spinning some random threads, which serve to support the future superstructure; upon these it forms an oval of a loose texture, consisting of what is called the floss-silk; within this it forms a firm and more consistent ball of silk, remaining during the whole business within the circumference of the spheroid that it is forming, resting on its hinder parts, and with its mouth and fore legs directing and fastening the threads. These threads are not directed in a regular circular form, but are spun in different spots, in an infinite number of zig-zag lines; so that when it is wound off, it proceeds in a very irregular manner, sometimes from one side of the cone, then from the other. This thread, when measured, has been found to be about three-hundred yards long, and so fine, that eight or ten are generally rolled off into one by the manufacturers. The silk-worm usually employs about three days in finishing this cone; the inside is generally smeared with a kind of gum, that is designed to keep out the rain: in this cone it assumes the pupa form, and remains therein from fifteen to thirty days, according to the warmth of the climate. When the moth is formed, it moistens the end of this cone, and by frequent motions of the head loosens the texture of the silk, so as to form a hole without breaking it.

When the silk-worm has acquired its perfect growth, the reservoirs of silk are full, and it is pressed by its sensations to get rid of this incumbrance, and accordingly spins a cone, the altitude and size of which are proportioned to its wants: by traversing backwards and forwards, it is relieved, and attains by an innate desire the end for which it was formed; and thus a caterpillar, whose form is rather disgusting to the human unphilosophic eye, becomes a considerable object of manufacture and trade, a source of wealth, and, from the extensive employment it affords, a blessing to thousands. The size of the cone is not always proportioned to that of the caterpillar; some that are small construct larger cones than others which exceed them in bulk.

There is a caterpillar which forms its silken cone in the shape of a boat turned bottom upwards, whence it is called by Reaumur the "coque en batteau;" the construction is complicated, and seems to require more art than is usually attributed to this insect. It consists of two principal parts, shaped like shells, which are united with considerable skill and propriety; each shell or side is framed by itself, and formed of an innumerable quantity of minute silk rings; in the fore part there is a projection, in which a small crevice may be perceived, which serves, when opened, for the escape of the moth; the sides are connected with so much art, that they open and shut as if framed with springs; so that the cone, from which the butterfly has escaped, appears as close as that which is still inhabited.

Those caterpillars which are not furnished with a silky cone, supply that want with various materials, which they possess sufficient skill to form into a proper habitation, to secure them while preparing for the perfect state; some construct theirs with leaves and branches, tying them fast together, and then strengthening the connection; others connect these leaves with great regularity; many strip themselves of their hairs, and form a mixture of hair and silk; others construct a cone of sand, or earth, cementing the particles with a kind of glue; some gnaw the wood into a kind of saw-dust, and glue it together; with an innumerable variety of modes suited to their present and future state.

OF THE BEETLE.

To make the reader more fully acquainted with a subject which affords such abundant matter for the exercise of his microscope, I shall proceed to describe, in as concise a manner as I am able, the changes of a few insects of different classes, beginning with the beetle.

The beetle is of the first or coleopterous class, having four wings. The two upper ones are crustaceous, and form a case to the lower ones; when they are shut, there is a longitudinal suture down the back: this formation of the wings is necessary, as the beetle often lives under the surface of the earth, in holes which it digs by its own industry and strength. These cases save the real wings from the damage which they might otherwise sustain, by rubbing or crushing against the sides of its abode; they serve also to keep the wings clean, and produce a buzzing noise when the animal rises in the air. The strength of this insect is astonishing; it has been estimated that, bulk for bulk, their muscles are a thousand times stronger than those of a man!

The beetle is only an insect disengaged from the pupa form; the pupa is a transformation in like manner from the worm or larva, and this proceeds from the egg; so that here, as in the foregoing instances, one insect is exhibited in four different states of life, after passing through three of which, and the various inconveniences attendant on them, it is advanced to a more perfect state. When a larva, it trains a miserable existence under the earth; in the pupa form it is deprived of motion, and as it were dead; but the beetle itself lives at pleasure above and under ground, and also in the air, enjoying a higher degree of life, which it has attained by slow progression, after passing through difficulties, affliction, and death.

If we judge of the rank which the beetle holds in the scale of animation, from the places where they are generally found, from the food which nourishes them, from the disgusting and odious forms of many, from their antipathy to light, and their delight in darkness, we shall not form great ideas of the dignity of their situation. But as all things are rendered subservient to the laws of divine order, it is sufficient for us to contemplate the wonders that are displayed in this and every other organ of life, for the reception of which, from the FOUNTAIN AND SOURCE OF ALL LIFE, each individual is adapted, and that in a manner corresponding to the state of existence it is to enjoy, and the energies it is called forth to represent.

The egg of the rhinoceros beetle* is of an oblong round figure, of a white colour; the shell thin, tender, and flexible; the teeth of the worm that is within the shell come to perfection before the other parts; so that as soon as it is hatched, it is capable of devouring, and nourishing itself with the wood among which it is placed. The larva or worm is curiously folded in the egg, the tail resting between the teeth, which are disposed on each side the belly; the worm in proper time breaks the shell, in the same manner as a chicken, and crawls from thence to the next substance suitable for its food. The worm, when it is hatched, is very white, has six legs, and a wrinkled naked body, but the other parts are all covered with hair; the head is then also bigger than the whole body, a circumstance which may be observed in larger animals, and which is founded on wise reasons.† If the egg be observed from time to time while the insect is within it, the beating of the heart may be perceived.

The eggs of the earth-worm, the snail, and the beetle, will afford many subjects for the microscope, and will be found to deserve a very attentive examination. Swammerdam was ac-

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* Scarabæus Acteon, Lin. Syst. Nat. p. 541-3.

† Swammerdam's Book of Nature, pt. 1, p. 33.

customed to hatch them in a dish, covered with white paper, which he always kept in a moist state. To preserve these and similar eggs, they must be pierced with a fine needle; the contained liquors must be pressed out, after which they should be blown up by means of a small glass tube, and then filled with a little resin dissolved in oil of spike.

The worm of the rhinoceros beetle, like other insects in the larva state, changes its skin; in order to effect which, it discharges all its excrement, and forms a convenient hole in the earth, in which it may perform the wonderful operation; for it does not, like the serpent, cast off merely an external covering, but the throat, a part of the stomach, and the inward surface of the great gut, change at the same time their skin: as if it were to increase the wonder, and to call forth our attention to these representative changes, some hundreds of pulmonary pipes cast also each its delicate skin, a transparent membrane is taken from the eyes, and the skull remains fixed to the exuvia. After the operation, the head and teeth are white and tender, though at other times as hard as bone; so that the larva, when provoked, will attempt to gnaw iron. For an accurate anatomical description of this worm, I must refer the reader to Swammerdam; he will find it, like the rest of this author's works, well worthy of his attentive perusal. To dissect it, he first killed it in spirit of wine, or suffocated it in rain water rather more than lukewarm, not taking it out from thence for some hours. This preparation prevents an improper contraction of the muscular fibres.

When the time approaches for the worm to assume the pupa form, it generally penetrates deeper into the ground,* or those

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* The larvæ of those beetles which live under ground are in general heavy, idle, and voracious; on the contrary, the larvæ which inhabit the waters are exceedingly active.

places where it inhabits, to find a situation that it can more easily suit to its subsequent process. Having found a proper place, it forms with the hinder feet a polished cavity, in this it lies for sometime immoveable; after which, by voiding excrementitious substances, and by the evaporation of humidity, it becomes thinner and shorter, the skin more furrowed and wrinkled, so that it soon appears as if it were starved by degrees. If it be dissected about this period, the head, the belly, and the thorax may be clearly distinguished. While some external and internal parts are changing by a slow accretion, others are gently distended by the force of the blood and impelled humours. The body contracting itself, while the blood is propelled towards the head, forces the skull open in three parts, and the skin in the middle of the back is separated, by means of an undulating motion of the incisions of the back; at the same time the eyes, the horns, the lips, &c. cast their exuvia. During this operation, a thin watery humour is diffused between the old and new skin, which renders the separation easier. The process going on gradually, the worm is at last disengaged from its skin, and the limbs and parts are, by a continual unfolding, transformed into the pupa state; after which, it twists and compresses the exuvia by the fundament, and throws it towards the hinder part under the belly. The pupa is at this time very delicate, tender, and flexible; and affords a most astonishing appearance to an attentive observer. Swammerdam thinks it is scarce to be equalled among the wonders which are displayed in the insect part of the creation; in it the future parts of the beetle are finely exhibited, so disposed and formed, as soon to be able to serve the creature in a more perfect state of life, and to put on a more elegant form.

The pupa * of this insect weighs, a little after its change, much heavier than it does in its beetle state; this is also the case with

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* Swammerdam's Book of Nature, p. 144.

the pupa of the bee and hornet. The latter has been found to weigh ten times as much as the hornet itself; this is probably occasioned by a superabundant degree of moisture, by which these insects are kept in a state of inactivity, which may be compared to a kind of preternatural dropsy, till it is in some measure dissipated; in proportion as this moisture is evaporated, the skin hardens and dries: some days are required to exale this superfluous moisture. If the skin be taken off at this time, many curious circumstances may be noted; but what claims our attention most is, that the horn, which is so hard in the male beetle when in a state of maturity, that it will bear to be sharpened against a grindstone,* in the pupa state is quite soft, and more like a fluid than a solid substance. How long the scene of mutation continues is not known; some remain during the whole winter, more particularly those which quit the larva state in autumn, when a sudden cold checks their further operations, and consequently they remain in a torpid state, without any food, for several months. Some species of the beetle tribe go through all the stages of their existence in a season, while others employ near four years in the process, and live as winged insects a year..

When the proper time for the final change arrives, all the muscular parts grow strong, and are thus more able to shake off their last integuments, which is performed exactly in the same manner as in the passage of the insect from the larva to the pupa state; so that in this last skin, which is extremely delicate, the traces of the pulmonary tubes, that have been pulled off and turned out, again become visible.. All parts of the insect, and more particularly the wings and their cases, are at this period swelled and extended by the air and fluids which are driven into them through the arteries and pulmonary tubes; the wings are

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* Mouffet, p. 152.

now soft as wet paper, and the blood issues from them on the least wound; but when they have acquired their proper consistency, which in the elytra is very considerable, they do not exhibit the least sign of any fluid within them, though cut or torn almost asunder. The pupa being disengaged from its skin, assumes a different form, in which it is dignified with the name of a beetle, and acquires a distinction of sex, being either male or female. The insect now begins to enjoy a life far preferable to its former state of existence; from living in dirt and filth, under briars and thorns, it raises itself towards the skies, plays in the sun-beam, rejoices in its existence, and is nourished with the oozing liquors of flowers.

OF THE MUSCA CHAMÆLEON.

I shall now proceed to illustrate the nature of the different transformations in insects, by giving an account of the musca chamæleon. In the worm or larva condition it lives in the water, breathes by the tail, and carries its legs within a little snout near its mouth. When the time arrives for its pupa state, it goes through the change without casting off the skin of the larva. Lastly, in the imago, or fly state, it would infallibly perish in the water, that element which had hitherto supplied it with life and motion, was not the larva by nature instructed where to choose a suitable situation for its approaching transformation.

This insect is characterized by Linnæus as "Musca chamæleon. Habitat larva in aquis dulcibus; musca supra aquam obambulare solet." In a former edition of the Fauna Suecica he called it oestrus aquæ; but on a more minute examination, he found it was a musca; besides, the larvæ of all known oestri are nourished in the bodies of animals. The larva of this insect appears to consist of twelve annular divisions, see Plate XI. Fig. 1. by these it is separated into a head, thorax, and abdomen; but as the stomach and intestines lie equally in the thorax and abdomen, it is not easy to distinguish their limits until the insect approaches the pupa state. The parts most worthy of notice are the tail and snout. The tail is furnished with an elegant crown or circle of hair b, disposed quite round it in an annular form; by means of this the tail is supported on the surface of the water, while the worm or larva is moving therein, the body in the mean while hanging towards the bottom; it will sometimes remain in this situation for a considerable time, without the least sensible motion. When it is disposed to sink to the bottom by means of its tail, it generally bends the hairs of that part towards each other in the middle, but much closer towards the extremity; by these means a hollow space is formed, and the bladder of air pent up in it looks like a pearl, Fig. 2. Plate XI. It is by the assistance of this bubble, or little balloon, that the insect raises itself again to the surface of the water. If this bubble escape, it can replace it from the pulmonary tubes; sometimes large quantities of air may be seen to arise in bubbles from the tail of the worm to the surface of the water, and there mix with the incumbent atmosphere. This operation may be easily seen by placing the worm in a glass full of water, where it will afford a very entertaining spectacle. The snout is divided into three parts, of which that in the middle is immoveable; the two other parts grow from the sides of the former; these are moveable, vibrating in a very singular manner, like the tongues of lizards and serpents. The greatest strength of the creature is fixed in these lateral parts of the snout; it is on these that it walks when it is out of the water, appearing, as it were to walk on its mouth, using it to assist motion, as a parrot does its beak to climb, with greater advantage.

We shall now consider the external figure of this worm, as it appears with the microscope. It is small toward the head, larger about those parts which may be considered as the thorax; it then again diminishes, converging at the abdomen, and terminates in a sharp tail, surrounded with hairs in the form of the rays of a star.

This worm, the head and tail included, has twelve annular divisions, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, Fig. 3. Plate XI. Its skin resembles the covering of those animals that are provided with a crustaceous habit, more than it does that of naked worms or caterpillars; it is moderately hard, and like the rough skin called shagreen, being thick set with a number of grains, evenly distributed. The substance of the skin is firm and hard, and yet very flexible. On each side of the body are nine spiracula or holes, for the purpose of respiration; there are no such holes visible on the tail ring *a*, nor on the third ring counting from the head; for at the extremity of the tail there is an opening for the admission and expulsion of air; in the third ring the spiracula are very small, and appear only under the skin, near the place where the embryo wings of the future fly are concealed. It is remarkable that caterpillars, in general, have two rings without these spiracula; perhaps, because they change into flies with four wings, whereas this worm produces a fly that has only two. The skin has three different shades of colour; it is adorned with oblong black furrows, with spots of a light colour, and orbicular rings, from which there generally springs a hair, as in the figure before us, only the hair that grows on the insect's side is represented; besides this, there are here and there some other larger hairs, c c. The difference of colour in this worm arises from the quantity of grains in the same space; for in proportion as there is a greater or lesser quantity of these, the furrows and rings are of a deeper or paler colour. The head *d* is divided into three parts, and covered with a skin, the grains on which are hardly discernible. The eyes are rather protuberant, and lie forwards near the snout. It has also two small horns i i, on the fore part of the head. The snout is crooked, and ends in a sharp point as at f; but what is altogether singular and surprizing, though no doubt wisely contrived by the great and almighty Architect, is, that this insect's legs are placed near the snout, between the sinuses, in which the eyes are fixed. Each of these legs consists of three joints, the outermost of which is covered with hard and stiff hairs like bristles. From the next joint there springs a horny bone h h, which the insect uses as a kind of thumb; the joint is also of a black substance, between bone and horn in hardness; the third joint is of the same nature. To distinguish these particulars, the parts that form the upper sides of the mouth and the eyes must be separated by means of a small fine knife; you may then, by the assistance of the microscope, perceive that the leg is articulated, by means of some particular ligaments, with that portion of the insect's mouth which answers to the lower jaw in the human frame. We may then also discern the muscles which serve to move the legs, and draw them up into a cavity that lies between the snout and those parts of the mouth which are near the horns i i.

This insect not only walks with these legs at the bottom of the water, but even moves itself on land by means of them; it likewise makes use of them to swim, while it keeps its tail on the surface contiguous to the air, and hangs downward with the rest of the body in the water: in this situation no motion is perceived in it, but what arises from its legs, which it moves in a most elegant manner. It is reasonable to conclude from what has been said, that the principal part of the creature's strength lies in these legs; nor will it be difficult for those who are acquainted with the nature of the ancient hieroglyphics, which are now opening so clearly, to fix the rank of this insect in animated life, and point out those orders of being, and the moral state through which it receives its form and habits of life.

The snout is black and hard, the back part is quite solid, and somewhat of a globular form, whereas the front f, is sharp and hollow; on the back part three membranaceous divisions may be observed, by means of which, and the muscles contained in the snout, the insect can at pleasure expand or contract it.

The tail is constructed and planned with great skill and wisdom. The extreme verge or border, is surrounded by thirty hairs, and the sides adorned with others that are smaller; here and there the large hairs branch out into smaller ones, which may be reckoned as single hairs. These hairs are all rooted in the outer skin, which in this place is covered with rough grains, as may be seen by cutting it off, and holding it up, when dry, against the light, upon a thin plate of glass. By the same mode you will find, that at the extremities of the hairs there are also grains like those of the skin; in the middle of the tail there is a small opening, within it are minute holes, by which the insect inhales and expels the air it breathes. The hairs are very seldom disposed in so regular a manner as they are represented in Fig. 3. Plate XI. except when the insect floats with the body in the water, and the tail with its hairs a little lower than the surface, for they are then displayed exactly as delineated in the plate. The least motion downward of the tail produces a concavity in the water, and it then assumes the figure of a wine-glass, wide at the top, narrow at the bottom. The tail serves the larva both for the purposes of swimming and breathing, and it receives through the tail that which is the universal principle of life and motion in animals. By means of the hairs it can stop itself at pleasure when swimming, or remain suspended quietly in the water for any length of time. The motion of the insect in swimming is very beautiful, especially when it advances with its whole body floating on the surface of the water; after filling itself with air by the tail. To set out, it first bends the body to the right or left, and then contracts it in the form of the letter S, and again stretches it out in a strait line: by thus alternately contracting and then extending the body, it moves along on the surface of the water. It is of a very quiet disposition, and not to be disturbed by handling.

These larvæ are generally to be found in shallow standing waters, about the beginning of June, sooner or later, as the summer is more or less favourable; in some seasons they are to be found in great numbers, while in others, it is no easy matter to meet with them. They love to crawl on the plants and grass which grow in the water, and are often to be met with in ditches, floating on the surface of the water by means of their tail, the head and thorax at the same time hanging down; and in this situation they will turn over the clay and dirt with their snout and feet in search of food, which is generally a viscous matter that is common in small ponds and about the sides of ditches. This worm is very harmless, contrary to the opinion one might form at first sight, from the surprizing vibratory motion of the legs, which resembles the brandishing of an envenomed tongue or sting. They are most easily killed for dissection in spirit of turpentine.

After a certain period they pass into the pupa form; when they are about to change, they betake themselves to the herbs that float on the surface of the water, and creep gently thereon, till at length they lie partly on the dry surface, and partly on the water; when in the larva or pupa state, they can live in water, but can by no means inhabit there when changed into flies: indeed, man also, whilst in the uterus, lives in water, which he cannot do afterwards. When these worms have found a proper situation, they by degrees contract themselves, and in a manner scarce perceptible lose all power of motion. The inward parts of the worm's tail now separate from the outmost skin, and become greatly contracted; this probably gives the insect considerable pain: by this contraction, an empty space is left in the exterior skin, into which the air soon penetrates.

Thus this insect passes into the pupa state under its own skin, entirely different from that of the caterpillar, which casts off the exterior skin at this time; this change may often be observed to take place in the space of ten or twelve hours, but in what manner it is performed we are ignorant, as it is effected in a hidden unknown way, inwardly within the skin, which conceals it from our view.

Whilst the larva is changing under the skin, the body, head, and tail, separate insensibly from their outward vesture. The legs at this time, and their cartilaginous bones, are, on account of the parts which are withdrawn from them, left empty; the worm loses also now the former skull, the beak, together with the horny bones belonging thereto, which remain in the skin of the exuvia. It is worthy of notice, that the optic nerves separate also from the eyes, and no more perform their office. The muscles of the rings in like manner, and a great part of the pulmonary points of respiration, are separated from the external skin. Thus the whole body contracts itself by degrees into a small compact mass. At this time the gullet and the pulmonary tubes cast a coat within the skin. To make this evident, it is necessary to open the abdomen, when the pupa, its parts, together with the cast off pulmonary pipes, may be clearly seen.

An exact account of all the changes of the interior parts is to be found in Swammerdam's Book of Nature. These changes are best examined by taking the pupa out of the skin, or outside case, when it begins to harden; for as it has not then quite attained the pupa form, and the members are somewhat different from what they will be when in that state, it is more easy to observe their respective situation, than when the pupa is some days older, and has lost the greatest part of the superfluous humours. The pupa is inclosed in a double garment; the interior one is a thin membrane, which invests it very closely; the other, or exterior one, is formed of the outermost hard skin of the larva, within which it performs its changes in an invisible manner: it is this skin which gives it the appearance of the larva while in the pupa state.

When the time approaches that the hidden insect, now in the pupa form within its old covering, is to attain the imago, fly, or perfect state, which generally happens in about eleven days after the preceding change, the superfluous humours are evaporated by insensible perspiration. The little pupa is contracted into the fifth ring of the skin, and the four last rings of the abdomen are filled with air, through the aperture in the respiratory orifice of the tail. This may be seen by exposing the pupa for a short space to the rays of the sun, and then putting its tail in water, when you will find it breathe stronger than it did before, and, by expressing an air bubble out of its tail, and then sucking it in again, will manifestly perform the action of inspiration and expiration. the anterior part of the pupa is drawn back from the skin, and having partly deserted it, with the beak, head, and first ring of the breast, the little creature lies still, until its exhaling members have acquired strength to burst the two membranes which surround it.

If the exterior case be opened near this period, a wonderful variety of colour may be perceived through the thin skin which invests the pupa. The colours of many of the different parts are now changed; some parts from aqueous become membranaceous, some fleshy, and others crustaceous. The whole body becomes insensibly shaggy, the feet and claws begin to move: the variations may be accurately observed by opening a pupa every day until the time of change. For this purpose they should be laid on white paper in an earthen dish; they should also be made somewhat moist, and be kept under a glass: the paper serves the pupa to fix its claw to, when they come forth in the form of a fly. A little water should be poured into the dish, to keep the pupa from drying and suffocation.

When the fly begins to appear, the exterior skin is seen to move about the third and fourth anterior ring; the insect then uses all its efforts to promote its escape, and to quit the interior and exterior skin at one and the same time. The exterior skin is divided into four parts; the insect immediately afterwards breaks open its inner coat, and casting it off, escapes from the prison in which it was entombed, in the form of a beautiful fly. It is to be observed here, that there is nothing accidental in the breaking of the outermost skin, being perfectly conformable to the rule ordained, always happening in the same manner in all these changes: the skin also is, in those places where it is broke open, so constructed by the Author of nature, as if joined together by sutures. Having now acquired its perfect state, the little creature which lived before in water and mud, enters into a new scene of life, visits the fields and meadows, is transported through the air on its elegant wings, and sports in the wide expanse with unrestrained jollity and freedom.

The larva a queue de rat,* musca pendula, Lin. is also transformed under the skin, which hardens, and forms a case or general covering to the pupa: two horns are pushed out, while it is in this state, from the interior parts; they serve the purpose of respiration: this larva will be more particularly described in a subsequent part of this chapter.

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* Reaum. 8vo. edit. tom. 4, pt. 2, 11 mem. p. 199, plate 30 and 31.

According to Reaumur, the insects in this class, that is, those that pass into the pupa state under the skin of the larva, go through a change more than the caterpillar, a transformation taking place while under their skin, before they assume the pupa form.

The aquatic larva of the musca chamæleon retains its form to the last; but there are many insects that are transformed under their skin, which forms a cone or case for the pupa. In these the larva loses first its length; the body becoming shorter, assumes the figure of an egg; and the skin forms a hard and crustaceous case or solid lodging for the embryo insect.

OF THE LIBELLULA OR DRAGON FLY.

In the libellula we have an instance of those insects which are termed in the pupa state, semicompleta, that is, such as proceed from the egg in the figure which they preserve till the time arrives for assuming their wings; and who walk, act, and eat as well before that period as afterwards.

Of all the flies which adorn or diversify the face of nature, there are few, if any, more beautiful than the libellulæ: they are almost of all colours, green, blue, crimson, scarlet, and white; some unite a variety of the most vivid teints, and exhibit in one animal more different shades than are to be found in the rainbow. It is not to colour alone that their beauty is confined, it is heightened by the brilliancy of their eyes, and the delicate texture and wide expansion of their wings. The larva of the libellula is an inhabitant of the water, the fly itself is generally found hovering on the borders thereof.

These insects are produced from an egg, which is deposited in the water by the parent; the egg sinks to the bottom, and remains there till the young insect finds strength to break the shell. The larva is hexapode, and is not quite so long as the fly; on the trunk are four prominences or little bunches, which become more apparent, in proportion as the larva increases in size and changes its skin. These bunches contain the rudiments of the wings, which adorn the insect when in its perfect state.

The head of the larva is exceedingly singular, the whole fore part of it being covered with a mask, which fits it more exactly than the common mask does the human face, having proper cavities within to suit the different prominences of the face; it is of a triangular form, growing smaller towards the bottom; at this part there is a knuckle which fits a cavity near the neck, on this it turns as on a pivot. The upper part of this mask is divided into two pieces or shutters, which the insect can open or close at pleasure; it can also let down the whole mask whenever it pleases. The edges of the shutters are jagged like a saw. It makes use of the mask to seize and hold its prey. There is a considerable difference in the shape of these masks in different species of the libellula, some having two claws near the top of it, which they can thrust out or draw in, as most convenient; these render it a very formidable instrument to the insects on which they feed.

These animals generally live and feed at the bottom of the water, swimming only occasionally: their manner of swimming, or rather moving in the water; is curious, being by sudden jerks given at intervals; but this motion is not occasioned by their legs, which at this time are kept immoveable and close to the body; it is by forcing out a stream of water from the tail that the body is carried forward; this may be easily perceived, by placing them in a flat vessel, in which there is only just water enough to cover the bottom. Here the action of the water squirted from their tail will be very visible; it will occasion a small current, and give a sensible motion to any light bodies that are lying on the surface thereof. This action can only be effected at intervals, because after each expulsion the insect is obliged to inhale a fresh supply of water. The larva will sometimes turn its tail above the surface of the water, and eject a small stream from it as from a little fountain, and that with considerable force.

The pupa differs but very little from the larva, the bunches containing the wings grow large, and begin to appear like four short thick wings. It is full as lively as the larva, seeking and enjoying its food in the same manner: when it is arrived at its full growth, and is nearly ready to go through its last change, it approaches the edge of the water, or comes entirely out of it, fixing itself firmly to some piece of wood or other substance, by its acute claws. It remains for some time immoveable; the skin then opens down the back, and on the head; through this opening is exhibited the real head and eyes, and at length the legs; it then creeps gradually forward, drawing its wings, and then the body out of the skin. The wings, which are moist and folded, now expand themselves to their real size; the body is also extended till it has gained its proper dimensions, which extension is accomplished by the propelling force of the circulating fluids. When the wings and limbs are dry, it enters on a more noble state of life: in this new scene it enjoys itself to the fullest extent, feasts on the living fragrance issuing from innumerable openings, sports and revels in delight, and, having laid the foundation for its future progeny, sinks into an easy dissolution.

The dragon fly is of a ferocious and warlike disposition, hovering in the air like a bird of prey, in order to feed on and destroy every species of fly; its appetite is gross and voracious, not confining itself to small flies only, but the large flesh-fly, moths, and butterflies, are equally subjected to its tyranny. It frequents marshy grounds, where insects mostly abound.

The female of the CYNIPS OR GALL INSECT, which has no wings, passes through no transformation; while the male, which has four wings, passes through the pupa state before it becomes a fly. The only change, though a considerable one, which takes place in the female gall insect, is this, that after a certain time it fixes itself to the branch of a tree, without being able to detach itself; it afterwards increases much in size, and becomes like a true gall; the female, by remaining thus fixed for the greater part of her life, to the place where she was first seen, has very little the appearance of an animal; it is in this period of their life that they grow most and produce their young, while they appear a portion of the branch they adhere to; and what is more singular, the larger they grow, the less they appear like animals, and whilst they are employed in laying thousands of eggs, seem to be nothing but mere galls. The genera of gall insects are very extensive; they are to be found on almost every shrub and tree.

The APHIDES OR PLANT LICE, to arrive at their respective state, pass through that of the semicomplete pupa, and their wings do not appear till they have quitted their pupa state; but as in all the families of the pucerons there are many which never become winged, we must not forget to observe, that these undergo no transformation, remaining always the same, without changing their figure, though they increase in size and change their skin. It is remarkable, that amongst insects of the same kind, some individuals should be transformed, while others are not at all changed. These insects will be considered more fully in another part of this chapter.

Reaumur* has shewn that the SPIDER FLY, hyppobosca equina, Lin. lays so large an egg, that the fly which proceeds from it is as big as the mother, though the egg does not increase the least in size from the time it is first laid. The insect proceeds also from the egg in the imago or fly state; it is probably transformed in the egg, for Reaumur has found it in the pupa state therein, and having boiled some of their eggs which had been laid for some days, he found the insect in the form of an oval ball, similar to that in which the pupa of flies with two wings are generally found. De Geer is of opinion that the egg itself is a true larva, which, when it is born, has only to disengage its limbs, &c. from the shell which covers it; and he thinks this the more probable, because there is no embryo seen in this egg, but it is entirely filled with the insect; he has also perceived a contracting and dilating motion in the egg, while it was in the belly of the mother, and immediately after it was laid; circumstances which do not agree with a simple egg.

As M. Bonnet † has attempted to give a theory of these various changes, the following extract from it will, I hope, prove agreeable to the reader; it will at least tend to render his ideas of this wonderful subject clearer, and will probably open to his mind many new sources of contemplation.

An insect that must cast off its exuvia, or moult five times before it attains the pupa state, may be considered as composed of five organized bodies, inclosed within each other, and nourished

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* Reaumur, tom. 6, mem. 14.

† Bonnet Considerations sur les Corps organises. Contemplation of Nature, &c.

by common viscera, placed in the center: what the bud of the tree is to the invisible buds it contains, such is the exterior part of the caterpillar to the interior bodies it conceals in its bosom. Four of these bodies have the same essential structure, namely, that which is peculiar to the insect in its larva or caterpillar state: the fifth body is that of the pupa. The respective state of these bodies is in proportion to their distance from the center of the animal; those that are farthest off have most consistence, or unfold themselves soonest. When the exterior body has attained its full growth, that interior one which is next in order is considerably unfolded; it is then lodged in too narrow a compass, therefore it stretches on all sides the sheath which covers it; the vessels which nourish the external covering, are broken by this violent distension, and ceasing to act, the skin wrinkles and dries up; at length it opens, and the insect is cloathed with a new skin, and new organs. The insect generally fasts for a day or two preceding each change; this is probably occasioned by the violent state in which it then is, or it may be necessary to prevent obstructions, &c. let this be as it may, the insect is always very weak after it has changed its skin, the parts being as yet affected by the exertions they have gone through. The scaly parts, as the head and legs, are almost entirely membranaceous, and imbrued with a fluid that insinuates itself between the two skins, and thus facilitates their separation; this moisture evaporates by degrees, all the parts acquire a consistence, and the insect is then in a condition to act.

The first use that some caterpillars which live on leaves make of their new form, is to devour greedily their exuvia: sometimes they do not wait till their jaws have acquired their full strength; some have been seen to gnaw the shell from which they proceeded, and even the eggs of such caterpillars as have not been hatched.

When we have once formed the idea that all the exterior parts are inlaid, or included one within the other, the production of new organs does not appear so embarrassing, being nothing more than a simple developement; but it is more difficult to form any conception of the changes that happen in the viscera before and after the transformation, the various modifications they undergo eluding our researches. We have already observed, that a little before the change the caterpillar rejects the membrane that lines the intestinal bag: this bowel has hitherto digested only gross food, whereas it must hereafter digest that which is very delicate: a fluid that circulates in the caterpillar from the hind part towards the head, circulates a contrary way after transformation. Now if this inversion is as real as observation seems to indicate, how amazing the change the interior parts of the animal must have undergone? When the caterpillar moults, small clusters of the tracheal vessels are cast off with the exuvia, and new ones are substituted in their room; but how is this effected, and how are the lungs replaced by other lungs? The more we endeavour to investigate this subject, the more we find it is enveloped in darkness.

Whilst the powers of life are employed conformable to the laws of Divine Providence, to change the viscera, and give them a new form, they are also unfolding divers other organs, which were useless to the insect while in the larva state, but which are necessary to that which succeeds. That these interior operations of life may be carried on with greater energy, the animal is thrown into a kind of sleep; during this period, the corpus crassum is distributed into all the parts, in order to bring them to perfection, while the evaporation of the superfluous humours makes way for the elements of the fibres to approach each other, and unite more closely. The little wounds in the inside, which have been occasioned by the rupture of the vessels, are gradually consolidated; those parts which had been violently exercised, recover their tone, and the circulating fluids insensibly find their new channel. Lastly, many vessels are effaced, and turned into a liquid sediment, which is rejected by the perfect insect.

When these various changes are considered, we are surprized at the singularity of the means the AUTHOR OF NATURE has made choice of, in order to bring the different species of animals to perfection; and are apt to ask, why the caterpillar was not born a moth? why it passes through the larva and pupa state? why all insects that are transformed do not undergo the same change? These, and a variety of questions that may be started concerning the constituent substances of those existences which appear before us, derive their solution from the general system which is unknown to us. If all were to arrive at perfection at once, the chain would be broken, the creature unhappy, and man most of all. Let us also consider what riches we should have been deprived of, if the silk-worm had been born in its perfect state.

Amongst insects, some are produced in the state in which they will remain during their whole lives; others come forth inclosed in an egg, and are hatched from this into a form that admits of no variation; many come into the world under a form which differs but little from that which they have when arrived at an age of maturity; some again assume various forms, more or less remote from that which constitutes their perfect state; lastly, some go through part of these transformations in the body of the parent, and are born of an equal size with them. By these various changes, a single individual unites within itself two or three different species, and becomes successively the inhabitant of two or three worlds: and how great is the diversity of its operation in these various abodes!

Since it has been shewn that the larva or caterpillar is really the moth, crawling, eating, and spinning, under the form of the worm, and that the pupa is only the moth swathed up, it is clear that they are not three beings, but that the same individual feels, tastes, sees, and acts by different organs, at different periods of its life, having sensations and wants at one time, which it has not at another; these always bearing a relation to the organs which excite them.

OF THE RESPIRATION OF INSECTS.

As respiration is one of the most important actions in the life of every animal, great pains have been taken by many naturalists to investigate the nature of this action in insects; to prove its existence, and explain in what manner it is carried on. Malpighi, Swammerdam, Reaumur, and Lyonet have discovered in the caterpillar two air-vessels placed the whole length of the insect, these they have called the tracheæ; they have also shewn that an infinite number of ramifications proceed from these, and are dispersed through the whole body; that the tracheal vessels communicate with particular openings on the skin of the caterpillar, termed spiracula; there are nine of these on each side of the body. These vessels seem calculated for the reception of air; they contain no fluids, are of a cartilaginous nature, and when cut preserve their figure, and exhibit a well-terminated opening. Notwithstanding this discovery, respiration has not been proved to exist in many species of insects, and the mechanism thereof is very obscure in all; nor is the absence of it more surprising in the caterpillar or embryo state of insects, than in that of other animals, where we find that respiration is by no means necessary to existence previous to their birth, though indispensably so afterwards.

Reaumur thought that the air entered by the spiracula into the trachea, but was not expelled by the same orifice, and consequently that the respiration of insects was carried on in a manner totally different from that of other animals; that the air was expired through a number of small holes or pores which are to be found in the skin of the caterpillar, after having been conducted to them through the extremities of the finer ramifications of the tracheal vessels; whereas Bonnet, in consequence of a great variety of experiments, supposed that the inspiration and expiration of the air was through the spiracula, and that there was no expiration of air through the pores of the skin. These experiments were made either by plunging the caterpillars into water, or anointing them with fat and greasy substances, some all over, others only partially. The number of small bubbles which are observed to cover the surface of their bodies, when they are immerged in water, does not arise from the air which is included within, and then proceeding from them, but they are formed by the air which is lodged near the surface of their bodies, in the same manner that it is about all other substances. To render the experiments more accurate, and prevent the air from adhering to the skin, before he plunged the caterpillars in water he always brushed them over with an hair pencil; after this, very few air bubbles were found on their bodies when immerged in water. Caterpillars will remain a considerable time under water, without destroying the principle of life; and they also recover, in general, soon after they are taken out. To know whether a few only of the spiracula might not be sufficient for the purposes of respiration, he plunged some partially in water, so that only two or more spiracula remained in the open air: in these cases the caterpillar did not become torpid as it did when they were all immerged in water. One caterpillar, upon which Bonnet made his experiments, lived eight days suspended in water, with only two of its anterior spiracula in the air; during this time he observed, that when the insect moved itself, little streams of bubbles issued from the anterior spiracula on the left side; from this, and many other experiments, it appeared to him, that amongst all the eighteen spiracula, the two anterior and the two posterior are of the greatest use in respiration.* Sometimes when the apertures of these have been stopped with oil, the caterpillar has fallen into convulsions. If the posterior part had been oiled, that part became paralytic. Notwithstanding these experiments, and many more which have been made, the subject is far from being decided, and many still doubt whether there is any respiration in insects similar to ours, at least at certain periods of their life. This opinion seems to be further confirmed by the experiments of M. Lyonet. He confined several large musk beetles under a glass for more than half an hour, exposed to the fumes of burning sulphur; and, though during their continuance there the vapour was so thick that he could not see them, yet on their being liberated, they did not seem at all effected thereby.†

Supposing respiration to be absolutely necessary to the existence of the pupæ of different insects, when we reflect on the great solidity of their cases or cones, it is not easy to conceive how they can live several months under the earth, in spaces so confined, and almost impervious to the air: and indeed if they did respire, the same situation seems to preclude a continuance of the operation, as the air would soon be corrupted, and unfit for the offices of life. As the tracheæ are divided and subdivided to a prodigious degree of minuteness, it has been conjectured by

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* Philos. Trans. vol. xlv. p. 300.

† Lesser Theologie des Insectes, tom. 1, p. 124. Ibid. p. 126.

some writers, that they may act as so many sieves, which, by separations properly contrived, filtrate the air, and so furnish it to the body of different degrees of purity and subtilty, agreeable to the purposes and nature of the various parts. The experiments that have been made with the air-pump are by no means conclusive; the injury which the insect sustains when the atmospheric pressure is taken from the body, does not prove that it inspired and expired the air that we have removed; it only shews that an incumbent pressure is necessary to their comfortable existence, as it prevents the fluids from disengaging themselves in an aerial form, and as it counterbalances and re-acts on the principle of life, and, by keeping the action thereof in proper tone and order, confines and regulates its energies.

Though it is difficult to ascertain whether some insects respire, at least at certain periods of their existence, yet there are others to whom the inspiration and expiration of air seems absolutely necessary: there are many aquatic insects which are obliged to keep their tails suspended on the surface of the water for this purpose. To prove this, keep the tail under water, and you will perceive the insect to be agitated and uneasy, and to seek for some opening to expose this part to the air; if it find none, it soon goes to the bottom and dies. Some aquatic beetles resist the trial for a considerable time, while their larvæ can only support it for a few minutes. There is a circumstance which renders all experiments on this subject with insects doubtful and difficult, namely, the vast tenaciousness of the life principle in the lower orders of animated nature, and its dissemination through their whole frame.

Musschenbroeck inclosed the pupa of a moth in a glass tube, very little larger than the moth itself, and of the following figure.

The end A of the tube was drawn out in a capillary form, the other end was covered with a piece of wet bladder to exclude the air; the capillary end B was then plunged in water, which rose to D. He placed the capillary part of the tube before a microscope, on a small micrometer, in order to observe any motion or change in the situation of the water; as it is evident the expiration or inspiration of air by the insect would make it rise or fall alternately. In the first experiment he observed a small degree of motion at distant intervals, not above two or three times in an hour; in a second experiment on another subject, he could observe no motion at all. He then placed some pupæ under the receiver of an air-pump, in water which he had previously purged of its air; on exhausting the air from the receiver, he observed one bubble to arise in a part near the tail, and a few near the wings. The pupæ did not swell under the operation; on the contrary, on letting in the air, it was found to be diminished in a small degree, but in less than a quarter of an hour it recovered its former figure. M. Martinet published at Leyden, in 1753, a dissertation, in which, it is said, he has clearly proved by a number of experiments that the pupæ of caterpillars and some other insects do not respire.

OF RESPIRATION IN THE LARVA OF THE MUSCA PENDULA.

Among the insects in which respiration seems to be most clearly proved, are the larvæ of the musca pendula, Lin. These, while in the worm state, live under water in the mud, to which they affix themselves; the respiration of fresh air in this situation is necessary to their existence; for this purpose they are furnished with a tail, which often appears of an excessive length comparatively with the body, as this is seldom more than three quarters of an inch in length, while the tail is frequently more than four inches; it is composed of two tubes, which run one into the other, something similar to the tubes of a refracting telescope. Besides this, the materials of which the tubes are composed are capable of a great degree of extension. When the tail is at its full length, it is exceeding small, not being larger near the extremity than a horse-hair; there is a little knob at the end, which is furnished with small hairs, to extend on the water, in some measure resembling those at the tail of the musca chamæleon.

In the body of the larva are two large tracheal vessels; these air-vessels extend from the head to the tail, terminate in the respiring tubes, and receive the air from them. The larva quits the water when the time of its transformation approaches, and enters into the earth, where the skin hardens and forms a case in which the pupa is formed; soon after the change, four tubes or horns are seen projecting from the case: these Reaumur supposes to be organs for communicating air to the interior parts of the insect; they are connected with little bladders which are found filled with air, and by which it is conveyed to the spiracula of the pupa. The larvæ of gnats, and other small aquatic insects of the same kind, are furnished with small tubes, that play on the surface of the water, and convey the air from thence to the insect. Many other singularities are to be found amongst the aquatic larvæ.

OF THE GENERATION OF INSECTS.

One of the greatest mysteries in nature is generation, or that power by which the various species of animals, &c. are propagated, enabling one single individual to give birth to thousands, or even millions of individuals like itself; all formed agreeable to proportions which are only known to that ADORABLE WISDOM which has established them. We shall never be able to form any adequate conception of this power, till we are acquainted with the principles of life, and can trace their various gradations in different orders of beings. Many ancient philosophers, from a misconception and perversion of the sentiments of the more ancient sages, imagined that insects were produced from corrupt and putrefied substances; that organized bodies, animated with life, and framed in a most wonderful manner, owed their origin to mere chance! Not so the most ancient sages; they taught that every degree of life must proceed from the fountain and source of all life, and that therefore, when manifested, it must be replete with infinite wonders; but then they also shewed, that if in its descent through the higher orders of being it was perverted, it would be manifested in loathsome forms, and with filthy propensities; and that according to the degree of reception of the Divine Goodness and Truth, or the perversion thereof, new forms of life would be occasionally manifested. The gloom of night still wraps this subject in obscurity; will the dawn of day ere long gild the horizon of the scientific world? or is the time of its breaking forth yet far from us? Be this as it may, insects will be found to conform to that general law of order which runs through the whole of animated nature, namely, that the conjunction of the male and female is necessary for the production of their offspring. Where we cannot ascertain causes, we must be content with facts.

Though insects are, like larger animals, distinguished into male and female, yet in some classes there is a kind of mules, partaking of neither sex, though themselves originating from the conjunction of both: many other particularities relative to the sexes can only be touched upon here. In many insects the male and female are with difficulty distinguished, and in some they differ so widely, that an unskilful person might easily take the male and female of the same insect for different species; as for instance, in the phalæna humuli, piniaria, russula. The dissimilarity is still greater in those insects in which the male has wings and the female none, as in the coccus lampyris, phalæna antiqua, &c. In general the male is smaller than the female. The antennæ of the male are, for the most part, larger than those of the female. In some moths, and other insects which are furnished with feathered antennæ, the feathers of the male fly are large and beautiful, while those of the female are small, and hardly perceptible. Some male beetles are furnished with a horn, which is wanting in the female.

"Pleraque insectorum genitalia sua intra anum habent abscondita, et penes solitarios, sed nonnulla penem habent bifidum: cancri autem et aranei geminos, quemadmodum nonnulla amphibia, et quod mirandum in loco alieno, ut cancer, sub basi caudæ. Araneus mas palpos habet clavatos, qui penes sunt, juxta os utrinque unicum, quæ clavæ sexum nec speciem distinguunt; et fœmina vulvas suas habet in abdomine juxta pectus; heic vero si unquam vere dixeris: res plena timoris amor, si enim procus inauspicato accesserit, fœmina ipsum devorat, quod etiam fit, si non statim se retraxerit. Libellula fœmina genitale suum sub apice gerit caudæ, et mas sub pectore, adeo ut eum mas collum fœmina forcipe caudæ arripit, illa caudam suam pectori ejus adplicet, sicque peculiari ratione connexæ volitent."

Insects are either oviparous or viviparous; or, in other words, the species is perpetuated either by their laying of eggs, or bringing forth their young alive. The former is the more general case; there are but few instances of the latter. Those insects which pass through the different transformations already described, cannot propagate till they arrive at their imago or perfect state; and we believe there is seldom any conjunction of the sexes in other classes till they have moulted, or put off their last skin, the cancri and monoculi excepted.

To form a just idea of the ovaries of insects, I could wish the reader to consult the description that Swammerdam has given of that of the queen bee, and to take a view of the elegant figure that accompanies it, a figure that speaks to the eyes, and by them to the imagination. Malpighi has given a description of the ovaries of the silk-worm moth.

Reaumur mentions six or seven species of two-winged flies that are viviparous, bringing forth worms, which are afterwards transformed into flies. The womb of one of these is singularly curious; it is formed of a band rolled up in a spiral form, and about two inches and an half in length; so that it is seven or eight times longer than the body of the fly, and composed of worms placed one on the side of the other with wonderful art: they are many thousands in number.*

OF THE APHIDES OR PUCERONS.

These are a species of insects that have opened new views of the œconomy of animated beings; they belong to the hemiptera class. The rostrum is inflected, the antennæ are longer than the thorax; some have four erect wings, others are entirely without them. Towards the end of the abdomen there are two tubes ejecting that most delicate juice called honey-dew. Various names have been applied to them, the proper one is aphis, that by

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* Reaumur Mem. des Insectes, tom. 4, p. 415.

which they are most generally known, is puceron; they are also frequently called vine-fretters or plant-lice: many among the genera are both oviparous and viviparous, bringing forth their young alive in summer, but in autumn depositing their eggs upon the branches and bark of trees. The different aphides are very curious objects for the microscope: they are a very numerous genus, Linnæus has enumerated thirty-three different species, whose trivial names are taken from the plant which they inhabit, though it is probable the number is much larger, as the same plant is often found to support two or three different sorts of them. Their habits are very singular: an aphis or puceron, brought up in the most perfect solitude from the very moment of its birth, in a few days will be found in the midst of a numerous family; repeat the experiment on one of the individuals of this family, and you will find this second generation will multiply like its parent; and this you may pursue through many generations.

M. Bonnet had repeated experiments of this kind, as far as the sixth generation, which all uniformly presented the observer with fruitful virgins, when he was engaged in a series of new and tedious experiments, from a suspicion imparted by M. Trembley in a letter to him, who thus expresses himself: "I have formed the design of rearing several generations of solitary pucerons, in order to see if they would all equally bring forth young. In cases so remote from usual circumstances, it is allowed to try all sorts of means; and I argued with myself, Who knows but that one copulation might serve for several generations?" This "WHO KNOWS" persuaded M. Bonnet that he had not sufficiently pursued his investigations. He therefore now reared to the tenth generation his solitary aphides, having the patience to keep an exact account of the days and hours of the birth of each generation. The result of this pursuit was, his discovering both males and females among them, whose amours were not in the least equivocal; the males are produced only in the tenth generation, and are but few in number; these soon arriving at their full growth, copulate with the females, and the virtue of this copulation serves for ten successive generations; all these generations, except the first from fecundated eggs, are produced viviparous, and all the individuals are females, except those of the last generation, among whom some males appear, to lay the foundation of a fresh series.

In order to give a further insight into the nature of these insects, I shall insert an extract of a description of their different generations, by Dr. Richardson, as published in the Philosophical Transactions for the year 1771.

The great variety of species which occur in the insects now under consideration, may make an inquiry into their particular natures seem not a little perplexing, but by reducing them under their proper genera, the difficulty is considerably diminished. We may reasonably suppose all the insects, comprehended under any distinct genus, to partake of one general nature; and, by diligently examining any particular species, may thence gain some insight into the nature of all the rest. With this view Dr. Richardson chose out of the various sorts of aphides the largest of those found on the rose-tree, not only as its size makes it the more conspicuous, but as there are few others of so long a duration. This sort appears early in the spring, and continues late in the autumn; while several are limited to a much shorter term, in conformity to the different trees and plants from whence they draw their nourishment.

If at the beginning of February the weather happen to be so warm, as to make the buds of the rose-tree swell and appear green, small aphides are frequently to be found on them, though not larger than the young ones in summer, when first produced. It will be found, that those aphides which appear only in spring, proceed from small black oval eggs, which were deposited on the last year's shoots; though when it happens that the insects make too early an appearance, the greater part suffers from the sharp weather that usually succeeds; by which means the rose-trees are some years in a manner freed from them. The same kind of animal is then at one time of the year viviparous, and at another, oviparous. Those aphides which withstand the severity of the weather seldom come to their full growth before the month of April, at which time they usually begin to breed, after twice casting off their exuvia, or outward covering. It appears that they are all females, which produce each of them a numerous progeny, and that without having intercourse with any male insect; they are viviparous, and what is equally singular, the young ones all come into the world backwards. When they first come from the parent, they are enveloped by a thin membrane, having in this situation the appearance of an oval egg; these egg-like appearances adhere by one extremity to the mother, while the young ones contained in them extend the other, by that means gradually drawing the ruptured membrane over the head and body to the hind feet. During this operation, and for some time after, the fore part of the head adheres, by means of something glutinous, to the vent of the parent. Being thus suspended in the air, it soon frees itself from the membrane in which it was confined; and after its limbs are a little strengthened, is set down on some tender shoots, and left to provide for itself.

In the spring months there appear on the rose-trees but two generations of aphides, including those which proceed immediately from the last year's eggs; the warmth of the summer adds so much to their fertility, that no less than five generations succeed one another in the interval. One is produced in May, which casts off its covering; while the months of June and July each supply two more, which cast off their coverings three or four times, according to the different warmth of the season. This frequent change of their outward coat is the more extraordinary, because it is repeated more often when the insects come the soonest to their growth, which sometimes happens in ten days, where warmth and plenty of nourishment conspired.

Early in the month of June, some of the third generation, which were produced about the middle of May, after casting off their last covering, discover four erect wings, much longer than their bodies; and the same is observable in all the succeeding generations which are produced during the summer months, but still without any diversity of sex; for some time before the aphides come to their full growth, it is easy to distinguish which will have wings, by a remarkable fullness of the breast, which in the others is hardly to be distinguished from the body. When the last covering is rejected, the wings, which were before folded up in a very narrow compass, are gradually extended in a surprizing manner, till their dimensions are at last very considerable.

The increase of these insects in the summer time is so very great, that by wounding and exhausting the tender shoots, they would frequently suppress all vegetation, had they not many enemies to restrain them. Notwithstanding these insects have a numerous tribe of enemies, they are not without friends, if those may be considered as such, who are officious in their attendance for the good things they expect to reap thereby. The ant and the bee are of this kind, collecting the honey in which the aphides abound, but with this difference, that the ants are constant visitors, the bee only when flowers are scarce; the ants will suck in the honey while the aphides are in the act of discharging it, the bees only collect it from the leaves on which it has fallen.

In the autumn three more generations of aphides are produced, two of which generally make their appearance in the month of August, and the third before the middle of September. The two first differ in no respect from those which are found in summer; but the third differs greatly from all the rest. Though all the aphides which have hitherto appeared were females, in this tenth generation several male insects are found, but not by any means so numerous as the females.

The females have at first the same appearance with those of the former generations, but in a few days their colour changes from a green to a yellow, which is gradually converted into an orange before they come to their full growth; they differ also in another respect from those which occur in summer, for all these yellow females are without wings. The male insects are, however, still more remarkable, their outward appearance readily distinguishing them from this and all other generations. When first produced, they are not of a green colour like the rest, but of a reddish brown, and have afterwards a dark line along the back; they come to their full growth in about three weeks, and then cast off their last covering, the whole insect being after this of a bright yellow colour, the wings only excepted; but after this change to a deeper yellow, and in a very few hours to a dark brown, if we except the body, which is something lighter coloured, and has a reddish cast. The males no sooner come to maturity than they copulate with the females, who in a day or two after their intercourse with the males lay their eggs, generally near the buds. Where there are a number crowded together, they of course interfere with each other, in which case they will frequently deposit their eggs on other parts of the branches. It is highly probable that the aphides derive considerable advantages by living in society; the reiterated punctures of a great number of them may attract a larger quantity of nutritious juices to that part of the tree or plant where they have taken up their abode.

The aphides are very injurious to trees and vegetables of almost every kind; the species is so numerous, and all endued with so much fertility, that if they were not destroyed by a numerous host of enemies, the leaves, the branches, and the stem of every plant would be covered with them. On almost every leaf inhabited by aphides, a small worm is to be found, that feeds not upon the leaves, but upon these insects, devouring them with incredible rapacity: Reaumur supplied a single worm with above one-hundred aphides, every one of which it devoured in less than three hours. Indeed myriads of insects seem to be produced for no other purpose than to destroy them.

OF THE APIS OR BEE.

The bee belongs to the hymenoptera order, the mouth is furnished with two jaws, and a proboscis protected by a double sheath, see Fig. 3. Plate XIII. They have four wings; when these are at rest, the two foremost cover those behind. There is a sting in the tail of the working and female bee. Of the bee kind fifty-five species are enumerated by Linnæus. Our present observations are confined to the common or domestic bee.

In the natural history of insects new objects of surprize are continually rising before the observer: however singular the preceding account of the production of the aphides may appear, that of bees is not less so. This little republic has at all times gained universal esteem and admiration; and, though they have attracted the attention of the most ingenious and laborious inquirers into nature, yet the mode of propagating their species seems to have baffled the ingenuity of ages, and rendered all attempts to discover it abortive; even the labours and scrupulous attention of Swammerdam were unsuccessful. He spent one month entirely in examining, describing, and representing their intestines; and many months on other parts; employing whole days in making observations, and whole nights in registering them, till at last he brought his treatise of bees to the wished for perfection; a work which, from the commencement of natural history to our own times, has not its equal. Reaumur, however, thought he had in some measure removed the veil, and explained their manner of generating: he supposes the queen bee to be the only female in the hive, and the mother of the next generation; that the drones are the males, by which she is fecundated, and that the working bees, or those that collect wax on the flowers, that knead it, and form from it the combs and cells, which they afterwards fill with honey, are of neither sex. The queen bee is known by its size, being generally much larger than the working bee or the drone.

M. Schirach, a German naturalist, affirms that all the common bees are females in disguise, in which the organs that distinguish the sex, and particularly the ovaria, are obliterated, or at least from their extreme minuteness have escaped the observer's eye; that every one of these bees, in the earlier period of its existence, is capable of becoming a queen bee, if the whole community should think it proper to nurse it in a particular manner, and raise it to that rank: in short, that the queen bee lays only two kinds of eggs, those that are to produce the drones, and those from which the working bees are to proceed. Schirach made his experiments not only in the early spring months, but even as late as November. He cut off from an old hive a piece of the brood-comb, taking care that it contained worms which had been hatched about three days. He fixed this in an empty hive, together with a piece of honey-comb, for food to his bees, and then introduced a number of common bees into the hive. As soon as these found themselves deprived of their queen and their liberty, a dreadful uproar took place, which lasted for the space of twenty-four hours. On the cessation of this tumult, they betook themselves to work, first proceeding to the construction of a royal cell, and then taking the proper methods for feeding and hatching the brood inclosed with them; sometimes even on the second day the foundation of one or more royal cells were to be perceived; the view of which furnished certain indications that they had elected one of the inclosed worms to the sovereignty. The bees may now be left at liberty. The final result of these experiments is, that the colony of working bees being thus shut up with a morsel of brood-comb, not only hatch, but at the end of eighteen or twenty days produce from thence one or two queens, to all appearance proceeding from worms of the common sort, converted by them into a queen merely because they wanted one.* From experiments of the same kind, varied and often repeated, Schirach concludes that all the common working bees were originally of the female sex; but that if they are not fed, lodged, and brought up in a particular manner while they are in the larva state, their organs are not developed; and that it is to this circumstance attending the bringing up the queen, that the extension of the female organs is effected, and the difference in her form and size produced.

Mr. Debraw has carried the subject further, by discovering the impregnation of the eggs by the males, and the difference of the

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* Schirach Histoire Naturelle des Abeilles.

size among the drones or males; though indeed this last circumstance was not unknown to Mess. Maraldi and Reaumur. Mr. Debraw watched the glass hives with indefatigable attention, from the moment the bees, among which he took care there should be a large number of drones, were put into them, to the time of the queen's laying her eggs, which generally happens on the fourth or fifth day; he observed, that on the first or second day, always before the third from the time the eggs are placed in the cells, a great number of bees, fastening themselves to one another, hung down in the form of a curtain, from the top to the bottom of the hive; they had done the same at the time the queen deposited her eggs, an operation which seems contrived on purpose to conceal what is transacting; however, through some parts of this veil he was enabled to see some of the bees inserting the posterior part of their bodies each into a cell, and sinking into it, but continuing there only a little while. When they had retired, it was easy to discover a whitish liquor left in the angle of the basis of each cell, which contained an egg. In a day or two this liquor was absorbed into the embryo, which on the fourth day assumes its worm or larva state, to which the working bees bring a little honey for nourishment, during the first eight or ten days after its birth. When the bees find the worm has attained its full growth, they leave off bringing it food, they know it has no more need of it; they have still, however, another service to pay it, in which they never fail; it is that of shutting it up in its cell, where the larva is inclosed for eight or ten days: here a further change takes place; the larva, which was heretofore idle, now begins to work, and lines its cell with fine silk, while the working bee incloses it exteriorly with a wax covering. The concealed larva then voids its excrement, quits its skin, and assumes the pupa; at the end of some days the young bee acquires sufficient strength to quit the slender covering of the pupa, tears the wax covering of its cell, and proceeds a perfect insect.

To prove further that the eggs are fecundated by the males, and that their presence is necessary at the time of breeding, Mr. Debraw made the following experiments. They consist in leaving in a hive the queen, with only the common or working bees, without any drones, to see whether the eggs she laid would be prolific. To this end he took a swarm, and shook all the bees into a tub of water, leaving them there till they were quite senseless; by which means he could distinguish the drones without any danger of being stung: he then restored the queen and working bees to their former state, by spreading them on a brown paper in the sun; after this he replaced them in a glass hive, where they soon began to work as usual. The queen laid eggs, which, to his great surprize, were impregnated, for he imagined he had separated all the drones or males, and therefore omitted watching them; at the end of twenty days he found several of his eggs had, in the usual course of changes, produced bees, while some had withered away, and others were covered with honey. Hence he inferred, that some of the males had escaped his notice, and impregnated part of the eggs. To convince himself of this, he took away all the brood-comb that was in the hive, in order to oblige the bees to provide a fresh quantity, being determined to watch narrowly their motions after new eggs should be laid in the cells. On the second day after the eggs were deposited, he perceived the same operation that was mentioned before, namely, that of the bees hanging down in the form of a curtain, while others thrust the posterior part of their bodies into the cells. He then introduced his hand into the hive, broke off a piece of the comb, in which there were two of these insects; he found in neither of them any sting, a circumstance peculiar to the drones; upon dissection, with the assistance of a microscope, he discovered the four cylindrical bodies which contain the glutinous liquor of a whitish colour, as observed by Maraldi in the large drones. He was therefore now under the necessity of repeating his experiments, in destroying the males, and even those that might be suspected to be such. He once more immersed the same bees in water, and when they appeared in a senseless state, he gently pressed every one; in order to distinguish those armed with stings from those which had none, and which of course he supposed to be males: of these last he found fifty-seven, and replaced the swarm in a glass hive, where they immediately applied again to the work of making cells, and on the fourth or fifth day, very early in the morning, he had the pleasure to see the queen bee deposit her eggs in those cells: he continued watching most part of the ensuing days, but could discover nothing of what he had seen before.

The eggs, after the fourth day, instead of changing in the manner of caterpillars, were found in the same state they were in the first day, except that some were covered with honey. A singular event happened the next day, about noon; all the bees left their own hive, and were seen attempting to get into a neighbouring one, on the stool of which the queen was found dead, being no doubt slain in the engagement. This event seems to have arisen from the great desire of perpetuating their species, and to which end the concurrence of the males seems so absolutely necessary; it made them desert their habitations, where no males were left, in order to fix a residence in a new one, in which there was a good stock of them. To be further satisfied, Mr. Debraw took the brood-comb, which had not been impregnated, and divided it into two parts; one he placed under a glass bell, No. 1, with honey-comb for the bees food, taking care to leave a queen, but no drones, among the bees confined in it; the other piece of the brood-comb he placed under another glass bell, No. 2, with a few drones, a queen, and a proportionable number of common bees. The result was, that in the glass, No. 1, there was no impregnation, the eggs remaining in the same state they were in when put into the glass; and on giving the bees their liberty on the seventh day, they all flew away as was found to be the case in the former experiment; whereas in the glass, No. 2, the very day after the bees had been put into it, the eggs were impregnated by the drones, and the bees did not leave their hive on receiving their liberty.

The editor of the Cyclopædia says, that the small drones are all dead before the end of May, when the larger species appear, and supersede their use; and that it is not without reason that a modern author suggests, that a small number of drones are reserved to supply the necessities of the ensuing year; but that they are very little, if any, larger than the common bee.

It does not enter into our plan to notice further in this place the wonders of this little society. A bee-hive is certainly one of the finest objects that can offer itself to the eyes of the beholder. It is not easy to be weary of contemplating those workshops, where thousands of labourers are constantly engaged in different employments.*

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* The remarks made by the late Mr. Hunter on the experiments of Messrs. Schirach and Debraw, in my opinion, merit the attention of the reader; they are contained in his "Observations on Bees," comprizing a variety of information respecting the history and œconomy of those curious insects. This ingenious and interesting account is inserted in the Philosophical Transactions for the year 1792, page 128—195. I cannot altogether subscribe to his opinion relative to the minuteness and prolixity of Swammerdam. Edit.

OF THE EGGS OF INSECTS.

The eggs are contained and arranged in the body of the insect, in vessels which vary in number and figure in different species; the same variety is found in the eggs themselves: some are round, others oval, some cylindrical, and others nearly square; the shells of some are hard and smooth, while others are soft and flexible. It is a general rule, that eggs do not increase in size after they are laid; among insects, we find however an exception to this; the eggs of the tenthredo of Linnæus increase after they are laid, but their shell is soft and membranaceous. The eggs of insects differ in their colours; some may be found of almost every shade, of yellow, green, brown, and even black. The eggs of the lion puceron,* hemerobius, Lin. are very singular objects, and cannot have escaped the eye of any person who is conversant among the insects which live on trees; though of the many who have seen them, few, if any, have found what they really were. It is common to see on the leaves and pedicles of the leaves of the plumb-tree, and several other trees, as also on their young branches, a number of long and slender filaments, running out to about an inch in length; ten or twelve of these are usually seen placed near one another, and a vast number of these clusters are found on the same tree; each of these filaments is terminated by a sort of swelling or tubercle of the shape of an egg. They have generally been supposed to be of vegetable origin, and that they were a sort of parasitical plant growing out of others. There is a time when these egg-like balls are found open at the ends; in this state they very much resemble flowers, and have been figured as such by some authors, though they are only the

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* Reaumur Hist. de Insectes, vol. xi. p. 142.

shells of the eggs out of which the young animals have escaped after being hatched. If these eggs be examined by a microscope, a worm may be discovered in them; or they may be put into a box, in which, in due time, they will produce an insect, which, when viewed with a microscope, will be found to be the true lion puccron.

Divine Providence instructs the insects, by a lower species of perception, to deposit their eggs not only in safety from their numerous enemies, but also in situations where a sufficient quantity of food is on the spot to support and nourish the larva immediately on breaking the shell. Some deposit their eggs in the oak leaf, producing there the red gall; others choose the leaf of the poplar, which swells into a red node or bladder; to a similar cause we must attribute the red knob which is often seen on the willow leaf, and the three pointed protuberances upon the termination of the juniper branches. The leaves of the veronica and cerastium are drawn into a globular head by the eggs of an insect lodged therein. The phalæna neustria glues its eggs with great symmetry and propriety round the smaller branches of trees. Fig. 1. Plate X. represents a magnified view of the nest of eggs taken off the tree after the caterpillar had eat its way through them; the strong ground-work of gum, by which they are connected and bound together, is very visible in many places; they strengthen this connection further, by filling up all the intervening space between the eggs with a very tenacious substance. These eggs are crustaceous, and similar to those of the hen; Fig. 2 represents the natural size. Fig. 3 is a magnified vertical section of the eggs, shewing their oval shape; Fig. 4 the natural size. Fig. 5 is an horizontal section through the middle of the egg, and Fig. 6 the same not magnified. It is not easy to describe the beauty of these objects, when viewed in the lucernal microscope; the regularity with which they are placed, the delicacy of their texture, the beautiful and ever-varying colours which they present to the eye, give the spectator a high degree of rational delight.

In the Lapland Alps there is a fly covered with a downy hair, called the rhen-deer gad-fly, oestrus tarandi, Linn. it hovers all day over these animals, whose legs tremble under them; they prick up their ears, and flee to the mountains covered with ice and snow to escape from a little hovering fly, but generally in vain, for the insect but too soon finds an opportunity to lodge its egg in the back of the deer; the worm hatched from this egg perforates the skin, and remains under it during the whole winter: in the following year it becomes a fly. The oestrus bovis is an equal terror to oxen; the hippobosca equina, to horses; oestrus ovis,* to the sheep, &c.

The gnat, the ephemera, the phryganea, the libellula, hover over the water all day to drop their eggs, which are hatched in the water, and continue there all the time they are in the larva form. The mass formed by the gnat resembles a little vessel set afloat by the insect; each egg is in the form of a keel, these are curiously connected together. The gnat lays but one egg at a time, which she deposits on the water in a very ingenious and simple manner; she stretches her legs out, and crosses them, thus forming an angle to receive and hold the first egg; a second egg is soon placed next the first; then a third, and so on, till the base is capable of supporting itself; these, as they come to maturity, sink deeper. The spawn of this insect is sometimes above an inch long, and one-eighth of an inch in diameter, and tied by a little stem or stalk to some stick or stone. Sometimes they are laid in a single, sometimes in a double spiral line; sometimes

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* Oestrus ovis in naso sive sinu frontis animalium rumenantium. Linn.

transversely. Many moths cover their offspring with a thick bed of hair, which they gather from their own body; while others cover them with a glutinous composition, which, when hard, protects them from moisture, rain, and cold. The gall-flies, it has been observed, know how to open the nerves of the leaves, to deposit thus their eggs in a place which afterwards serves them for a lodging and a magazine of food. The solitary bees and wasps prepare an habitation for their little ones in the earth, placing there a proper quantity of food for them, when they proceed from the egg. The voracious and cruel spider is attentive and careful of its eggs; the wolf spider carries them on its back in a little bag formed of its silk, it cannot be separated from them but by violence, and exhibits the most marked signs of uneasiness when deprived of them: a circumstance the more remarkable, as they love to destroy each other, and even carry on their courtships with a diffidence and caution unknown in any other species of animals. The history of bees and wasps, and their care and attention to their offspring, is so well known, that I may with propriety pass it over here, and proceed just to notice the industrious ant, whose paternal affection and care is not so well known. They are not satisfied with placing their eggs in situations made on purpose, and to raise or rear them till they come to the nymph or pupa state, but they even extend their care to the pupæ themselves, removing them from their nest to the surface of the earth, whenever the weather is fine, that they may receive the benignant influence of the sun, carrying them back again as soon as the air begins to grow cold. If any accident disturb their nest, and disperse the pupæ, they manifest the greatest signs of distress, seeking those which are lost and scattered, placing them in some sheltered place while they repair the nest, when they again transport them to it.* Many

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* Lessers Theologie des Insectes, tom. 1, p. 143.

other curious particulars might be related relative to this industrious insect; as their uniting together in scooping out earth, the conveyance of materials for the construction of their nests, and the curious structure of the nest itself, which, though it appears piled up at random, will be found, on stricter examination, to be a work of art and design, with other circumstances which are too long to be enumerated here.

The fecundity of insects exceeds in an astonishing degree that of all the productions of nature; the vegetables which cover the surface of the earth bear no proportion to their multitudes, every plant supporting a number often of scarce perceptible creatures: of the fatal effects of their prodigious multiplication, our fruit trees, &c. are too frequently a deplorable testimony. On the continent whole provinces sometimes languish in consequence of the dreadful havoc made by them.

Reaumur calculated the fecundity of the queen bee as follows: he found that she laid in the two months of March and April 12,000 eggs, so that the swarm which left the hive in May consisted of near 12,000 bees, all produced from one mother: but this calculation falls short of that which was made by Leeuwenhoek on a fly, whose larva feeds on flesh, putrid carcases, &c. which multiply prodigiously, and that in a short space of time. One of these laid 144 eggs, from which he got as many flies in the first month; so that, supposing one-half of these to be females, in the third month we shall have 746,496, all produced in three months from one fly.

The following is an experiment of M. Lyonet on the generation of a moth which comes from the chenille a brosse: out of a brood of 350 eggs, produced by a single moth of this kind, he took 80, from which he obtained, when they were arrived at their perfect state, 15 females; from whence he deduces the following consequence: if 80 eggs give 15 females, the whole brood of 350 would have produced 65; these 65, supposing them as fertile as their mother, would have produced 22,750 caterpillars, among which there would have been at least 4265 females, who would have produced for the third generation 1,492,750 caterpillars. This number would have been much larger, if the number of females among those which were selected by M. Lyonet had been greater. M. de Geer counted in the belly of a moth 480 eggs; reducing these to 400, if supposing one-fourth only of these to be females and as fruitful as their mother, they will give birth to 40,000 caterpillars for the second generation; and for the third, supposing all things equal, four millions of caterpillars. It is not surprizing, therefore, that they are found so numerous in years that are favourable to their propagation. But the Creator of all things has for our sakes limited this abundant multiplication, and wisely ordained, that those species which are the most numerous shall have the greatest number of enemies, who, though constantly employed on the destruction of individuals, are unable to effect that of the species; by which means an equilibrium is preserved, and no one species preponderates. Few insects live long after their last transformation, but their species are continued by their amazing fecundity; their growth is completed, and their parts hardened sooner than those of larger animals, and the duration of their existence is proportionably limited. There are, however some species of flies which lie in a torpid state during the winter, and revive with the returning warmth of spring.

OF THE FOOD OF INSECTS.

There are few, if any, productions either of the animal or vegetable kingdoms, which do not supply some kind of insect with food. They may, therefore, be considered under two heads, those which live on vegetables, and those which are supported by animal food; each insect knows that which is proper to sustain its life, where to seek it, and how to procure it. I have already observed, that several insects, when arrived at a state of perfection, feed after their transformation upon food totally different from that which nourished them in their larva state.

Among those which feed on vegetables, some sink themselves in the earth, and by destroying the roots of the plants, do considerable injuries to our gardens. The food of others is dry and hard; they pierce the wood, reduce it to powder, and then feed on it; some, as the cossus, attack and destroy the trees, while the food of others more delicate is the leaves. The leaf is eaten in a different manner by different insects; some eat the whole substance, while others feed only on the parenchymous parts, which are contained between its superficial membranes, forming withinside the leaf paths and galleries. These insects are not always content with the leaf, but attack the flower also: even this food is too gross for many; the bee, the butterfly, the moth, as well as several species of flies, feed only on the honey, or finer juices, which they collect from flowers. We are continually finding the larva of some insect in pears, plumbs, peaches, and other fruit; these unwelcome intruders on the produce of human industry divide fruits, grain, and corn with us, often depriving us of large quantities. There is, indeed, no part of a plant which does not serve as food to different insects; some have one kind of plant marked out for them to inhabit and feed on, others have another assigned to them, on which, and no other, they will feed; each has its appropriate food, and though the parent animal eats not at all, or lives upon food entirely different, yet she is guided, as has before been observed, to deposit her eggs on that peculiar shrub or plant that will be food for her young; while some, more voracious than the rest, feed upon all with equal avidity; but in countries less cultivated than our own, their annoyance and devastations are terrible. The gryllus migratorius, a few years since, poured out of Tartary in such quantities, as to lay waste a great part of Europe, producing almost unequalled calamities, swarming in such multitudes as to cloud the air and cover the ground, mocking human power and craft; wherever they settled, all verdure disappeared, and the summer fruitfulness was turned into winter desolation; in Sweden the cattle perished with hunger, and the men were forced to abandon their country, and fly to the neighbouring regions.* The far greater part feed only, however, on one species of plant, or at most on those which are similar to it, and the same species may always be found on the same plant. Reaumur says, that the caterpillar which infests and feeds upon the cabbage, destroys in twenty-four hours more than twice its weight. If larger animals required a proportionable quantity, the earth would not afford sufficient nourishment for its inhabitants.

A great number of insects reject vegetable, and live on animal food; some seeking that which is beginning to putrefy, while others delight in food entirely putrid; others again are nourished by the most filthy puddles, and disgusting excrements; some attack and feed on man himself, while others are nourished by his provision, his cloaths, his furniture: some prey upon insects of another species; others, again, attack their own, and harrass each other with perpetual carnage. Reaumur informs us, that those insects which feed upon dead carcases never attack living animals; the flesh-fly deposits her eggs in the bodies of dead animals, where her progeny receive that nourishment best adapted for them; but this fly never attempts to lay her eggs in the flesh of sound and living animals.

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* Select Dissertations from the Amœnitates Academicæ, vol. 1, p. 398.

Every animal has its appropriate lice, which feed on and infest it. M. Rhedi has given an accurate account of a great number of these little noxious creatures accompanied with figures; but, as if it were not sufficient that these creatures should dwell and live on the external part of the body, and suck the blood of the animal that they infest, we find another species of insects seeking their food in the more vital parts, and feeding on the flesh of the animal, while full of life and health. Reaumur has given an history of a fly, oestrus bovis, the larva of which lives upon the backs, and feeds on the flesh of young oxen and cows, where it produces a kind of tumor. The fly lodges its eggs in the flesh, by making a number of little wounds, in each of which it deposits eggs, so that every wound becomes a nest, the eggs of which are hatched by the heat of the animal. Here the larvæ find abundant food, at the same time that they are protected from the changes of the weather; and here they stay till they are fit for transformation. The parts they inhabit are often easy to be discovered by a kind of lump or tumor, which they form by their ravages; this tumor suppurates, and is filled with matter; on this disgusting substance the larvæ feed, and their heads are always found plunged in it.*

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* The obscure and singular habitations of the British oestri are the stomach and intestines of the horse, the frontal and maxillary sinuses of sheep, and beneath the skin of the backs of horned cattle. In other parts of the world they inhabit various other animals.

The larva of the oestrus bovis lives beneath the skin of horned cattle, between it and the cellular membrane, in a proper sack or abcess, which is rather larger than the insect, and by narrowing upwards opens externally to the air by a small aperture. When arrived at its full growth, it effects its escape from the abcess by pressing against the external opening; when the opening has thus obtained the size of a small pea, the larva writhes itself through, and falls from the back of the animal to the ground; and, seeking a convenient retreat, becomes a chrysalis, in which state it continues from about the latter end of June to about the middle of August: the perfect insect, on leaving the chrysalis, forces open a very remarkable marginated triangular lid or operculum. The oestrus in its perfect or fly state is the largest of the European species of this genus, and is very beautiful. Although its effects on the cattle have been so often

Neither the larva, pupa, or even the egg-state of some insects are exempt from the attacks of others, who deposit their eggs in them; these, after having passed through the usual transformations, become what is termed the ichneumon fly. The following are the curious observations of an ingenious naturalist on this fly. " As I was observing," says he, " one day some caterpillars which were feeding voluptuously on a cabbage leaf, my attention was attracted to part of the plant, about which a little fly was buzzing on its wing, as if deliberating where to settle: I was surprized to see the herd of caterpillars, creatures of twenty times its size, endeavouring in an uncouth manner, by various contor-

remarked, yet the fly itself is rarely seen or taken, as the attempt would be attended with considerable danger. The pain it inflicts in depositing its egg is much more severe than in any of the other species: when one of the cattle is attacked by this fly, it is easily known by the extreme terror and agitation of the whole herd; the unfortunate object of the attack runs bellowing from among them to some distant part of the heath, or the nearest water, while the tail, from the severity of the pain, is held with a tremulous motion straight from the body, in the direction of the spine, and the head and neck are also stretched out to the utmost. The rest, from fear, generally follow to the water, and disperse to different parts of the field. The larvæ of this insect are mostly known among the country people by the name of wornuls, wormuls, or warbles, or more properly bots.

The larva of the oestrus equi is very commonly found in the stomach of horses. These larvæ attach themselves to every part of the stomach, but are generally most numerous about the pylorus; and are sometimes found in the intestines. They hang most commonly in clusters, being fixed by the small end to the inner membrane of the stomach, to which they adhere by two small hooks or tentacula. The larvæ having attained their full growth in about a month, on dropping to the ground find some convenient retreat, change to the chrysalis, and in about six or seven weeks the fly appears.

The larva of the oestrus hæmorrhoidalis resembles in almost every respect that of the oestrus equi, and occupies the same situation in the stomach of the horse. When it is ripe, and has passed through the intestines and the sphincter ani it assumes the chrysalis state in about two days, and in about two months the fly appears.

The generally received opinion has been that the female fly enters the anus of the horse to deposit its eggs, and Reaumur relates this circumstance on the authority of Dr. Gaspari; from the account of its getting beneath the tail, it is probable that the fly he saw was the hippobosca equina, which frequently does this: its getting within the rectum appears to have been additions of the body to get out of its way, and more so whenever the fly poised on the wing as if going to drop; at length the creature made its choice, and seated itself on the back of one of the largest and fairest of the cluster; it was in vain the unhappy reptile endeavoured to dislodge the enemy. If the caterpillar had shewn terror on the approach of the fly, its anguish at intervals now seemed intolerable, and I soon found that it was in consequence of the strokes or wounds given by the fly. At every wound the poor caterpillar wreathed and twisted its whole frame, endeavouring to disengage itself, by shaking off the enemy, sometimes aiming its mouth towards the place; but it was all in

tional. That a fly might deposit its eggs on the verge of the anus is not impossible, but we know no instance of it: the fact is, that the part chosen by the oestrus hæmorrhoidalis for this purpose is the lips of the horse, which is very distressing to the animal from the excessive titillation it occasions; for he immediately after rubs his mouth against the ground, his fore legs, or sometimes against a tree, or if two are standing together, they often rub themselves against each other. At the sight of this fly, the horse appears much agitated, and moves its head backward and forward in the air to baulk its touch, and prevent its darting on the lips; but the fly, watching for a favourable opportunity, continues to repeat the operation; till at length, the enraged animal endeavours to avoid it by galloping away to a distant part of the field. If still pursued, its last resource is in the water, where the oestrus is never observed to follow him.

The oestrus veterinus is by Linnæus called nasalis, from an idea of its entering the nostrils of the horse to deposit its eggs, which it could not well do without destroying its wings, and is therefore probably as much a fable as the " mire per anum intrans" of the oestrus hæmorrhoidalis.

The oestrus ovis is mostly found in the horns and frontal sinuses of the sheep, though it has been remarked that the membranes lining these cavities were hardly at all inflamed, while those of the maxillary sinuses were highly so; from which it is suspected that they inhabit the maxillary sinuses, and crawl, on the death of the animal, into these situations in the horns and frontal sinuses. When the larvæ are full-grown they fall through the nostrils, and change to the pupa state, lying on the earth, or adhering by the side to a blade of grass. The fly bursts the shell of the pupa in about two months.

The above concise account of the different oestri is extracted from the excellent paper on the subject by Mr. B. Clark, F. L. S. For his more ample description, accompanied with coloured figures of the several British species, see Transactions of the Linnean Society, vol. iii. page 283—329, just published. Edit.

vain, its little, but cruel tormentor kept its place. When it had inflicted thirty or forty of these wounds, it took its flight with a visible triumph; in each of these wounds the little fly had deposited an egg. I took the caterpillar home with me, to observe the progress of the eggs which were thus placed in its body, taking care to give it a fresh supply of leaves from time to time; it recovered to all appearance in a few hours from the wounds it had received, and from that time, for the space of four or five days, seemed to feed with its usual avidity. The eggs were all hatched into small oblong voracious worms, which fed from the moment of their appearance on the flesh of the caterpillar, in whose body they were inclosed, and seemingly without wounding the organs of respiration or digestion; and when they had arrived at their full growth, they eat their way out of the sides of the animal, at the same time destroying it. The caterpillar thus attacked by the larva of the ichneumon never escapes, its destruction is infallible; but then its life is not taken away at once; the larva, while it is feeding thereon, knows how to spare the parts which are essential to its life, because its own is at that time tied up in that of the caterpillar. No butterfly is produced from it; the worms that feed on the wretched creature, are no sooner out of its body, than every one spins its own web, and under this they pass the state of rest necessary to introduce them to their winged form."* To treat of each species of the ichneumon would alone fill a volume; Linnæus enumerates no less than seventy-seven of them.†

Of this strange scene it is difficult for us to form a proper judgment; we are unacquainted with the organs of the cater-

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* Inspector, No. 64.

† "The genus of insects called ichneumon derive their support and nourishment from other insects, some depositing their eggs in the larva, others again in the pupa, and some even in the

pillar, ignorant of the nature of its sensations, and therefore we cannot be assured what may be the effects of that which we see it suffer. "It is wisdom to suppose we are ignorant, while we know the Creator cannot be cruel." From revelation we learn, that man is the mean through which life is conveyed to the creatures of this lower world; that by sinking into error, and fostering evil, he perverts his own life, and corrupts all that which proceeds from him: so that the effects are the same on the orders beneath him, as would arise to the world if a continual cloud was placed between us and the sun, depriving us at once of the salutary effects of its invigorating heat and cheering light. Hence there is in this degraded world an obscure and melancholy shade cast over all the beauties of creation.

Lastly, the number of insects which feed upon others, nay, some even upon their own species, is very great: it is among these that we find the traces of the greatest art and cunning, as well in attack as defence; some indeed use main force alone. Most persons are acquainted with the dexterous arts of the spider, the curious construction of the web he spins, and the central position he takes, in order to watch more effectually the least motion that may be communicated to its tender net. Those who wish to pursue this subject further, will find ample satisfaction by consulting the works of Reaumur and De Geer.

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ovum or egg itself, the contents of which, minute as they are, are sufficient to support the young larvæ until their change into their pupa state. Some deposit only one egg in a place, as the ichneumon ovulorum, and others again a great number, as ichneumon puparum, &c. but whether the egg be placed in the pupa, larva, or ovum, the destruction of the foster parent is inevitable. The larvæ of large moths or butterflies that have been wounded by an ichneumon, live and feed, though with evident marks of disease, until those parasites are full fed, and able to change into their second or pupa state." See Observations on the Œconomy of the Ichneumon Manifestator, in the Transactions of the Linnean Society, vol. 3, p. 23 & seq. by T. Marsham, Esq. Sec. L. S. Edit.

OF THE HABITATION OF INSECTS.

Insects may be divided, with respect to their habitations, into two classes, aquatic and terrestrial.

Stagnant waters are generally filled with insects, who live therein in different manners. These are, 1. Aquatic insects which remain always on the superficies of the water, or which at least plunge themselves therein but rarely. 2. Others that live only in the water, and cannot subsist out of it. 3. Many, after having lived in the water while in the larva and pupa state, quit it afterwards with wings, and become entirely terrestrial. 4. Some undergo all their transformations in the water, and then become amphibious. 5. Others again are born and grow in the water, but undergo their pupa state on dry land, and after they are arrived at their perfect state, live equally in air and water; and 6. There are some who live at the same time part in the water and part on land, but after their transformation cease to be aquatic.

Among the insects which remain on the superficies of the water, are some spiders, which run with great address and agility, without moistening their feet or their body; when they repose themselves, they extend their feet as much as possible. There are also aquatic bugs, which swim, or rather run on the water with great velocity, and by troops; another bug walks very slowly on the water; the gyrinus moves very swiftly, and in circles. There is a species of podura* which live in society, and are often accumulated together in little black lumps. Those insects which always live in the water are generally born with the

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* De Geer Discours sur les Insectes, tom. 2, p. 103.

figure which they retain during their whole lives, as the monoculi, crabs, several kinds of water mites, &c.

Those insects which, after having lived in the water, leave it when in a winged state, are very numerous: among these we may reckon the libellula, the ephemera, the phryganea, culices, tipulæ, and some species of muscæ. All these, when in the larva and pupa state, live in the water; but when they have assumed their perfect form, are entirely terrestrial, and would perish in their former element.

The notonecta, the nepa or aquatic scorpion, &c. never quit the water till they have passed through all their transformations, when they become amphibious, generally quitting it in the evening.

The water-beetles, of which there are many species, remain in the water all day, but toward evening come upon the ground and fly about, then plunge themselves again in the water at the approach of the rising sun. The larvæ of these insects are entirely aquatic, but when the time of their pupa state arrives, they take to the earth, where they make a spherical case; so that these insects are aquatic in the larva, terrestrial in the pupa, and amphibious in the imago state.

We find an instance of an insect that lives at the same time in the water and the air, in the singular larva described by Reaumur, Memoires de l'Acad. in 1714, p. 203. It has the head and tail in the water, while the rest of the body is continually kept above the surface. In order to support itself in this singular position, it bends the body, bringing the head near the tail, raising the rest above the water, and supporting itself against some fixed object, as a plant, or against the borders of the pond; or, if it be placed in a glass vessel, against the sides of the vessel; and if the glass be inclined gently, so that the water may nearly cover the larva, it immediately changes its position, in order that part of the body may be kept dry.

At the baths of Abano, a small town in the Venetian state, there is a multitude of springs, strongly impregnated with sulphur, and of a boiling heat. In the midst of these boiling springs, within three feet of four or five of them, there is a tepid one about blood-warm. In this water, not only the common potamogetons and confervas, or pond-weeds and water-mosses are found growing in an healthy state, but numbers of small black water beetles are seen swimming about, which die on being taken out and plunged suddenly into cold water.*

Many insects that live under the surface of the earth crawl out on certain occasions, as the julus, scolopendra, and the oniscus; they are often also to be found under stones, or pieces of rotten wood. Some insects remain under ground part of their life, but quit that situation after their change; as do some caterpillars, many of the coleoptera class, &c. There are some species of spiders, which form habitations in sand; one of which makes a hole in the sand, lining it with a kind of silk, to prevent its crumbling away; this spider generally keeps on the watch near the mouth of the hole, and, if a fly approach, runs at it with such velocity, as seldom to fail in its attempt of seizing the little animal, which is immediately conveyed to the den of the spider. The formica-leo, or ant-lion, also inhabits sand.†

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* Jones's Physiological Disquisitions, p. 171.

† The art and dexterity with which the formica-leo entraps ants, as well as other insects, merits notice; he makes a pit in fine dry sand, shaped like a funnel or an inverted cone, at the

Another spider, discovered by M. l'Abbe Sauvage,* burrows in the earth like a rabbit, making a hole one or two feet deep, of a regular diameter, and sufficiently large to move itself with ease. It lines the whole of it, either to keep the ground from tumbling in, or in order to perceive more regularly at the bottom what happens at the mouth, at which it forms a kind of door, made of different layers of earth, connected together by threads and covered with a strong web of a close texture; the threads are prolonged on one side, and fixed to the ground, so as to form a strong joint; the door is hung in such a manner, as always to fall by its own gravity. One of these cases or nests is in her Majesty's cabinet at Kew.

The several parts of trees and plants afford a variety of habitations for insects, where they find an abundance of food. They dwell, 1. in the roots; 2. in the wood; 3. in the leaves, and in the galls which grow upon them and the branches; 4. in the flowers; 5. in the fruits and grains. To enumerate the various species of these inhabitants would be endless; many particulars have been already noticed; it has also appeared that some inhabit the most fœtid substances they can find, while others dwell with and live on the larger animals; so that it only remains just to

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point or reverted apex of which he takes his station, concealing every part of his body except the tips of his two horns; these are expanded to the two sides of the pit. When an insect treads on the edge of this precipice, it perhaps slides into it; if not, its steps remove a little of the sand, which of course descends down the sides, and gives the enemy notice of his prey. He then throws up the sand with which his head is covered, to involve the insect, and bring it to the bottom with the returning force of the sand: this, by repeated efforts he is sure to effect, as all the attempts of the unfortunate victim to escape, when once within the verge of the pit, are in vain. One species of the formica-leo forms no pit to entrap its prey, but seizes it by main force. Edit.

* Histoire de l'Acad. 1758, p. 26.

mention some of those in whom industry and art is more strongly marked to our eyes than in others.

Among the solitary bees there are so many curious circumstances to be described, that a single volume would not suffice to contain the particulars; we shall here only relate such as concern their habitations. One of these forms its nest under ground, which is composed of several cells artfully let into each other, but not covered with a common inclosure; each cell consists of two or three membranes, inexpressibly fine, and placed over each other. The cavity, in which the nest is placed, is smeared over with a layer of matter, like that of which the cells are formed, and apparently similar to the viscous humour which snails spread in their passage from one place to another, and it is probable that they are formed of the same materials; this substance, though of so delicate a nature, gives them such a degree of consistency, that they may be handled without altering their form. An egg is deposited at the bottom of each cell, where, after it is hatched, the worm finds itself in the midst of a plentiful stock of provision; for in each cell there is placed a quantity of paste, or a kind of wax, which is to serve as food for the worm, and support the wall of the cell. The worm is also instructed so to conduct itself, and eat this food, as to leave sufficient props for supporting the walls of its apartment. Many species of these bees content themselves with penetrating into the earth, scooping out hollow cavities therein, polishing the walls, then depositing an egg and a sufficient quantity of provisions.

There is another species, that forms its nest under ground with remarkable industry; this bee generally makes a perpendicular hole in the earth about three inches deep, and cylindrical, till within about three-fourths of an inch of the bottom, when it begins to enlarge; as soon as the bee has given it the suitable proportions, it proceeds to line not only the whole inside of its dwelling, but round the entrance; the substance with which it is lined is of a crimson colour, and looks like satin. From this circumstance Reaumur* terms it the tapestry bee. This tapestry or lining is formed of fragments of the flowers of the wild poppy, which she cuts out curiously, and then seizing them with her legs, conveys them to her nest. If the pieces are wrinkled, she first straightens and then affixes them to her walls with wonderous art; she generally applies two layers of these fragments one over the other. If the piece she has cut and transported be too large for the place she intends it for, she clips off the superfluous parts and conveys the shreds out of the apartment. After the bee has lined her cell, she fills it nearly half an inch deep with a paste proper to nourish the larva when hatched from the egg; when the bee has amassed a sufficient quantity of paste, she then takes her tapestry, and folds it over the paste and egg, which are by these means inclosed as it were in a bag of paste; this done, she fills up with earth the empty space that is above the bag. There is another bee which does the same with rose-leaves, and in the substance of a thick post. A friend of mine had a piece of wood cut from a strong post that supported the roof of a cart-house, full of these cells or round holes, three-eighths of an inch in diameter, and about three-fourths deep, each of which was filled with these rose-leaf cases finely covered in at top and bottom.

The mason bee is so called by Reaumur from the manner of its building its nest. These bees collect with their jaws small parcels of earth and sand, which they glue together with a strong cement furnished from the proboscis; and of this they form a simple but commodious habitation, which is generally placed

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* Reaumur Memoires pour l'Histoire des Insectes, edit. 8vo. tom. 6, partie 1, p. 170.

along walls that are exposed to the south. Each nest resembles a lump of rude earth, of about six or seven inches diameter, thrown against the wall; the labour of constructing so large an edifice must be very great, as the bee can only carry a few grains at a time. The exterior form is rude and irregular, but the construction and art exhibited in the interior parts make up for this seeming defect; it is generally divided into twelve or fifteen cells, separated from each other by a thick wall; in each of these an egg is deposited by the parent bee. The cells are not constructed all at once, for when one is finished, she places an egg therein, with a sufficient quantity of honey to nourish the larva; she then builds another. When the insect is arrived at a proper state, it penetrates through its inclosures by means of its strong jaws. When all the bees have quitted the nest, there are as many holes on the surface thereof as there are cells within. We find no neutral bees among this species, or at least we do not know of any being yet discovered.

Another species of the solitary bee (apis centuncularis, Linn.) constructs her nest in pieces of rotten wood, and has therefore been called the carpenter bee.* She divides it into stages, disposing them sometimes in three rows, with partitions curiously left between each; in these she deposits her eggs, with the food necessary for the young ones when hatched. They separate the wood in a very expeditious manner, by dividing its ligneous fibres or threads, till they have made a proper sized hole.

The art and sagacity displayed by another bee,† whose nest is constructed of single pieces of leaves, is truly wonderful. The nest itself is cylindrical, formed of several cells, placed one within

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* Geoffroy Hist. abregee des Insectes, tom. 2, p. 401.

† Reaumur Memoires pour l'Histoire des Insectes, tom. 6, par. 1, p. 122.

the other, as thimbles are in a hard-ware shop. The cells consist of several pieces cut from one leaf, of forms and proportions proper to coincide with the place each is intended to occupy. The outer case or cover is formed with equal care and exactness. In a word, says Bonnet, there is so much exactness, symmetry, uniformity, and skill, in this little master-piece, that we should not believe it to be the work of a fly, if we did not know at what school she learnt the art of constructing it. In each cell the mother deposits an almost liquid substance, and yet so nicely are the cells formed, as not to suffer any of this substance to be lost. But for a minute account of the works of this bee, and the curious mechanism of its cells, we must refer the reader to Reaumur's admirable history of insects.

The proceedings of the mason ichneumon wasp,* sphex, Linn. are totally different from those of the common wasp, though equally curious. It generally begins its work in May, and continues it for the greatest part of June. The true object of her labour seems to be the digging of a hole a few inches deep in the ground; yet in the constructing of this, she forms a hollow tube above ground, the base of which is the aperture of the hole, and which is raised as high above ground as the hole is deep below; it is formed with a great deal of care, resembling a gross kind of fillagree work, consisting of the sand drawn from the hole. The sand out of which she excavates her cell, is nearly as hard as a common stone; this it readily softens with a penetrating liquor with which she is well provided; a drop or two of it is imbibed immediately by the sand on which it falls, which is instantly rendered so soft, that she can separate and knead it with her teeth and fore feet, forming it into a small ball, which she places on the edge of the hole as the foundation stone of the pillar she

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* Reaumur Mem. pour l'Histoire des Insectes, tom. xi. par. 2, p. 9.

is going to erect; the whole of it is formed of such balls, ranged circularly, and then placed one above the other. She leaves her work at intervals, probably in order to renew her stock of that liquor which is so necessary for her operations. These intervals are of short duration; she soon returns, and labours with so much activity and ardour, that in a few hours she will dig a hole two or three inches deep, and raise a hollow pillar two inches high. After the column has been raised a certain height perpendicular from the ground, it begins to curve a little, which curvature increases till it is finished, though the cylindrical form is maintained: she constructs several of these holes all of the same form, and for the same purpose. It is easy to see why the hole was dug in the ground; that it was destined to receive an egg; but it is not so easy to perceive why the tube of sand was formed. By attending to the labours of the wasp, one end, however, may be discovered; it will be found to serve the purpose of a scaffold, and that the balls are as useful to the wasp, as materials, &c. to the mason; and are therefore placed as much within her reach as possible. She uses them to stop and fill up the hole after she has deposited an egg therein, so that the pillar is then destroyed, and not the least remains left in the nest. The parent wasp generally leaves ten or twelve worms as provision necessary and proper for the growth of the young larva: no purveyor could take better precautions than our wasp, for she has received her instructions from HIM who provides for the necessities of all his creatures. In selecting the worms, she chooses those of a proper size, that they may be sufficient in quantity, and of an age that will not be in danger of perishing with hunger, in which case they would have been corrupted; she therefore selects them when they have their full growth. It is also observed, that if she choose a larger sort, she gives a less number of them, and so reciprocally.

From a retrospect view of this chapter, we may observe a striking difference between man and the lower orders of animal creation. Man is born totally ignorant; so much so, that he has no knowledge even of the mother's breast, till he has been brought acquainted with it by repeated trials; he has no innate ideas, is unable to choose what is proper for his food; he cannot form his voice to any articulate pronunciation, or to express the affections of love; whereas the quadruped, the bird, and the insect, are born to all that knowledge which is necessary for the gratification of those desires or that love which forms their life; and, consequently, in the knowledge of every thing relating to their well-being, their food, their habitations, the commerce of the sexes, their provision for their young, &c. from the impulse of the pleasure arising from these innate desires and affections, the larva is also prompted to seek and aspire after a change of its earthly state. If it were not foreign to the subject in hand, it might be easy to shew, by a variety of reasons, that this imperfection of man at his nativity constitutes his real perfection, and places him infinitely, if I may so speak, above the brute creation; for man is not created relatively perfect, but formed a recipient of all perfection.

OF THE TERMITES, GENERALLY CALLED WHITE ANTS.

As no insects exceed the termites in their wonderful œconomy, wise contrivances, and stupendous buildings, it will be proper to give the reader some account of them; which I am enabled to do from the excellent paper written by the late Mr. Smeathman, and published in the Philosophical Transactions for the year 1781, part 1.

The termites are represented by Linnæus as the greatest plagues of both Indies, and are indeed justly deemed so every where between the tropics, on account of the vast damages sustained through them in consequence of their eating and perforating wooden buildings, utensils, furniture, &c. which are totally destroyed by them if not timely prevented; for no substance less hard than metal or stone can escape their most destructive jaws.

These insects have been noticed by various travellers in different parts of the torrid zone; where numerous, as is the case with all equinoctial continents, and islands not fully cultivated, many persons have been excited by curiosity to observe them; and, indeed, those devoid of that disposition must have been very fortunate, if, after a short residence, they were not compelled to pay them attention for the preservation of their property. They make their approaches chiefly under ground, descending below the foundations of houses and stores, at several feet from the surface, and rising again either in the floors, or entering at the bottoms of the posts of which the sides of the buildings are composed, boring quite through them, following the course of the fibres to the top, or making lateral perforations and cavities here and there as they proceed.

While some are employed in gutting the posts, others ascend from them, entering a rafter, or some other part of the roof. If they once find the thatch, which seems to be a favourite food, they soon bring up wet clay, and build their pipes or galleries through the roof in various directions, as long as it will support them; sometimes eating the palm-tree leaves and branches of which it is composed, and perhaps, for variety seems very pleasing to them, the rattan, or other running plant, which is used as a cord to tie the various parts of the roof together, and that to the posts which support it. Thus, with the assistance of the rats, who during the rainy season are apt to shelter themselves there, and to burrow through it, they very soon ruin the house, by weakening the fastenings, and exposing it to the wet. In the mean time the posts will be perforated in every direction as full of holes as that timber in the bottoms of ships, which has been bored by the worms; the fibrous and knotty parts, which are the hardest, being left to the last.

These insects are not less expeditious in destroying the shelves, wainscotting, and other fixtures of an house, than the house itself. They are continually piercing and boring in all directions, and sometimes go out of the broadside of one post into that of another adjoining to it; but they prefer and always destroy the softer substances the first, and are particularly fond of pine and fir boards, which they excavate and carry away with wonderful dispatch and astonishing cunning; for, except a shelf has something standing upon it, as a book, or any thing else which may tempt them, they will not perforate the surface, but artfully preserve it quite whole, and eat away all the inside, except a few fibres which barely keep the two sides connected together; so that a piece of an inch-board, which appears solid to the eye, will not weigh much more than two sheets of pasteboard of equal dimensions, after these animals have been a little while in possession of it. In short, the termites are so insidious in their attacks, that we cannot be too much upon our guard against them: they will sometimes begin and raise their works, especially in new houses, through the floor. If you destroy the work so begun, and make a fire upon the spot, the next night they will attempt to rise through another part; and if they happen to emerge under a chest or trunk, early in the night will pierce the bottom, and destroy or spoil every thing in it before the morning. On these accounts the inhabitants set all their chests or boxes upon stones or bricks, so as to leave the bottoms of such furniture some inches above the ground, which not only prevents these insects finding them out so readily, but preserves the bottoms from a corrosive damp, which would strike from the earth through, and rot every thing therein: a vast deal of vermin also would harbour under, such as cockroaches, centipedes, millepedes, scorpions, ants, and various other noisome insects.

It may be presumed that they have obtained the name of ants from the similarity in their manner of living with those insects, which is in large communities, that erect very extraordinary nests, for the most part on the surface of the ground; from whence their excursions are made through subterraneous passages or covered galleries, which they build whenever necessity obliges, or plunder induces them to march above ground, and at a great distance from their habitations, carry on a business of depredation and destruction scarce credible but to those who have seen it; but, notwithstanding they live in communities, and are, like the ants, omnivorous; though, like them, at a certain period they are furnished with four wings, and emigrate or colonize at the same season, they are by no means the same kind of insects, nor does their form correspond with that of ants in any one state of their existence.

The termites resemble the ants, indeed, in their provident and diligent labour, but surpass them, as well as the bees, wasps, beavers, and all other animals, in the art of building, as much as Europeans excel the most uncultivated savages. They shew more substantial instances of ingenuity and industry than any other animals; and do, in fact, lay up vast magazines of provisions and other stores; a degree of prudence which has of late years been denied, perhaps without reason, to the ants.

The communities consist of one male and one female, which are generally the common parents of the whole or greater part of the rest, and of three orders of insects, apparently very different species, but really the same, which together compose great commonwealths or rather monarchies.

The great Linnæus having seen or heard of but two of these orders, has classed the genus erroneously, for he has placed it among the aptera, or insects without wings; whereas the insect in its perfect state, having four wings without any sting, belongs to the neuroptera; in which class it will constitute a new genus of many species.

The different species of this genus resemble each other in form, in their manner of living, and in their good and bad qualities, but differ as much as birds in the manner of building their habitations or nests, and in the choice of the materials of which they compose them.

There are some species which build upon the surface of the ground, or part above and part beneath; and one or two species, perhaps more, that build on the stem or branches of trees.

There are of every species of termites three orders: 1. The working insects, which for brevity we shall call labourers. 2. The fighters or soldiers, which do not labour; and 3. The winged or perfect insects, which are male and female, and capable of propagation. From these the kings and queens are chosen, and nature has so ordered it, that they emigrate within a few weeks after their elevation to this state, and either establish new kingdoms, or perish within a day or two. Of these, the working insects or labourers are always the most numerous; among that species emphatically called termes bellicosus, which is the largest, there seem to be at the least one-hundred labourers to one of the fighting insects or soldiers. They are in this state about one-fourth of an inch long, and twenty-five of them weigh about a grain, so that they are not so large as some of our ants; from their external habits and fondness for wood, they have been very expressively called wood-lice by some people, and the whole genus has been known by that name, particularly among the French. They resemble them, it is true, very much at a distance; they run as fast or faster than any other insect of their size, and are incessantly in a bustle.

The second order, or soldiers, have a very different appearance from the labourers, and have been by some authors supposed to be the males, and the former neuters; but they are, in fact, the same insects as the foregoing, only they have undergone a change of form, and approached one degree nearer to the perfect state. They are much larger, being half an inch long, and equal in size to fifteen of the labourers. There is now, likewise, a most remarkable circumstance in the form of the head and mouth; for in the former state the mouth is evidently calculated for gnawing and holding bodies; but in this state, the jaws being shaped like two very sharp awls a little jagged, they are incapable of any thing but piercing or wounding, for which purposes they are well calculated, being as hard as a crab's claw and placed in a strong horny head larger than all the rest of the body together.

The insect in its perfect state is varied still more in its form; the head, thorax, and abdomen, differ almost entirely from the same parts in the labourers and soldiers; and, besides this, the animal is now furnished with four fine large brownish transparent wings, with which it is, at the time of emigration, to wing its way in search of a new settlement; in short, it differs so much from its form and appearance in the two other states, that it has never been supposed to be the same animal, but by those who have seen it in the same nest; and some of these have distrusted the evidence of their senses. It was so long before Mr. Smeathman met with them in the nests, that he doubted the information which was given him by the natives, that they belonged to the same family: indeed, twenty nests may be opened without finding one winged one; for those are to be found only just before the commencement of the rainy season, when they undergo the last change, which is preparative to their colonization. Add to this, they sometimes abandon an outward part of their building, the community being diminished by some accident that is unknown; sometimes different species of the real ant, formica, possess themselves by force of a lodgment, and so are frequently dislodged from the same nest, and taken for the same kind of insects. This is often the case with the nests of the smaller species, which are frequently totally abandoned by the termites, and completely inhabited by different species of ants, cockroaches, scolopendræ, scorpions, and other vermin fond of obscure retreats, that occupy different parts of their roomy buildings.

In the winged state, their size as well as form is altered. Their bodies in this state measure between six and seven-tenths of an inch in length, their wings above two inches and an half from tip to tip, and they are equal in bulk to about thirty labourers, or two soldiers. They are furnished with two large eyes placed on each side of the head; if they had any before, they are not easily to be distinguished. In this form the animal comes abroad during or soon after the first tornado, which at the latter end of the dry season proclaims the approach of the ensuing rains, and seldom waits for a second or third shower; if the first, as is generally the case, happen in the night, and bring much wet after it, the quantities that are to be found the next morning all over the surface of the earth, but particularly on the waters, is astonishing; for their wings are only calculated to carry them a few hours; and after the rising of the sun, not one in a thousand is to be found with four wings, unless the morning continues rainy, when here and there a solitary being is seen winging its way from one place to another, as if solicitous to avoid its numerous enemies, particularly various species of ants, which are hunting on every spray, on every leaf, and in every possible place for this unhappy race, of which probably not one pair in many millions are preserved to fulfil the first law of nature, and lay the foundation of a new community. Not only all kinds of ants, and other insects, but birds, and carnivorous reptiles, are upon the hunt for them, and the inhabitants of many countries eat them.

From one of the most active, industrious, and rapacious; from one of the most fierce and implacable little animals in the world, they are in this state changed into an innocent helpless insect, incapable of making the least resistance to the smallest ant. The ants are to be seen on every side in infinite numbers, of various species and sizes, dragging these annual victims to their different nests. Some are however so fortunate as to escape, and be discovered by the labouring insects that are continually running about the surface of the ground under their covered galleries, the little industrious creatures immediately inclose them in a small chamber of clay, suitable to their size, into which at first they leave but one small entrance, only large enough for themselves and the soldiers to go in and out, but necessity obliges them to make more entrances. The voluntary subjects charge themselves with the task of providing for the offspring of their sovereigns, as well as to work and to fight for them, until they shall have raised a progeny capable at least of dividing the task with them.

The business of propagation soon commences; and the labourers having constructed a small wooden nursery, hereafter to be described, carry the eggs and lodge them there as fast as they can obtain them from the queen.

About this time a most extraordinary change begins to take place in the queen, to which we know nothing similar, except in the pulex penetrans of Linnæus, the jigger of the West-Indies, and in the different species of coccus cochineal. The abdomen of this female begins gradually to extend and enlarge to such an enormous size, that an old queen will have it increased so as to be fifteen hundred or two thousand times the bulk of the rest of her body, and twenty or thirty thousand times the bulk of a labourer; the skin between the segments of the abdomen extends in every direction, and at last the segments are removed to half an inch distance from each other, though at first the length of the whole abdomen was not above half an inch. They preserve their dark-brown colour, and the upper part of the abdomen is marked with a regular series of brown bars, from the thorax to the posterior part of the abdomen, while the intervals between them are covered with a thin, delicate, transparent skin, and appear of a fine cream colour, a little shaded by the dark colour of the intestines and watery fluid seen here and there beneath. It is supposed that the animal is upwards of two years old when the abdomen is increased to three inches in length: they have sometimes been found of near twice that size. The abdomen is then of an irregular oblong shape, being contracted by the muscles of every segment, and is become one vast matrix full of eggs, which make long circumvolutions through an innumerable quantity of very minute vessels, that circulate round the inside in a serpentine manner, which would exercise the ingenuity of a skilful anatomist to dissect and develope. This singular matrix is not more remarkable for its amazing extension and size, than for its peristaltic motion, which resembles the undulation of waves, and continues incessantly without any apparent effort of the animal; so that one part or other is alternately rising and sinking in perpetual succession. The matrix seems never at rest, but to be always protruding eggs to the amount, in old queens, of sixty in a minute, or eighty thousand and upwards in one day of twenty-four hours.

These eggs are instantly taken from her body by her attendants, and carried to the nurseries, which in a great nest may some of them be four or five feet distant in a straight line, and consequently much farther by their winding galleries. Here the young, when they are hatched, are attended and provided with every thing necessary, until they are able to shift for themselves, and take their share of the labours of the community.

The termes bellicosus being the largest species, is most remarkable, and best known on the coast of Africa. It erects immense buildings of well-tempered clay or earth, which are contrived and finished with such art and ingenuity, that we are at a loss to say whether they are most to be admired on that account, or for their enormous magnitude and solidity. The reason that the larger termites have been most remarked is obvious; they not only build larger and more curious nests, but are also more numerous and do infinitely more mischief to mankind.*

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* It may appear surprizing, that a Being perfectly good should have created animals which seem to serve no other end but to spread destruction and desolation wherever they go. But let us be cautious in suspecting any imperfection in the Father of the universe: what, on a superficial view may seem only productive of mischief, will upon mature deliberation be found worthy of that wisdom which pervades every part of the creation. Many poisons prove valuable medicines; storms are beneficial; and diseases often preserve life, and are conducive to its future enjoyments. The termites, it must be allowed, are frequently pernicious to mankind, but they are also very useful, and even necessary; one valuable purpose which they serve, is, to destroy decayed trees and other substances, which, if left on the surface of the ground in hot climates, would in a short time pollute the air. In this respect, they resemble very much the common flies, which are regarded by the generality of mankind as noxious, and at best, as useless beings in the creation; but this is certainly for want of due consideration. There are not probably in all nature animals of more importance; and it would not be difficult to prove, that we should feel the want of one or two species of large quadrupeds much less than of one or two species of

The nests of this species are so numerous all over the island of Bananas, and the adjacent continent of Africa, that it is scarcely possible to stand upon any open place, such as a rice plantation, or other clear spot, where one of these buildings is not to be seen almost close to each other. In some parts near Senegal, as mentioned by M. Adanson, their number, magnitude, and closeness of situation, make them appear like the villages of the natives. These buildings are usually termed hills, by the inhabitants as well as strangers, from their outward appearance, which is that of little hills more or less conical, generally very much in the form of sugar-loaves, and about ten or twelve feet in perpendicular height above the common surface of the ground.

These hills continue quite bare until they are six or eight feet high; but, in time, the dead barren clay of which they are composed becomes fertilized by the genial power of the elements in these prolific climates, and the addition of vegetable salts and other matters brought by the wind; and in the second or third year the hillock, if not overshaded by trees, becomes like the rest of the earth, almost covered with grass and other plants; and

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these despicable looking insects. Nothing is more disagreeable or more pestiferous than putrid substances; and it is apparent to all who have made the observation, that these little insects contribute more to the quick dissolution and dispersion of putrescent matter than any other. They are so necessary in all hot climates, that even in the open fields a dead animal or small putrid substance cannot be laid on the ground two minutes, before it will be covered with flies and their maggots, which instantly entering, quickly devour one part, and, perforating the rest in various directions, expose the whole to be much sooner dissipated by the elements. Thus it is with the termites; the rapid vegetation in hot climates, of which no idea can be formed by any thing to be seen in this, is equalled by as great a degree of destruction from natural as well as accidental causes. When trees and even woods are in part destroyed by tornados or fire, it is wonderful to observe how many agents are employed in hastening the total dissolution of the rest; in this business none are so expert or so expeditious and effectual as the termites, who in a few weeks destroy and carry away the bodies of large trees without leaving a particle behind; thus clearing the place for other vegetables, which soon fill up every vacancy. See Encycl. Brit. art. Termes. Edit.

in the dry season, when the herbage is burnt up by the rays of the sun, it is not much unlike a very large hay-cock.

Every one of these buildings consists of two distinct parts, the exterior and interior. The exterior cover is one large clay shell, in the form of a dome, capacious and strong enough to inclose and shelter the interior building from the vicissitudes of the weather, and the inhabitants from the attacks of natural or accidental enemies. The external cover is always, therefore, much stronger than the interior building, which is the habitable part, divided with wonderful regularity and contrivance into an amazing number of apartments for the residence of the king and queen, for the nursing of their numerous progeny, and for magazines, which are always found well filled with stores and provisions.

These hills make their first appearance above ground by a little turret or two in the shape of sugar-loaves, which are run a foot high or more; soon after, at some little distance, while the former are increasing in height and size, they rise others, and so go on increasing the number, and widening them at the base, till their works below are covered with these turrets, which the insects always raise highest and largest towards the middle of the hill, and by filling up the intervals between each turret, collect them as it were into one dome. They are not very curious or exact about these turrets, except in making them very solid and strong; and when, by the junction of them, the dome is completed, for which purpose the turrets serve as scaffolds, they take away the middle ones entirely, except the tops, which joined together make the crown of the cupola, and apply the clay to the building of the works within, or to erecting fresh turrets for the purpose of raising the hillock still higher; so that no doubt some-part of the clay is used several times, like the boards and posts of a mason's scaffold.

The royal chamber, which, on account of its being adapted for, and occupied by the king and queen, appears to be in the opinion of this little people, of the most consequence, is always situated as near the center of the interior building as possible, and generally about the height of the common surface of the ground, at a pace or two from the hillock; it is always nearly in the shape of half an egg or an obtuse oval within, and may be supposed to represent a long oven. In the infant state of the colony, it is not above an inch, or thereabouts, in length; but in time will be increased to six or eight inches or more in the clear, being always in proportion to the size of the queen, who, increasing in bulk as in age, at length requires a chamber of such dimensions. The floor is horizontal, sometimes an inch thick and upward of solid clay; the roof also, which is one solid and well-turned oval arch, is generally of about the same solidity, but in some places it is not a quarter of an inch thick; this is on the sides where it joins the floor, and where the doors or entrances are made. These entrances will not admit any animal larger than the soldiers or labourers; so that the king, and the queen, who is when full grown a thousand times the weight of a king, can never possibly go out. The royal chamber, if in a large hillock, is surrounded by an innumerable quantity of others, of different sizes, shapes, and dimensions; but all of them arched, sometimes of a circular, sometimes of an elliptical form. These chambers either open into each other, or have communicating passages, and being always empty, are evidently made for the soldiers and attendants; of whom, it will soon appear, great numbers are necessary, and of course always in waiting.

These apartments are joined by the magazines and nurseries; the former are chambers of clay, and are always well filled with provisions, which to the naked eye seem to consist of the raspings of wood and plants, which the termites destroy, but are found by the microscope to be chiefly composed of the gums or inspissated juices of plants, thrown together in little masses, some of which are finer than others, and resemble the sugar about preserved fruits; others are like drops of gum. The magazines are intermixed with the nurseries, buildings totally different from the rest of the apartments, being composed entirely of wooden materials, seemingly joined together with gums. They are called nurseries because they are invariably occupied by the eggs and young ones, which appear at first in the shape of labourers, but as white as snow. These buildings are exceedingly compact, and divided into many very small irregular-shaped chambers, placed all round the royal apartments, and as near as possible to them.

When the nest is in the infant state, the nurseries are close to the royal chamber; but as in process of time the queen increases in size, it is necessary to enlarge the chamber for her accommodation; and as she then lays a greater number of eggs, and requires a more numerous train of attendants, so it is necessary to enlarge and increase the number of the adjacent apartments; for which purpose, the small nurseries which are first built, are taken to pieces, rebuilt a little further off, a size larger, and the number of them increased at the same time. Thus they continually enlarge their apartments, pull down, repair, or rebuild, according to their wants, with a degree of sagacity, regularity, and foresight, not even imitated by any other kind of animals or insects. The nurseries are inclosed in chambers of clay, like those which contain the provisions, but much more extensive. In the early state of the nest they are not larger than an hazel nut, but in great hills are often as large as a child's head of a year old.

The royal chamber is situated nearly on a level with the surface of the ground, at an equal distance from all the sides of the building, and directly under the apex of the hill. It is, on all sides, both above and below, surrounded by what may be called the royal apartments, which have only labourers and soldiers in them, and can be intended for no other purpose than for these to wait in, either to guard or serve their common father and mother, on whose safety depends the happiness, and, according to the account of the negroes, even the existence of the whole community.

These apartments form an intricate labyrinth, which extends a foot or more in diameter from the royal chamber on every side. Here the nurseries and magazines of provisions begin, and being separated by small empty chambers and galleries, which go round them, or communicate from one to the other, are continued on all sides to the outward shell, and reach up within it two-thirds or three-fourths of its height, having an open area in the middle under the dome, resembling the nave of an old cathedral. This area is surrounded by large gothic arches, which are sometimes two or three feet high next the front of the area, but diminish very rapidly as they recede from thence, like the arches of aisles in perspective, and are soon lost among the innumerable chambers and nurseries behind them. All these chambers, and the passages leading to and from them, being arched, contribute to support one another; and while the interior large arches prevent their falling into the center, and keep the area open, the exterior building supports them on the outside.

The interior building, or assemblage of nurseries, chambers, &c. has a flattish top or roof without any perforation; by this contrivance, if any water should penetrate the external dome, the apartments below are preserved from injury. It is never exactly flat and uniform, because they are always adding to it by building more chambers and nurseries: so that the divisions or columns between the future arched apartments resemble the pinnacles upon the fronts of some old buildings, and demand particular notice, as affording one proof that for the most part the insects project their arches, and do not make them by excavation. The area is likewise water-proof, and contrived so as to let the water off, if it should get in and run over, by some short way, into the subterraneous passages, which run under the lowest apartments in the hill in various directions, and are of an astonishing size, being wider than the bore of a great cannon. There is an account of one that was measured, which was perfectly cylindrical, and thirteen inches in diameter.

These subterraneous passages or galleries are lined very thick with the same kind of clay of which the hill is composed, and ascend the inside of the outward shell in a spiral manner; winding round the whole building up to the top, they intersect each other at different heights, opening either immediately into the dome in various places, and into the interior building, the new turrets, &c. or communicating thereto by other galleries of different bores or diameters, either circular or oval.

From every part of these large galleries are various small pipes or galleries, leading to different parts of the building; under ground there are a great many which lead downward, by sloping descents three and four feet perpendicular among the gravel, from whence the labouring termites cull the finer parts, which being worked up in their mouths to the consistence of mortar, becomes that solid clay or stone, of which their hills and all their buildings, except the nurseries, are composed. Other galleries again ascend and lead out horizontally on every side, and are carried under ground near to the surface, a vast distance.

There is a kind of necessity for the galleries under the hills being thus large, as they are the great thoroughfares for all the labourers and soldiers going forth or returning upon any business whatever, whether fetching clay, wood, water, or provisions; and they are certainly well calculated for the purposes to which they are applied, by the spiral slope which is given them.

Those species which build either the roofed turrets, or the nests in the trees, seem in most instances to have a strong resemblance to the preceding, both in their form and œconomy, going through the same changes from the egg to the winged state. The queens also increase to a great size when compared with the labourers, but very short of those queens before described. The largest are from about an inch to an inch and an half long, and not much thicker than a common quill. There is the same kind of peristaltic motion in the abdomen, but in a much smaller degree; and as the animal is incapable of moving from her place, the eggs, no doubt are carried to the different cells by the labourers, and reared with a care similar to that which is practised in the larger nests.

It is remarkable of all these different species, that the working and the fighting insects never expose themselves to the open air, but either travel under ground, or within such trees and substances as they destroy; except, indeed, when they cannot proceed by their latent passages, and find it convenient or necessary to search for plunder above ground: in that case they make pipes of that material with which they build their nests. The larger sort use the red clay; the turret builders use the black clay; and those which build in the trees employ the same ligneous substance of which their nests are composed.

The termites, except their heads, are exceedingly soft, and covered with a very thin and delicate skin; being blind, they are no match on open ground for the ants, who can see, and are all of them covered with a strong horny shell not easily pierced, and are of dispositions bold, active, and rapacious..

Whenever the termites are dislodged from their covered ways, the various species of formicæ or ants, who probably are as numerous above ground, as the latter are in their subterraneous passages, instantly seize and drag them away to their nests, to feed the young brood. The termites are, therefore, exceedingly solicitous about the preserving their covered ways in good repair; and if you demolish one of them for a few inches in length, it is wonderful how soon they re-build it. At first in their hurry they get into the open part an inch or two, but stop so suddenly, that it is very apparent they are surprized; for, though some run straight on, and get under the arch as speedily as possible in the further part, most of them run as fast back, and very few will venture through that part of the track which is left uncovered. In a few minutes you will perceive them re-building the arch, and by the next morning they will have restored their gallery for three or four yards in length, if so much has been ruined; and upon opening it again, will be found as numerous as ever under it, passing both ways. If you continue to destroy it several times, they will at length seem to give up the point, and build another in a different direction; but, if the old one should lead to some favourite plunder, in a few days will re-build it again, and, unless you destroy their nest, never totally abandon their gallery.

OF THE HABITATIONS OF CATERPILLARS.

Though the view which has already been given of the various proceedings of insects in forming their habitations, has extended to some length, I cannot with propriety omit noticing the wonderful art and industry which is manifested in these respects by the caterpillar; and more particularly so, as from the larva state the foundation of all our present knowledge of the natural history of insects has been obtained.

Some species of caterpillars form a kind of hammock, in which they eat and go through their various changes; while others erect a silken tent, under which they live until they have consumed the surrounding herbs. They then leave their abodes, and pitch their tents in a more fruitful spot.

Many associate together all their lives; these proceed from the same moth, who deposited her eggs near each other, or rather laid them in a heap, forming as it were a kind of nest. They are generally hatched on the same day, and, living together, constitute a new species of republic, in which all are brethren. They often amount to near six hundred in a family, though they are frequently to be found with only about two hundred. Of these social caterpillars there are some species which not only continue with the society while they are in a larva state, but even place their pupæ close together. There are other kinds who associate only for a short period.

Among the vast variety of insects which inhabit the oak, there is a species of caterpillar which live separate till they arrive at a certain age; they then assemble together, and do not quit each other till they attain their perfect state. As the number thus assembled is considerable, the nest is also very large. They remain in-doors during the day, not leaving their habitation till sun-set. When they go out, one of the body precedes the rest as a chief, whom they regularly follow; when the leader stops, the rest do the same, and wait till it goes on again, before they recommence their march. The first file generally consists of a single caterpillar, which is succeeded by a double file; these, by three in a row, which are then followed by files of five, and so on. They keep exceeding close to each other, not leaving any interval either between the ranks, or those in each rank; all of them following their captain in every direction, whether straight or crooked. After they have taken their repast, which is done on the march, they return to their nest in the same order in which they set out.

This mode is followed till they are full grown, when each forms a cone, in which it is changed into a chrysalis. M. Bonnet has shewn, that though these caterpillars proceed often very far from their nest, it is by no means difficult for them to get back again, because they spin over all the places in their rout. The first leads the way, the second follows spinning, the third spins after the first and second, and so on with the rest. All these threads form by degrees a small shining track, a little path; and all these paths meet at the nest. To be fully convinced of the use of these threads, let any one but break the continuation of them in some particular part, and he will see the little caterpillars turn back, as if they were at a loss, till one more daring than the rest restores the communication by spinning new threads.

The reader who is desirous of a fuller information concerning the habits of these, as well as many other insects, must be referred to the laborious and interesting memoirs of Reaumur. Happy if he should, like De Geer, be induced thereby to follow the steps of so great a master; he will derive from thence a continual source of new pleasures and increasing delights; and the more he extends the boundaries of his observations, the more he will be convinced that INFINITY is, as it were, impressed on all the works of the CREATOR.

Different species of caterpillars are often to be found in great numbers on the same tree or plant; but then as they seem to have no connection with each other, and the actions of the one have no influence on the rest, they may be considered as solitary; but there are others who seem still more independent of each other, and greater friends to solitude, constructing a lodging formed of leaves tied together with considerable ingenuity, in which they live as in a hermitage. The operation by which these tie the leaves together, is far surpassed by another kind, who fold and bend one part of the leaf till it meets the other. These are again exceeded by those who roll the leaves which they inhabit. For this purpose the caterpillar chooses a part of a leaf which it finds in some degree bent; here it establishes its abode, and begins its work, moving the head with great velocity in a curved line, or rather vibrating it like a pendulum, the middle of the body being the center on which it moves. At each motion of the head a thread is spun, and fixed to that part to which the head seems to be applied. The threads are extended from the bent to the flat part of the leaf, being always adjusted both in length and strength to the nature of the leaf, and the curvature which is to be given to it.

De Geer attending to the operations of a species of this kind of caterpillar, observed that at each new thread it spun, the edges of the leaf insensibly approached to each other, and were bent more and more, in proportion as the caterpillar spun new threads; when the last thread that was spun was tight, that which preceded it was loose and floating in the air. To effect this, the caterpillar, after it has fixed a thread to the two edges of the leaf, and before it spins another, draws it towards itself by the hooks of its feet, and by these means bends the leaf; it then spins another thread, to maintain the leaf in this position, which it again pulls towards itself, and repeats the operation, till it has bent the leaf in its whole direction. It now begins again, placing the threads further back upon the bent part of the leaf, and by proceeding in this manner, it is rolled up; when it has finished this business, it strengthens the work, by fastening the ends of the leaf together. The habitation thus formed is a kind of hollow cylinder, open to the light at both ends, the sides of it affording the insect food and protection, for within it the creature feeds in fafety. In the same case they are also transformed; at the approach of the change the caterpillar lines the rolled leaf with silk, that the rough parts of it may not injure the chrysalis.

A great number of the smaller larvæ require an artificial covering, to protect them from the open air. Among these, some inhabit the interior parts of leaves, making their way between the superior and inferior membranes, living upon the parenchymous parts of the leaf; and as they are exceedingly small, a leaf affords them a spacious habitation. If the distance between the membranes be not large enough for them, they enlarge the space by forming different folds in one of them, in which they can move with ease: from these circumstances they have been named by Reaumur miners of leaves. This illustrious author has described these larvæ, the flies into which they are changed, and all the various methods made use of by them in performing this work. Some mine a large oval or circular space; others form a kind of gallery, which is sometimes straight, sometimes crooked. They only leave a thin membrane on the upper side of the leaf; but they leave the under side more substantial. One species of moth which proceeds from these larvæ is very small but exceedingly beautiful.

The larvæ of the phryganea mostly live in little cases of their own building, which are formed of a variety of materials, that they train after them in the water wherever they go. These cases are generally cylindrical, and open at both ends; the inside is lined with silk spun by the larva, the outside formed of different substances, as bits of reed, stone, gravel, and some entirely of small shells, &c. which they arrange and manage with singular dexterity: they never quit this case. When they walk, they put out the head, and a few of the first rings of the body, training the case after them.

Having lived in the water for some time, they become inhabitants of the air. They assume the pupa form in the water, closing up the two ends of the case with bars of silk, by which it is secured from the attacks of its enemies; and at the same time there is a free passage for the water, which is still necessary for its existence. At a proper period the pupa forces its way through the case, and makes for the land, where its further change instantly commences, and is soon completed.

We shall close these specimens of the industry of insects with an account of that which is displayed by the larvæ of the tineæ. The greatest part of the body of these little creatures, except the head and six fore feet, is covered over with a thin tender skin; the body of the insect is cylindrical, and lodged in a tube which is open at both ends. Soon after they are born, they begin to cover themselves, and are, therefore, seldom to be found but in these tubes or cases. They are in general so small, that it is not easy to distinguish the cases without a magnifier; but as the body lengthens, the case becomes too short; it is, therefore, part of its daily employ to lengthen it. For this purpose it extends the head beyond the tube, and having found the materials which answer its purpose, it tears it off, and brings it to the end of the tube, and fixes it there, repeating this manœuvre till it has sufficiently lengthened it. After it has finished one end, it turns itself round within the case, and performs the same operation at the other.

This does not terminate their labours, for the tube must also be increased in diameter, as it soon becomes too small for the body; the means they make use of to enlarge it, is precisely the same as we ourselves should adopt under similar circumstances. The insect slits the tube at the two opposite sides, at the same end, and inserts in the slit two pieces of the required size; it then performs the same at the other end. By these means they soon enlarge it sufficiently, without exposing themselves to the air during the operation. The outside of these cases is made of silk, hair, &c. the inside is of silk only. Their covering always partakes of the colour of the cloth or tree, &c. from whence it was taken; if it pass over a red piece, the colour will be red. When they are come to their perfect growth, they abandon the cloth, and seek for a proper place wherein they may pass from their present to a more perfect state.

I cannot conclude this long chapter better than in the words of Mr. Stillingfleet. "Many are apt to treat with contempt any man whom they see employed in poring over a moss, or examining an insect, from day to day, thinking that he spends his time and his life in unimportant and barren speculations; yet were the whole scene of nature laid open to our views, were we admitted to behold the connections and dependences of every thing on every other, and to trace the œconomy of nature through the smaller, as well as greater parts of this globe, we might, perhaps, be obliged to own that we were mistaken; that the Supreme Architect had contrived his works in such a manner, that we cannot properly be said to be unconcerned in any one of them; and, therefore, that studies, which seem upon a slight view to be quite useless, may in the end appear of no small importance to mankind. Nay, were we only to look back into the history of arts and sciences, we must be convinced that we are apt to judge over hastily of things of this nature. We should there find many proofs that he who gave this instinctive curiosity to some of his creatures, gave it for good and great purposes, and that he rewards with useful discoveries all these minute researches.

" It is true, this does not always happen to the searcher, or his contemporaries, nor even sometimes to the immediate succeeding generation; but I am apt to think, that advantages of one kind or other always accrue to mankind from such pursuits; some men are born to observe and record what perhaps by itself is perfectly useless, but yet of great importance to another who follows and goes a step further, still as useless; to him another succeeds, and thus by degrees, till at last one of a superior genius comes, who laying all that has been done before this time together, brings on a new face of things, improves, adorns, exalts human society.

" All those speculations concerning lines and numbers, so ardently pursued, and so exquisitely conducted by the Grecians, what did they aim at? or what did they produce for ages? a little arithmetic, and the first elements of geometry, were all they had need of. This Plato asserts; and though, as being himself an able mathematician, and remarkably fond of these sciences, he recommends the study of them; yet he makes use of motives that have no relation to the common purposes of life.

" When Kepler, from a blind and strong impulse, merely to find analogies in nature, discovered that famous one between the distance of the several planets from the sun, and the periods in which they complete their revolutions, of what importance was it to him or the world?

"Again; when Galileo, pushed on by the same irresistible curiosity, found out the law by which bodies fall to the earth, did he, or could he foresee that any good would come from his ingenious theorems; or was any immediate use made of them?

"Yet had not the Greeks pushed their abstract speculations so far, had not Kepler and Galileo made the above-mentioned discoveries, we never could have seen the greatest work that ever came from the hands of man, Sir Isaac Newton's Principia.

"Some obscure person, whose name is not so much as known, diverting himself idly, as a stander-by would have thought, with trying experiments on a seemingly contemptible piece of stone, found out a guide for mariners on the ocean, and such a guide as no science, however subtil and sublime its speculations may be, however wonderful its conclusions, would ever have arrived at. It was mere curiosity that put Sir Thomas Millington upon examining the minute parts of flowers; but his discoveries have produced the most perfect and most useful system of botany that the world has yet seen.

"Other instances might be produced to prove, that bare curiosity in one age, is the source of the greatest utility in another; and what has frequently been said of chemists, may be applied to every other kind of vertuosi. They hunt, perhaps, after chimeras and impossibilities; they find something really valuable by the bye. We are but instruments under the Supreme Director, and do not so much as know, in many cases, what is of most importance for us to search after; but we may be sure of one thing, viz. that if we study and follow nature, whatever paths we are led into, we shall at last arrive at something valuable to ourselves and others, but of what kind we must be content to remain ignorant."

CHAP. VI.

A GENERAL VIEW OF THE INTERNAL PARTS OF INSECTS, AND MORE PARTICULARLY OF THE CATERPILLAR OF THE PHALÆNA COSSUS---A DESCRIPTION OF SUNDRY MISCELLANEOUS OBJECTS.

THE interior part of insects includes four principal viscera; the spinal marrow, the intestinal bag, the heart, and tracheal vessels.

The spinal marrow, or principal trunk of the nerves of insects, is a whitish thread, extended the whole length from the head to the hindermost part, furnished at intervals with small knots or ganglions. From these knots proceed the nervous threads that are supposed to be the instruments of sensation and motion.

On the medullary thread is placed the intestinal bag, which is equal to it in length; it is a long gut, in which are contained the oesophagus, the stomach, and intestines.

Along the back, and parallel to the intestinal bag, runs a long thin vessel, in which may be perceived through the skin of the insect alternate contractions and dilatations; this part is supposed to perform the functions of the heart.

The tracheal vessels of insects are very similar to those of plants; are of the same structure, colour, and elasticity, and are, like them, dispersed through the whole body.

A clearer idea of these parts will be obtained by the short extract I shall give of M. Lyonet's work; which, at the same time that it displays the wonderful organization of insects, shews how worthy it is of the attention of a rational being; and, though this description is confined to a particular species, it will be found to accord in general with a great number.

Of all the modifications of which matter is susceptible, the most noble is undoubtedly the organization thereof. In the structure of animals, the Sovereign Wisdom is exhibited to our view in the most striking manner. The body of an animal is a little particular system more or less complicated, and which, like the system of the universe at large, is the result of the combination and connection of a multitude of different parts, which all conspire to produce one general effect, the manifestation of the principle which we term life. So wonderful are these combinations that we are incapable of comprehending, or even of admiring sufficiently the astonishing apparatus of springs, levers, counter-weights, tubes of different diameters, &c. which constitute these organical machines. The interior parts of the insect, the most despicable in appearance, would absorb all the powers of the most able anatomist. He would be lost in the labyrinth as soon as he attempted to explore all its windings. A truth that will be evident to every one who considers only the small portion here introduced of the anatomy of the caterpillar inhabiting the trunk of the willow-tree. This caterpillar produces the phalæna cossus, or goat-moth. M. Lyonet in his admirable work entitled, "Traite Anatomique de la Chenille qui ronge le Bois de Saule," has given an ample and minute description of this insect. In the following concise abstract enough will appear to convince the reader of the utility of microscopic glasses, in displaying the wonders of the creation, and to afford additional proof that the attention of the Almighty is not confined merely to objects of magnitude.

In a former edition of this work, I entered into a more minute detail of the several parts contained in the figures exhibited in plate XII. This account I have now omitted, as after all it could not convey a clear idea of the muscles alone, much less of the different parts of the caterpillar, without a reference to other plates of M. Lyonet's work. I therefore concluded it would be better to let the figures speak for themselves, and then give a general description of the interior parts of the caterpillar; referring the reader for full particulars to the original.

Figures 1 and 2 represent the muscles of the caterpillar, when it is opened at the belly. Fig. 3 and 4 exhibit a view of the muscles when it is opened at the back. Fig. 5 and 6, an anatomical delineation of the head; so complex is this organ, that in order to give an adequate idea of its structure, M. Lyonet has employed no less than twenty figures. Fig. 7 is an out-line of the head more magnified than in the last figures. In order to obtain the views here exhibited, the muscles were freed as well from fat, as from the nerves and other vessels.

The BODY of the caterpillar in the Plate Fig. 2 and 3, is divided into twelve parts, corresponding to its rings marked by the numbers 1 to 12; to the first number the word RING is affixed. Each of these rings is distinguished from that which follows, and that preceding it, by a kind of neck or small hollow part. By conceiving a line to pass through these necks, and forming boundaries to the rings, we acquire twelve more divisions, Fig. 1 and 4; these are also marked with the numbers 1 to 12; to the first the word DIVISION is annexed. The several parts exhibited in the divisions, Fig. 1, are the muscles; those in Fig. 2, under the word ring, are also muscles, which appear when those in Fig. 1 are removed, lying under them.

The anatomical delineation of the muscles of the head, Fig. 5 and 6, should be considered as consisting of two figures, which join in the middle, being terminated by the superior and inferior lines. The head, as here represented, is magnified about three-hundred times. H H are the two palpi: the truncated muscles d, belong to the lower lip, and form a part of those which give it motion: K, the two ganglions of the neck united: I I, the two silk vessels: L, the oesophagus: M, the two dissolving vessels: the Hebrew letters denote the continuation of the cephalic arteries: S T U W and X are the ten abductor muscles of the jaw: under e e and f f are seen four occipital muscles: a a, a nerve of the first pair, belonging to the ganglion of the neck; b, a branch of this nerve.

Fig. 7 is an outline of the head magnified considerably more than in the last figure, exhibiting the nerves as seen from the under part. Excepting in two or three instances, only one nerve of each pair is shewn, as a greater number would have occasioned confusion. The nerves of the first ganglion of the neck are designed by capital letters; those of the ganglion a, are distinguished by Roman letters; those of the small ganglion, by Greek characters; and those of the frontal ganglion, except one, by numbers.

A GENERAL VIEW OF THE INTERIOR PARTS OF THE CATERPILLAR.

The MUSCLES have neither the exterior form, nor the colour of those of larger animals. In their natural state they are soft, and have the appearance of a jelly; they are of a greyish blue, and the silver-coloured appearance of the aerial or pulmonary vessels, which creep over and penetrate their substance, exhibits under the microscope a most beautiful spectacle. When the caterpillar has been soaked for some time in spirit of wine, they lose their elasticity and transparency, and become firm, opake, and white; the aerial vessels disappear. At first sight they might be taken for tendons, as they are of the same colour and possess almost the same lustre. They are generally flat, and of an equal size throughout; the middle seldom differs either in colour, substance, or size, from the extremities. The ends are fixed to the skin; the rest of the muscle is generally free and floating; several of them branch out considerably; the branches extend sometimes so far, that it is not always easy to discover whether they are distinct and separate muscles, or parts of another. They are of a moderate strength; those that have been soaked in spirit of wine, when examined by the microscope, will be found to be covered with a membrane which may be separated from them; they then appear to consist of several parallel bands, disposed according to the length of the muscle. These, when divided by the assistance of very fine needles, appear to be composed of still smaller bundles of fibres, in the same direction; which, when examined by a very deep magnifier, and in a favourable light, appear twisted like a small cord. The muscular fibres of the spider, which are much larger than those of the caterpillar, are found on examination to consist of two substances, one soft, and the other hard; the last is twisted round the former spirally, and thus gives to it the afore-mentioned cord-like appearance. If the muscles are separated by means of very fine needles, in a drop of some fluid, we find that they are not only composed of fibres, membranes, and aerial vessels, but also of nerves; and, from the drops of oil that may be seen floating on the fluid, that they are also furnished with many unctuous particles. The muscles in a caterpillar are very numerous, exceeding by much those of the human body; the reader may form some idea of their number by inspecting Fig. 1 2 3 and 4 of Plate XII. They occupy the greatest part of the head; there is an amazing number at the oesophagus, the intestines, &c. the skin is as it were lined by different beds of them, placed one under the other, and ranged with very great symmetry. The number of muscles that our observer has been able to distinguish is truly astonishing; he found 228 in the head, 1647 in the body, and 2066 in the intestinal tube, making in all 3941!

The SPINAL MARROW, and the brain of the caterpillar, if it can be said to have any, seem to have very little relation to those of man; in the last, the brain is inclosed in a bony cavity; it occupies the greatest part of the head, and is anfractuose, and divided into lobes. There is nothing similar to this in the caterpillar; we find indeed in the head of that which we are describing, a part which seems to answer the purpose of the brain, because the nerves that are disseminated through the head are derived from it; but then this part is unprotected, and so small, that it does not occupy one-fifth part of the head; the surface is smooth, and has neither lobes nor anfractuousness; and if we must call this a brain, the caterpillar may be said to have thirteen, as there are twelve more such parts following each other in a line; they are nearly of the same size with that in the head, and of the same substance, and it is from them that the nerves are distributed through the whole body. Lest the idea of thirteen brains might be disagreeable to his readers, Lyonet has called these parts ganglions. The spinal marrow in the human species descends down the back, inclosed in a bony case; is large with respect to its length, and not divided into branches, diminishing in thickness in proportion as it is removed further from the brain. In the caterpillar, the spinal marrow goes along the belly, is not inclosed in any tube, is very small, forks out at intervals, and is nearly of the same thickness throughout, except at the ganglions. For a description of the numerous vessels, and curious texture of these parts, reference must be had to the original work of Lyonet. The substance of the spinal marrow, and of the ganglions, is not near so tender and easily separated as in man; it has a very great degree of tenacity, and does not break without considerable tension. The substance of the ganglions differs from that of the spinal marrow, as no vessels can be discovered in the latter, whereas the former are full of very delicate ones. The patient anatomist of the caterpillar has counted forty-five pair of nerves, and two single ones; so that there are ninety-two principal nerves, whose ramifications are innumerable.

The TRACHEAL ARTERIES of the caterpillar are two large aerial elastic vessels, which with their numerous ramifications may be pressed close together, and drawn out considerably, but return immediately to their usual size when the tension ceases; they creep under the skin close to the spiracula, one at the right side of the insect, the other at the left, each of them communicating with the air, by means of nine spiracula; they are nearly as long as the body, beginning at the first spiraculum, and going a little farther than the last, terminating in some branches which extend to the extremities of the body. Round about each spiraculum the tracheal artery pushes forth a great number of branches, which are again divided into smaller ones; these further subdivide, and spread through the whole body of the caterpillar. This vessel and its principal branches are composed of three coats, which may be separated one from the other. The exterior covering is a thick membrane, furnished with a great number of fibres, which describe a vast variety of circles round it, communicating with each other by numerous shoots. The second is very thin and transparent; no particular vessel is distinguished in it. The third is composed of scaly threads, which are generally turned in a spiral form, and come so near each other, as scarce to leave any interval; these threads are curiously united with the membrane which occupies the intervals, and form a tube which is always open, notwithstanding the flexure of the vessel. There are also many other peculiarities in its structure, which cannot be well explained without more plates. The principal tracheal vessels branch out into 236 smaller ones, from which there spring 1326 different ramifications.

The part of the caterpillar which naturalists call the HEART, without being certain that it performs the functions thereof, is of a nature very different from that of larger animals. It is almost as long as the caterpillar itself, lies immediately under the skin at the top of the back, entering into the head, and terminating near the mouth. It is large and spacious towards the last rings of the body, and diminishes very much as it approaches the head, from the fourth to the twelfth division; it has on both sides, at each division, an appendage, which partly covers the muscles of the back; but, growing narrower as it approaches the lateral line, forms a number of irregular lozenge-shaped bodies. This muscular tube has been called the heart of the caterpillar; first, because it is generally filled with a kind of lymph, which has been supposed to be the blood of the caterpillar; secondly, because in all caterpillars, whose skin is in some degree transparent, continual, regular, and alternate dilatations and contractions may be perceived along the superior line, beginning at the eleventh ring, and going on from ring to ring to the fourth, whence this vessel has been considered as a file of hearts; but still this viscera seems to have very little relation to the heart of larger animals; we find no vessel opening into it, to answer to the aorta, vena cava, &c. &c. Near the eighth division are two white oblong masses, that join the tube of the heart; they have been called reniform bodies, because they are something similar to a kidney in their shape.

The CORPUS CRASSUM is, with respect to volume, the most considerable part of the whole caterpillar; it is the first and only substance that is seen on opening it, forming a kind of sheath, which envelopes and covers all the entrails, and introducing itself into the head, enters all the muscles of the body, filling the greatest part of the empty spaces in the caterpillar. It is of a milk-white colour. In its configuration it is very similar to the human brain. When the different masses of the corpus crassum which covers the entrails are removed, the largest parts are the oesophagus, the ventricle, and the large intestines.

The OESOPHAGUS descends from the bottom of the mouth to about the fourth division. The anterior part which is in the head is fleshy, narrow, and fixed by different muscles to the crustaceous parts thereof; the lower part which passes into the body is wider, and forms a kind of membranaceous bag, which is covered with very small muscles; near the stomach it is again narrower, and is as it were bridled by a strong nerve, which is fixed to it at distant intervals.

The VENTRICLE begins a little above the fourth division, where the oesophagus finishes, and terminates at the tenth division; it is about seven times longer than it is broad; the anterior part, which is the broadest, is generally folded. The folds diminish with the bulk, in proportion as it approaches the intestines. An assemblage of nerves cover the surface, it is surrounded by a number of aerial vessels, and opens into a tube, which Lyonet calls the large intestine.

There are three of these large tubes or INTESTINES, each of which differs from the other so much, both in structure and character as to require a particular name to distinguish them; though this is not the place to enumerate these characteristic differences. As most caterpillars are endued with a power or faculty of spinning, they are provided with two vessels where the substance is prepared, which, when drawn out, and extended in the air, becomes a silken thread; these two vessels are termed the silk-vessels or tubes; in the caterpillar of the cossus, they are often above three inches long, and are distinguished into three parts, the anterior, the intermediate, and posterior. It has also two other vessels, which are supposed to prepare and contain the liquor by which it dissolves the wood on which it feeds.

Thus have we endeavoured to give the reader some idea of the wonderful organization of this apparently imperfect animal. Assuredly the four-thousand* muscles employed in the construction of the caterpillar of the cossus cannot be considered without the deepest astonishment: their admirable co-ordination and junction with other parts equally numerous, yet all harmonizing and acting together as if they were essentially one, naturally lead the mind to consider the nature and perfection of creation, and to perceive that it is an exhibition of the highest wisdom; and that this wisdom, which in the minutest things gives evidence of such an immense attention to order and use, has, no doubt, framed the whole for some great purpose; but what that purpose is, exceeds the present limits of the human understanding to discover.

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* Lyonet sur la Chenille de Saule, p. 584.

A DESCRIPTION
OF
SUNDRY MISCELLANEOUS OBJECTS,
EXHIBITED
IN SEVERAL PLATES OF THIS WORK.

OF THE LEPAS ANATIFERA OR BARNACLE.*

Plate XIII. Fig. 1 and 2.

This is a tender and brittle shell-fish of a very peculiar species; its length is about an inch, and its diameter about three quarters of an inch. The shell is not composed of two pieces or valves, as in others, but of five; two of these are larger than the rest, to which are affixed two smaller ones; the fifth piece is long, slender, and crooked, running down length-ways, and covering the joinings of the other pieces. The shell part is of a pale red, variegated with white; it adheres to a neck or pedicle of an inch long, and about a fifth of an inch in diameter; by which means it affixes itself to old wood, to stones, to sea-plants, or any other solid substance that lies under water. It can shorten or extend this neck at pleasure, which resembles a small gut, and is usually full of a glareous liquor; it is composed of two membranes, an external one, hard and brown, an internal one, soft

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* This animal is classed by Linnæus among the Vermes Testaceæ. Its generic character is: Animal, resembling a triton; Shell, consisting of several unequal valves; affixed by its base. Specific character: Pedunculated Barnacle, with compressed shell consisting of five valves. Syst. Nat. p. 1107, 1109. Edit.

and of an orange colour. The large portions of the shell open and shut in the manner of the bivalves; the others, being moveable by means of their membranaceous attachments, give way to the opening of these, and to the motions of the body of the fish in any direction. It is furnished with a cluster of filaments or tentacula, placed in a row on each side, usually twelve, sometimes fourteen in number. They are a kind of arms appropriated for catching its prey, and therefore placed so as to surround the mouth of the animal, which is situated between them, and consequently easily receives what they thrust towards it. By the motion of these arms, which may be exerted in such a manner as to play either within or without the cavity of the shell, it forms a current of water, which brings with it the prey it feeds upon. Fig. 1 represents two of these arms as magnified by the microscope; Fig. 2, the natural size of those from which these drawings were made. Each arm consists of several joints, and each joint is furnished on the concave side of the arm with a brush of fibrillæ or long hairs. The arms, when viewed in the microscope, seem rather opake; but they may be rendered transparent, and form a most beautiful object, by extracting out of the interior cavity a bundle of longitudinal fibres, which runs the whole length of the arm. Mr. Needham * thinks the motion and use of these arms illustrates the nature of that rotatory motion which some writers have thought they discovered in the wheel animal.

In the midst of the arms is a hollow trunk, consisting of a jointed fibrous or hairy tube, which incloses a long round tongue or proboscis, that the animal can push occasionally out of the

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* Needham's Microscopical Observations.

tube or sheath, and retract at pleasure. The mouth of this animal is singular in its kind, consisting of six laminæ, which go off with a bend, indented like a saw on the convex edge, and by their circular disposition are so ranged, that the teeth in the alternate elevation and depression of each plate, act against whatever intervenes between them. The plates are placed together in such a manner, that to the naked eye they form an aperture not much unlike the mouth of a contracted purse.

The western isles of Scotland, and some other parts of the British dominions, are abundantly stored, at certain times of the year, with a bird of the goose kind, commonly known in those places by the name of the brent goose or barnacle. These birds rarely breed with us, but seek, for their sitting season, islands less frequented than those where we find them in common. The seeing the birds so frequent, and yet never finding any of their nests, induced ignorant people to believe they never had any, and that they were not bread like other birds.

About the very shores where these birds are most common, the lepas anatifera is also found in great abundance. The fishermen, who observed vast quantities of these shells affixed to rotten wood, or dead trees that were floating in the water, or lodged by it on the shore, were soon led to imagine that the fibrous substances that hung out of them resembled feathers, and persuaded themselves that the geese, whose origin they could before by no means make out, were bred from them, instead of being hatched, like other birds, from eggs.* It was afterwards affirmed, that the shells themselves originally grew on the trees, in the manner of their fruit; and that the young bird, having in the shell ob-

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* Hill's Natural History of Animals.

tained its plumage, dropt from thence into the water. From this arose the opinion that the barnacle or brent goose was the produce of a tree.*

OF THE LEUCOPSIS DORSIGERA.

Plate XVII. Fig. 1, 2, and 3.

This very beautiful and singular insect was first pointed out to me by T. Marsham, Esq. Sec. L. S. who had seen it in the cabinet of insects belonging to the Queen, in the royal observatory at Richmond. Her Majesty was pleased to permit me to have the drawing taken from it, from which this plate was engraved. When Mr. Marsham first saw it at Richmond, he considered it as a non-descript insect, and an unique in this country. But he has since found that it is mentioned by Fabricius, in his Systema Entomologiæ, as a new genus under the name of leucospis dorsigera. There is one of the insects in the cabinet of the celebrated Linnæus, now in the possession of J. E. Smith, M. D. F. R. S. & Pr. L. S. Sulz, and other writers, have also described it.

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* The absurd idea, that the brent goose or barnacle derived its origin from this shell, was not confined to the illiterate; men of science, incautiously confiding in the bold assertions of the ignorant, appear to have given full credit to this truly curious hypothesis, and disseminated the knowledge of it in their writings. Even Gerard, the author of the Herbal, caught the infection: so confident was he of the fact, that he invited the credulous to apply to him for full satisfaction; his words are, " For the truth hereof, if any do doubt, may it please them to repaire unto me, and I shall satisfie them by the testimonie of good witnesses." See his Herbal, page 1587.

Barbut says, " This fabulous account originated from the sea-fowls, when ready to lay their eggs, depositing them on the marine plants; and, pecking sometimes these anatiferous shells, oblige the fish to come out, which having devoured, they lay eggs in their place. The young when hatched break through their prison, and fly away." Genera Vermium, Pars ii. page 13.

EDIT.

It appears at first sight like a wasp, to which genus the folded wings would have given it a place, had not the remarkable sting or tube on the back removed it from thence. It is probably a species between, and uniting the sphex and wasp, in some degree partaking of the characters of both. The antennæ are black and cylindrical, increasing in thickness towards the extremity; the joint nearest the head is yellow, the head is black, the thorax is also black, encompassed round with a yellow line, and furnished with a cross one of the same colour near the head. The scutellum is yellow, the abdomen black, with two yellow bands, and a spot of the same colour on each side between the bands. A deep black polished groove extends down the back, from the thorax to the anus, into which the sting turns and is deposited, leaving the anus very circular; a yellow line runs on each side the sting. The anus and the whole body, when viewed with a shallow magnifier, appear punctuated; these points, when examined in the microscope, appear hexagonal, as in the plate; and in the center of each hexagon a small hair is to be seen; the feet are yellow, the hinder thighs very thick and dentated, forming also a groove for the next joint; they are yellow with black spots. This insect is found in Italy, Switzerland, France, and Germany. Fig. 1 shews it very much magnified; Fig. 2 is a side view of it less magnified; Fig. 3 is the object of its real size.

OF THE LOBSTER INSECT.

Plate XVIII. Fig. 1 and 6.

This extraordinary little creature was found by my ingenious friend, Mr. John Adams, of Edmonton; he was at the New Inn, Waltham Abbey, where it was spied by some labouring men who were drinking their porter. The man who first perceived it, thought it was of an uncommon form; on a more minute inspection, it was supposed to be a louse with unusual long horns; others thought it was a mite. This produced a debate, which attracted the attention of my friend, who obtained the insect from them for further observation. Mr. Martin has given some account of it in the third volume of "The Young Gentleman and Lady's Philosophy." Mr. Adams favoured me with the insect, that an accurate drawing might be taken from it, which I thought would be highly pleasing not only to the lovers of microscopic observations, but also to the entomologist. It appears to be quite a distinct species from the phalangium cancroides of Linnæus, of which a good drawing has been given by Hooke, Rösel, Schæffer, &c. it has also been described by Scopoli, Geoffroy, and other naturalists; not one, however, of these descriptions agrees with the animal under consideration. The abdomen of this is more extended, the claws are larger and much more obtuse; the body of the other being nearly orbicular, the claws slender, and finishing almost in a point, more transparent, and of a paler colour. It is very probable, that there are several species nearly similar. Mr. Marsham has two in his possession, one like the drawings of Reaumur, the other not to be distinguished from that which is represented in the plate, except that it wants the break or dent in the claws, so conspicuous in this. The latter he caught on a flower in Essex, the first week in August, firmly affixed by its claws to the thigh of a large fly, and could not disengage it from thence without considerable difficulty; to accomplish which, he was obliged to tear off the fly's leg, and was much surprized to see the bold little creature spring forward full a quarter of an inch, and once more seize its prey, from which he again found it very difficult to disengage it. Fig. 1 represents the insect considerably magnified, Fig. 6 the natural size.*

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* According to Aldrovandus, this insect was not unknown to Aristotle, who mentions it as being found in books and paper. Wolphius, on the authority of Gesner, says that a few are

OF THE THRIPS PHYSAPUS.

Plate XVIII. Fig. 3, 4, and 5.

The insect, which is represented very considerably magnified at Fig. 3, is of the hemiptera class. It was first described and figured by De Geer in the Swedish Transactions for 1744, under the name of physapus ater, alis albis; Linnæus afterwards introduced it in a subsequent edition of the Systema Naturæ distinguished by the name thrips physapus.

These insects live upon plants, and particularly in flowers. The one figured here is the black thrips, with white wings; the antennæ have six articulations; the body is black; the wings whitish, long, and hairy; the head small, with two large reticular

to be met with in some parts of Switzerland. Scaliger also notices it, having found two of them in his books. It has been by various systematic writers referred to different genera; De Geer has instituted a new genus for it under the name of chelifer; Fabricius has remanded it to that of scorpio, to which perhaps it is more nearly allied than any other.

Amongst the number of naturalists who have observed and described the insect, it appears rather extraordinary that none have met with one similar to that in the plate, in respect to the break in the claws. In a cabinet of curious microscopic objects which I purchased several years since, and which originally came from Holland, there were four of them in the most perfect condition. A botanical friend, Mr. Young, also favoured me with a living one which he found among some plants collected by him in one of his excursions; but, as his box contained a variety of plants, and he did not discover the insect till his return, it was impossible to ascertain the particular one on which it was taken. All these resembled the one here exhibited, excepting the claws being longer and more slender, and being deficient in the distinguishing characteristic; I have lately seen another, in which the two fangs that are shewn highly magnified in Plate 85 of the Naturalist's Miscellany, are very apparent, being so large, as to exceed in diameter the thickest part of the claws.

My respectable friend, Matthew Yatman, Esq. informs me, that some years since one was found on a bottle of wine packed in saw-dust, at the house in which he then resided in Percy eyes. The antennæ are of an equal size throughout, and divided into six oval pieces which are articulated together. The extremities of the feet are furnished with a membranaceous and flexible bladder, which it can throw out and draw in at pleasure. It places and presses this bladder against the substances on which it is walking, and seems to fix itself thereby to them; the bladder sometimes appears concave towards the bottom, the concavity increasing or diminishing in proportion to the degree of pressure.

They have four wings, two upper and two under ones; these last are with great difficulty perceived, they are fixed to the upper part of the breast, lying horizontally; both of them are rather pointed towards the edges, and have a strong nerve running round them, which is set with a fringe of fribrillæ, tufted at the extremity. The wings are represented by themselves at Fig. 4; the insect of the real size at Fig. 5. They are to be found in great plenty in the spring and summer, in the flowers of the dandelion, and various other plants.

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street; on putting the point of a pin towards it to remove it from the bottle, it ran backward, put itself into an attitude of defence, and opened its claws as meditating vengeance. In the same cellar one had many years previous been discovered, sufficiently large to admit its being fastened to a card with thread by a young gentleman, being at least four times the usual size.

Rösel says it dwells among paper, in old books and their bindings, in chests of drawers, and in the crevices of old buildings. In order to discover whether the insect possessed a sting, he often by various means endeavoured to irritate it; but it never shewed the smallest inclination to defend itself, on the contrary, it always endeavoured to avoid a contest; if so, it evidently appears that those few met with in this country are of a more bold and warlike disposition.

Seba asserts that these insects resemble the large scorpions, the tail excepted, which is small, and usually concealed by being drawn close to the under part of the abdomen; but in this respect he must probably have been mistaken, as it does not appear that this circumstance has been noticed by any other person. EDIT.

OF THE SKIN OF THE LUMP SUCKER.

Plate XVIII. Fig. 2 and 7.

For a full description of this singular fish, I must refer the reader to Pennant's British Zoology, vol. iii. p. 117. The Linnean name is cyclopterus lumpus. Fig. 2 is a piece of the skin highly magnified: there are no scales on the body, but a great number of tubercles, which are here exhibited. Fig. 7 is the natural size of the object.

These fishes being extremely fat, renders them an agreeable diet to the natives of Greenland, in which seas they abound in the months of April and May; they also resort in multitudes during spring to the coast of Sutherland, near the Ord of Caithness in North Britain, where the seals prey greatly upon them, leaving the skins; numbers of which thus emptied float at that season ashore. When a good specimen is procured, it forms a most beautiful object for the opake microscope.

OF THE CIMEX STRIATUS.

Plate XX. Fig. 1 and A.

This is a beautiful insect of the hemiptera class, or that kind where the elytra are only in part crustaceous, and which do not form a longitudinal suture down the back, but fold over about one-third of their length toward the bottom, where it is also partly transparent. It is of the genus cimex, and called striatus by Linnæus. Its colours are bright and elegantly disposed: the head, proboscis, and thorax are black. The thorax is ornamented with yellow spots, the middle one large, and occupying almost one-third of the posterior part; the other two are on each side, and triangular. The scutellum has two yellow oblong spots, pointed at each end; the ground of the elytra is a bright yellow, spotted and striped with black. The nerves are yellow, and there is a brilliant triangular spot of orange, which unites the crustaceous and membranaceous parts; the latter is brown and clouded. The feet are of a fine red, and the rings of the abdomen are black, edged with white. This pretty insect is to be found in June, upon the elm-tree. It is represented at A of the natural size.

OF THE CHRYSOMELA ASPARAGI.

Plate XX. Fig. 2 and B.

A very common, though elegant insect of the coleoptera class, is represented at Fig. 2, as seen in the lucernal microscope, and of its natural size at B; it is called by Linnæus chrysomela asparagi, from the larva feeding on the leaves of that plant. Its shape is oblong, the antennæ black, composed of many joints nearly oval. The head is of a bright, but deep blue; the thorax red and cylindrical; the elytra blue, with a yellow margin, and three spots of the same colour on each, one at the base of an oblong form, and two united with the margin; the legs are black, but the under side of the belly is of the same blue colour with the elytra and head. This little animal, when viewed by the naked eye, scarcely appears to deserve any notice; but when examined by the microscope, is one of the most pleasing opake objects we have. It is found in June, on the asparagus after it has run to seed. De Geer says, that it is very scarce in Sweden.

OF THE MELOE MONOCEROS.

Plate XX. Fig. 3 and C.

The insect which comes at present under our inspection is particularly adapted to shew the advantages of the microscope, which alone will discover the peculiarities of its figure; this is so remarkable, that entomologists appear undetermined as to its genus. Geoffroy formed a new one for it, under the title of notoxus, in which he has been followed by Fabricius; even Linnæus himself could not determine at first where to place it, for in the Fauna Suecica he makes it an attelabus, but in the last edition of the Systema Naturæ he has fixed it as a meloe, calling it the meloe monoceros; but still he adds, "genus difficile terminatur forte huic proximum." Both Geoffroy and Schæffer have given figures of it, but as they had not that kind of microscope which would assist them, their figures are imperfect.

The head is black, and appears to be hid or buried under the thorax, which projects forwards like a horn; the antennæ are composed of many articulations, and with the feet are of a dingy yellow. The hinder part of the thorax is reddish, the fore part black. The elytra are yellow, with a black longitudinal line down the suture; there is a band of the same colour near the apex, and also a black point near the base; the whole animal is curiously covered with hair. Geoffroy says it is found on umbelliferous plants: the one here described was found in May; the natural size is seen at C.

Plate XIX. Fig. 1 and 2,

Represent two magnified views of the feet of the monoculus apus of Linnæus. They are curiously contrived to assist the animal in swimming, and form very agreeable objects for the microscope. Fig. 2 and 4 are the same objects of the natural size.

OF THE SCALES OF FISH.

The outside covering or scales of fish afford an immense variety of beautiful objects for the microscope. They are formed in the most admirable manner, and arranged with inconceivable regularity and symmetry: some are long, others nearly round, others again square; varying in shape, not only in different species, but even considerably on the same fish; those which are taken from one part not being entirely similar to those which are taken from another.

Leeuwenhoeck supposed each scale to consist of an infinity of scales laid one over the other; or, more simply, of an infinity of strata, of which those next to the body of the fish are the largest.

These strata, when viewed with the microscope, exhibit specimens of wonderful mechanism and exquisite workmanship. In some scales we discover a prodigious number of concentric flutings, too fine, as well as too near each other, to be easily enumerated; they are probably formed by the edges of each stratum, denoting the limits thereof, and the different stages of the growth of the scale. These flutings are often traversed by others diverging from the center of the scale, and generally proceeding from thence in a straight line to the circumference.

Plate X. Fig. 7, exhibits a scale from a species of the parrot fish of the West-Indies, considerably magnified. Fig. 8, the real size of the scale.

Plate X. Fig. 9, is a magnified scale of the sea-perch, which is found on the English coast. Fig. 10, the same scale of the natural size.

Plate XIX. Fig. 7, a scale from the haddock, as seen in the microscope. Fig. 8, the same of the natural size.

Plate XIX. Fig. 9, a scale from a species of perch from the West-Indies, magnified. Fig. 10, the scale of its real size.

Plate XIX. Fig. 11, a scale from the sole-fish, delineated as it appears in the microscope; the pointed part is that which stands without the skin, as may be seen in Fig. 5, which represents a piece of the skin of a sole, as viewed by the opake microscope. Fig. 6 and 12, the same objects of their real size.

CHAP. VII.

THE NATURAL HISTORY OF THE HYDRA, OR FRESH-WATER POLYPE.

HAVING in the two preceding chapters given the reader such a general idea of the history and œconomy of a great variety of those minute animated bodies, called insects, as I am inclined to hope has not only afforded him entertainment and instruction, but tended to excite an emulation for further researches; I shall endeavour to gratify so laudable a disposition, by introducing him to a class of beings whose œconomy and singular properties equally engage the attention of the philosopher and the natural historian; a scene which opposes our general system of vitality, and which presents to the eye of the mind, as well as that of the body, a series of astonishing wonders. It is among the minutiæ of nature that we find her models most diversified, and displaying the marvellous fecundity of its powers.

The polypes described in this chapter are fresh-water insects, of the genus of hydra, of the order of zoophytes, and class of vermes. The body consists of a single tube, furnished at one end with long arms, by these it seizes small worms, and conveys them to its mouth. It has, according to our general notions, neither head, heart, stomach, nor intestines of any kind; and is without the distinction of sexes, yet extremely prolific. From the simplicity of its structure those of its œconomy and functions are probably derived. When they are cut or divided into a number of pieces, the separated parts in a very little time become so many perfect and distinct animals; each piece having a power of producing a head, a tail, and the other organs necessary for its existence.

They are generally known by the name of polype; but as this was thought by many to be improper, because that, strictly speaking, they have no feet, Linnæus called the genus hydra, probably from their property of re-producing the parts which are cut off, a circumstance that naturally brings to mind the fabulous story of the Lernean hydra. Dr. Hill called them biota, on account of the strong principle of life with which every part is endued.

Leeuwenhoeck, whose indefatigable industry in his researches after small insects permitted very few things to escape his notice, discovered these animals, and gave some account of them in the Philosophical Transactions for the year 1703. There is also in the same volume a letter from an anonymous hand on this subject. We had, however, no regular account of them, their various habits, their different species, or of their wonderful properties, till the year 1740, when they first engaged the attention of M. Trembley, to whose assiduity and observations we are indebted for the display of their nature and œconomy.

Previous to the successful experiments of this gentleman, Leibnitz and Boerhaave, as well as some of the ancient philosophers, reflecting on the various gradations in the scale of animated nature, had endeavoured to prove that there might be degrees of life between the animal and the plant, and that animals might be found which would propagate by slips, like plants. These conjectures were verified by Trembley, but not in consequence of any pre-conceived ideas in favour of such a supposition; on the contrary, it was only by repeated observations that he could destroy his own prejudices, and join these wonderful beings to the animal kingdom.*

Though natural history is so fruitful in extraordinary facts, it has hitherto produced none so singular as the various properties of the different species of the hydra.

I shall endeavour, first, to trace the progress of this discovery, in which we shall see with what sage caution and accuracy Trembley, and other naturalists examined this wonderful phænomenon, and what accumulated evidence was judged necessary to establish the fact.

We find M. Trembley writing in January, 1741, to M. Bonnet, that he did not know whether he should call the object which then engaged his attention, a plant or an animal. "I have

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* A great part of the knowledge of the ancients consisted in an extensive variety of ingenious hypotheses, the result of intense study and application; and it need not excite surprize, if, amongst a number of suppositions, some of them have since been found conformable to truth.

The moderns, animated by the example of the great Bacon, by an abundance of experiments frequently repeated, and the assistance of good instruments, have introduced unquestionable demonstration in the place of speculation; this renders the present philosophy very far superior to that of the ancients.

Thus it is with respect to the subject now under consideration; many of the ancients conjectured that animated beings might exist possessed of the wonderful properties of the hydra; that some of them, however, were even witnesses of the fact, cannot well be disputed; though it may be fairly presumed, that their knowledge of this animal, comparatively with that we are now in possession of, was very circumscribed and imperfect.

St. Augustine relates that one of his friends performed the experiment before him, of cutting a polype in two, and that immediately the two parts thus separated betook themselves to flight, studied it," says he, "ever since June last, and have found in it striking characteristics of both plant and animal.' It is a little aquatic being. At first sight, every one imagines it to be a plant; but if it be a plant, it is sensitive and ambulant; if it be an animal, it may be propagated by slips or cuttings, like many plants." It was not till the month of March, in the same year, that he could satisfy himself as to their nature.

When Reaumur saw, for the first time, two polypes formed from one that he had divided into two parts, he could hardly believe his eyes; and even after having repeated the operation an hundred times, and again examined it an hundred more, he says that the sight was not become familiar to him.

The first account the Royal Society received of the surprizing properties of the hydra, was in a letter from M. Buffon, dated the 18th of July, 1741, to Martin Folkes, Esq. their president, acquainting them with the discovery of a small insect called a polypus, which is found sticking about the common duck weed, and which, being cut in two, puts forth from the upper part a tail, and from the lower end a head, so as to become two animals

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moving with precipitation different ways. The original passage is too long to be here inserted, but may be found in his work "De Quantitate Animæ," c. 62, p. 431, col. 1.

Aristotle, speaking of insects with many feet, expresses himself nearly in the same manner; without naming the particular creatures to which he alludes, he observes, that there are of these animals or insects, as well as of plants and trees, some that propagate themselves by shoots; and, as what were but the parts of a tree before, become thus distinct and separate trees; so, in cutting one of these animals, the pieces which before composed altogether but one animal, become suddenly so many distinct individuals. And he adds, that the soul in these insects is in effect but one, though multiplied in its powers, as it is in plants. Aristot. de Histor. Animal. tom. 1, lib. 4, cap. 7, pag. 824, & de Part. Animal. lib. 4, tom. 1, cap. 6, pag. 1028. &c. This will suffice to shew that the antients were not entirely unacquainted with the subject before us; though it does not derogate from the merit of Leeuwenhoeck, Trembley, and other ingenious naturalists, by whose assiduous and patient investigations we have obtained a more perfect knowledge of this astonishing class of animated beings. Edit.

instead of one. If it be cut into three parts, the middlemost puts out from one end a head, and from the other a tail, so as to become three distinct animals, all living like the first, and performing the various offices of their species: which observations are, adds Buffon, well averred.

There is no phænomenon in all natural history more astonishing than this, that man, at pleasure, should have a kind of creative power, and out of one life make two, each completely formed with all its apparatus and functions, its perceptions and powers of motion and self-preservation; and as complete in all respects as that from which they derived their existence, and equally enjoying the humble gratifications of their nature.*

Mr. Folkes, in confirmation of the foregoing article, communicated to the Society a letter from the Hon. W. Bentinck, Esq. at the Hague, dated September, describing the insects discovered by Trembley, adding, that he himself had seen them. In November, a letter was read from Dr. Gronovius, of Leyden, giving an account of a water insect not yet known to, or described by any author; after describing it, he adds, " but what is more surprizing, if this animal is cut into five or six pieces, in a few hours there will be as many animals, exactly similar to their parent." The accounts of this animal were so extraordinary, that they were not credited until Professors Albinus and Musschenbroeck were provided with some specimens, and found all that had been related thereof to be exactly true.

November 25, a letter from Cambridge was read to the Royal Society, in which the author endeavours to lessen, by reason, the prejudices which then combated the belief of these facts. " Some

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* Goldsmith's History of the Earth and Animated Nature.

of our friends, says the author, who are firmly attached to the general metaphysical notions they have formerly learned, reason strongly against the possibility of such a fact: but I have myself owned on other occasions, my distrust of the truth, or certainty at least, of some of those principles, and I shall make no scruple of acknowledging, that I have already seen so many strange things in nature, that I am become very diffident of all general assertions, and very cautious in affirming what may or may not possibly be. The most common operations both of the animal and vegetable world, are all in themselves astonishing, and nothing but daily experience and constant observation can make us see without amazement an animal bring forth another of the same kind, or a tree blossom and bear leaves and fruit.

" The same observation and experience make it also familiar to us, that, besides the first way of propagating vegetables from their respective fruit and seed, they are also propagated from cuttings, and every one knows that a twig of a willow particularly, cut off and only stuck into the ground, does presently take root and grow, and become as real and perfect a tree as the original one from which it was taken. Here then we find in the vegetable kingdom quite common, the very thing of which we have an example before us in the animal kingdom, in this new-discovered insect. The best philosophers have long observed strong analogies between these two classes of beings; and the more they have penetrated into nature, the more they have extended this analogy: now in such a scale, who is the man that will be bold to say, just here animal life entirely ends, and here vegetable life begins? or, just so far, and no farther, one sort of operation goes; and just here another sort, quite different, takes its place? or again, who will venture to say, life in every animal is a thing absolutely different from that which we dignify by the same name in every vegetable?" Thus does the author endeavour to persuade the prejudiced, and lead them to pay attention to the facts which were now laid open to their view, and which were further confirmed by a letter from M. Trembley, in January 1740; which letter was strengthened by an extract from the preface to the sixth volume of Reaumur's history of insects. In March, 1742, Mr. Folkes gave an account of them to the Royal Society, from observations made on several polypes which had been sent by M. Trembley from Holland to him. The insects now began to be known, and were soon found in England, and the experiments that had been made on them abroad were published by Mr. Folkes,[*] my father,[†] and Mr. Baker:[‡] conviction now became too strong for argument, and metaphysical objections gave way to facts. The animal is described in the following manner:

HYDRA.[§]

Flos: os terminale, cinctum cirris setaceis. Stirps vaga, gelatinosa, uniflora, basi se affigens.[‖]

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[*] Philosophical Transactions. [†] Micrographia Illustrata. [‡] Natural History of the Polype.

[§] The hydræ or polypes have generally been denominated Insects: is there not a manifest impropriety in the application of this term to them? If we admit of the systematic arrangement of Linnæus, we find that he has divided the animal kingdom into six classes: 1. Mammalia. 2. Aves. 3. Amphibia. 4. Pisces. 5. *Insecta*; and 6. *Vermes*. Of the last or *Vermes*, the Zoophytes (from ζώοφυτον, or animal plant) constitute the fifth order. He defines it as Animalia composita, efflorescentia more vegetabilium: amongst these he includes the various species of Vorticellæ and Hydræ.

The term animalculæ, or small animals, is certainly not inapplicable to them, but they differ materially in the peculiar characteristics by which insects are distinguished, see page 179, and pages 215—220. They do not undergo those transformations to which insects are subject, and which have been so fully described in the preceding part of this work: their figure, habits, and œconomy are also very different. In short, they seem to be in every respect, except their minuteness, quite a distinct race of animated beings, as will be more fully exemplified in the following pages. Edit.

[‖] Lin. Syst. Nat. p. 1320.

This animal fixes itself by its base, it is gelatinous, linear, naked, can contract itself, and change its place. Its mouth, which is at one end, is surrounded by hair, like feelers. It sends forth its young ones from its sides, which drop off.

1. Hydra viridis, tentaculis subdenis brevioribus.

Green polype, generally with about ten short arms; it is represented in Plate XXI. Fig. 5.

2. Hydra fusca, tentaculis suboctonis longissimis.

This polype has very long arms, often eight in number; it is represented at Plate XXI. Fig. 7. The arms are several times longer than the body.

3. Hydra grisea, tentaculis subseptenis longioribus.

This polype has also generally long arms, in number about seven; it is of a yellowish colour, small towards the bottom; it is represented at Plate XXI. Fig. 6.

4. Hydra pallens, tentaculis subsenis mediocribus.

The arms of this polype are generally about six in number, and of a moderate length.

5. Hydra hydatula, tentaculis quaternis obsoletis corpore vesicario. Plate XXI. Fig. 1, 2, 3, 4.

This polype has a vesicular body, and four obsolete arms; is found in the abdomen of sheep, swine, &c.

6. Hydra stentorea, tentaculis ciliaribus corpore infundibuliformi.

This polype has been called tunnel-shaped; the mouth is surrounded with a row of hairs; it is represented at Plate XXII. Fig. 27 and 28.

7. Hydra socialis, mutica torosa rugosa.

Bearded, thick, and wrinkled. Plate XXI. Fig. 11.

OF THE HYDRA VIRIDIS, HYDRA FUSCA, AND HYDRA GRISEA.

Plate XXI. and XXIII.

These three species of the hydra having been those on which the greatest number of experiments have been made, and of which we have the best information, it is of these only I shall speak in the following account, unless it is particularly mentioned otherwise.

There are few animals more difficult to describe than the hydra, as it has scarce any thing constant in its form, varying continually in its figure: they are often so beset with young, as to appear ramose and divaricated, the young ones constituting as it were a part of the parent's body.

Whoever has looked with care at the bottom of a wet shallow ditch, when the water is stagnant, and the sun has been powerful, may remember to have seen many little transparent lumps, of a jelly-like appearance, about the size of a pea, and flatted on one side; the same appearances are also often to be seen on the under side of the leaves of those weeds or plants that grow on the surface of the water; these are the hydræ gathered up into a quiescent state, and seemingly inanimate, because either undisturbed or not excited by the calls of appetite to action. They are generally fixed by one end to some solid substance, at the other end there is a large opening, round about which the arms are placed as so many rays round a center, which center is the mouth.

They are slender and pellucid, formed of a tender kind of substance, in consistence something like the horns of a snail, and can contract the body into a very small compass, or extend it to a considerable length. They can do the same with the arms; with these they seize minute worms and various kinds of aquatic insects, bring them to the mouth, and swallow them. After the food is digested, and the nutritive parts which are employed in sustaining its life are separated from the rest, they reject the remainder by the mouth.

The first polype which Trembley discovered was one of the hydra viridis, represented in Plate XXI. Fig. 5. These are generally of a fine green colour. The indications of spontaneous motion were first perceived in the arms of these little creatures; they can extend or contract, bend and wind them divers ways. Upon the slightest touch they contract themselves so much, as to appear little more than a grain of a green substance, the arms disappearing entirely. He soon after found the hydra grisea, Fig. 6, and saw it eat, swallow, and digest worms much larger than itself. This discovery was soon followed by that of the hydra fusca, Fig. 7.

The most general attitudes of these hydræ are those which are represented in Fig. 5 and 6 of the same plate. They fix the posterior extremity *b* against a plant or other substance, as *c f*; the body *a b*, and the arms *a c*, being extended in the water. There is a small difference in the attitudes of the three kinds which we are now describing.

The bodies of the hydra viridis, Fig. 5, and of the hydra grisea, Fig. 6, diminish from the anterior to the posterior extremity by an almost insensible gradation. The hydra fusca does not diminish in the same gradual manner, but from the anterior extremity *a*, to the part *d*, which is often two-thirds of the length of their body, it is nearly of an equal size; from this part it becomes abruptly smaller, and goes on from thence of a regular size to the end. The number of arms in these three kinds are at least six, and at most twelve or thirteen, though eighteen may sometimes be found on the hydra grisea. They can contract their bodies till they are not above one-tenth of an inch in length; they can also stop at any intermediate degree, either of contraction or extension, from the greatest to the least. The species represented at Fig. 5, are generally about half an inch long when stretched out. Those exhibited at Fig. 6 and 7, are about three-fourths of an inch, or one inch in length, though some are to be found at times about an inch and half long. The arms of the hydra viridis, Fig. 5, are seldom longer than their bodies; those of Fig. 6 are commonly one inch long, while those of Fig. 7 are generally about eight inches; whence Trembley has called it the long-armed polype.

The bulk of the hydræ decreases in proportion as they extend themselves, and vice versa. They may be made to contract themselves, either by touching them, or agitating the water in which they are contained. They all contract themselves so much when taken out of the water, as to appear only like a little lump of jelly. They can contract or extend their arms without extending or contracting the body, or the body, without making any alteration in the arms; or they can contract or dilate only some of the arms, independent of the rest: they can also bend their body and arms in all possible directions. Those represented at Fig. 7 let their arms in general hang down, making different turns and returns, often directing some of them back again to the top of the water. They can also dilate the body at different places, sometimes at one part, and then again at another; sometimes they are thick set with folds, which, if carelessly viewed, might be taken for rings.

They have a progressive motion, which is performed by that power by which they stretch out, contract, and turn themselves every way. For suppose the hydra or polype, *a b*, Fig. 16, to be fixed by the tail *b*, having the body and the arms *a* extended in the water; in order to advance, it draws itself together, by bending itself so as to bring the head and arms down to the substance on which it is to move; to do this, it fixes the head or the arms as in Fig. 17; when these are well fixed, it loosens the tail, and draws it towards the head, as in Fig. 18, which it again loosens, and resting on the tail, stretches it out, as in Fig. 19. It is easy to see from this account, that their manner of walking is very analogous to that of various terrestrial and aquatic animals. They walk very slow, often stopping in the middle of a step, turning and winding their body and arms every way. Their step is sometimes very singular, as in the following instance: suppose the polype *a b*, Fig. 20, to be fixed by the tail *b*, the body and arms being extended in the water, it first bends the fore-part towards the substance on which it is moving, and fixes it thereto, as at *a*, Fig. 21; it then loosens the lower end, and raises it up perpendicular, as in Fig. 22; now bending the body to the other side, it fixes the tail, as in Fig. 23; then loosening the anterior end, it rises up, as in Fig. 24.

They descend at pleasure to the bottom of the water, and ascend again, either by the sides, or upon some aquatic plants; they often hang from the surface of the water, resting as it were upon the tail; or, at other times they are suspended by one arm from it. They walk also with ease upon the surface of the water. If the extremity of the tail *b*, Fig. 7, be examined with a magnifying glass, a small part of it will be found to be dry, and above the surface of the water, and as it were in a little concave space, of which the tail forms the bottom, so that it seems to be suspended on the surface of the water, on the same principle that a small pin or needle is made to swim.

Hence, when a polype means to pass from the sides of the glass to the surface of the water, it has only to put that part out of the water by which it means to be supported, and give it time to dry, which it always does upon these occasions. They attach themselves so firmly by the tail to aquatic plants, stones, &c. as not to be easily driven from the place where they have fixed themselves; they often further strengthen these attachments by means of one or two of their arms, which they throw out and fix to adjacent substances, as so many anchors.

The mouth of the polype or hydra is situated at the fore-part of the body, in the middle between the shooting forth of the arms. The mouth assumes different appearances, according to the different purposes of the insect; sometimes it is lengthened out, and forms a little conical nipple, as in Plate XXIII. A. Fig. 13; sometimes it appears truncated, as in Plate XXI. Fig. 8; at other times the interval between the arms appears closed, as in Plate XXIII. A. Fig. 2 and 12; or hollow, as in Fig. 11 of the same plate. If it be observed with a deep magnifier in either of the two last cases, a small aperture may be discovered.

The mouth of the polype opens into the stomach, which is a kind of bag or gut that goes from head to tail; this may be perceived by the naked eye, when the animal is exposed to a strong light, or a candle placed on the opposite side to the eye; for the colour of the polype does not destroy the transparency thereof. The stomach will, however, be better seen, if the eye be assisted by a deep magnifier; one of them is represented as highly magnified in Plate XXI. Fig. 8. To be fully satisfied whether they were perforated throughout, Trembley cut one transversely into three parts; each piece immediately contracted itself, and became very short; being then placed in a shallow glass full of water, and viewed through the microscope, they were found to be visibly perforated. Their microscopic appearance is represented in Plate XXIII. A. Fig. 6, 7, 8; its mouth was at the anterior end *a*, Fig. 8, of one of these parts. The tail was at the end *b* of the third part, Fig. 6; as this piece was also perforated, it plainly appears that the tail of the hydra is open. The perforation, which is thus continued from one end to the other, is called the stomach, because it contains and digests the aliments. The skin which incloses the bag, and forms the stomach, is the skin of the polype itself; so that the animal may be said to consist of but one skin, disposed in the form of a tube or gut open at both ends. On opening the polype, no vessels are to be distinguished; and whatever be the nature of its organization, it must reside in the skin.

The skin must be so far organized, as to perform all the operations necessary for the nutrition and growth of the animal, without considering those that are necessary for its various motions. Whatever are the means the Author of Nature has employed for these purposes, we are ignorant of them. If their skin be examined by a microscope, it appears like shagreen, or as if it were covered with little grains; these are more or less separated from each other, according to the degree in which the body is extended or contracted.

If the lips of a polype be cut transversely, and placed so that the cut part of the skin may lie directly before the microscope, the skin throughout its whole thickness will be found to consist of an infinite number of these grains. To know whether the inside of the stomach was formed of similar grains, several of them have been laid open and examined by the microscope; the interior surface was then found to consist of an immense number of them, being as it were more shagreened than the exterior one, and less transparent. The grains are not strongly united to each other, but may be separated without much trouble. Plate XXIII. A. Fig. 10, represents a piece of skin thus laid open. To examine these particulars further, a piece of skin a, Fig. 9, was laid in a few drops of water, on a piece of glass before the microscope, and some of the grains were separated from it, as at b c d, by pressing them with the point of a pin; in endeavouring to open them, they spread themselves into all parts of the water, and at last remained in heaps, as at e and f.

If a polype be carefully placed before the microscope, without wounding it, you will seldom be disappointed in seeing some of these grains detach themselves from the superficies thereof, and that even in the most healthy.

But if the grains separate themselves in large quantities, it is the symptom of a very dangerous disorder; the surface of the polype thus attacked becomes more and more irregular, and is no longer well terminated and defined as before. The grains fall off on all sides, the body and arms contract and dilate, it becomes of a white shining colour, loses its form as at a, Fig. 4, and then dissolves into a heap of grains, as at b, Fig. 5. The progress of this disorder is most easily observed in the hydra viridis.

A very attentive and accurate examination shews that the skin is formed of a kind of glareous substance, a species of gum, which fills up the intervals between the grains, in which they are lodged, and by which they are attached, though weakly, together. It has been already observed, that it is to these grains that it owes its shagreen-like appearance; it is from them also that it derives its colour; for, when they are separated from the polype, they are the same colour with it, whereas the glareous matter is without any distinguishing colour. The construction of the polype seems then to be confined to these glandular grains, to the viscous matter, and the invisible fibres which act upon the glareous substance.

The structure of the arms of the polypes is very analogous to that of their body. When they are examined by the microscope, either in a contracted or dilated state, their surface is shagreened; if the arm be much contracted, it appears more so than the body; on the contrary, it appears less so in proportion as they are more extended; almost quite smooth when at their full extension; so that in the hydra viridis the appearance of the arms is continually varying, and these variations are more sensible towards the extremity of the arm than at its origin, as in Plate XXI. Fig. 10; but more thinly scattered, or farther asunder, in the parts further on, as at Fig. 9. The hairs which are exhibited in this figure cannot be seen without a very deep magnifier, however they indicate a further degree of organization in this little animal. The extremity is often terminated by a knob.

All animals of this kind have a remarkable attachment to turn towards the light, and this might naturally induce the inquirer to look for their eyes; but how carefully soever this search has been pursued, and however excellent the microscope with which every part has been examined, yet no appearance of this organ has been found. Notwithstanding this, they constantly turn themselves toward the light; so that if that part of the glass in which we placed them be turned from it, they will be found the next day to have removed themselves to the side that is next the light, and the dark side will be quite depopulated.

OF THE FOOD OF THE HYDRÆ, AND THEIR METHOD OF SEIZING AND SWALLOWING THEIR PREY.

As the hydra fusca, Plate XXI. Fig. 7, has the longest arms, its manner of feeding, and the different manœuvres it makes use of to seize and manage its prey, are more remarkable than those of the two other species; it will be, therefore, this kind only which will be principally spoken of under the present head. To obtain a proper view, it should be placed in a glass seven or eight inches deep. If the polype be fixed near the top of the glass, the arms for the most part hang down toward the bottom. This is a very convenient situation for feeding it, and observing its management of the food.

The polypes are in general very voracious: an hungry one extends its arms as a fisherman his nets; it spreads them every way, so that they form a circle of considerable extent, every part of which is entirely within the reach of one of them. In this expanded posture it lies in expectation of its food; whatever comes within the verge of this circle is seized by one or other of its arms: the arms are then contracted till the prey is brought to the mouth, when it is soon devoured. While the arms are contracting and exerting themselves vigorously to counteract the efforts of the animal, which it has seized, to escape, they may be observed to swell like the muscles of the human body when they are in a state of exertion.

Though in general all ideas are derived from the senses, there are certainly some that seem infused into us independently of the exertions of any sense. This may be confirmed by many instances of animal instinct; among others, it may be illustrated by the polype. Who taught it, when just separated from the parent stock, to expand its arms, that it might catch its prey? That its native element abounded with insects? or that these were its proper food? No sense that we are acquainted with could first give the information.

The polype does not always wait for its prey, it feels for it, and in a manner follows it. It may be asked how can it perform this if destitute of vision? or do the glandular grains answer the purpose of eyes? Who can answer the question? what are our own eyes but glandular grains of a larger size? If this should be the case, our hydra, like the libellulæ and other insects, would realize, nay, exceed the fables of the ancients, being an Argus entirely composed of eyes. Be this as it may, they are certainly in possession of some sensation by which they are informed of the approach of their prey, and which renders them attentive to all that may confirm or destroy this perception.

When the arms of a polype are extended within a glass, put a centipe or any kind of worm into it, see Plate XXIV. A. Fig. 1, and with the point of a pin push it towards one of the arms; as soon as it touches this it is seized; the worm or centipe endeavours by quick and strong efforts to disengage itself, often swimming and dragging the arm from one side of the glass to the other. This violent motion of the prey obliges the polype to contract strongly the arm; in doing which, it often twists it in the form of a cork-screw, as at o i, by which means it shortens it more rapidly. The struggles of the devoted animal soon bring it in contact with another arm; these contracting further, the little creature is presently engaged with all the arms, and by degrees conveyed to the mouth, against which it is held and subdued.

When a polype has nothing to eat, its mouth is generally open, but so small, that it can scarce be perceived without the assistance of a magnifying glass; but as soon as the arms have conveyed the prey to the mouth, it opens itself wider, and this in proportion to the size of the animal that is to be devoured; the lips gradually dilate, and adjust themselves accurately to the figure of the prey. The greatest part of the animals on which the polype feeds, are to its mouth, what an apple the size of our heads would be to the mouth of a man.

The worms or other minute animals which are seized by the polype, are not always brought to the mouth in the same situation; if they be presented to it by one of their extremities, it is not requisite that the polype should open its mouth considerably, and in effect it only opens it so wide, as precisely to give entrance to the worm, Fig. 5. If it be not too long for the stomach, it remains there extended; but if it be longer, the end which first enters is bent, so that when the worm is entirely swallowed, it may be seen lying folded in the stomach, Plate XXIV. B. Fig. 12.

If the middle, or any other part of the worm, be presented to the mouth of the polype, it seizes this part with the lips, extending them on both sides, and applying them against the worm, so that the mouth assumes the form of a boat, pointed at each end, Plate XXIV. A. Fig. 2; the polype gradually closes the two points of its boat-like lips, and by this motion and suction swallows the worm, Fig. 4.

The polypes kill worms so speedily, that Fontana thinks they must contain the most active and powerful venom; for the lips of a polype scarce touch the worm, but it expires, so great is the energy of the poison it conveys into it, though no wound can be observed in the dead animal.

As soon as the stomach is filled, its capacity is enlarged, the body is shortened, Plate XXIV. A. Fig. 6, the arms are for the most part contracted, the polype hangs down without motion, and appears to be in a kind of stupor, and very different from its shape when extended; but in proportion as the food is digested, and it has voided the excrementitious parts, the body lengthens, and gradually recovers its usual form.

The transparency of the polype permits us to see distinctly the worm it has swallowed, Plate XXIV. B. Fig. 12, which gradually loses its form. It is at first macerated in the stomach of the polype, and when the nutritious juices are separated from it, the remainder is discharged by the mouth, Fig. 13. It is with these, as with other voracious animals, as they devour a great quantity of food at once, so also they can fast for a long time. The history of insects furnishes many examples of this kind.

One circumstance is observable, which probably contributes much to the digestion of their food, namely, that the aliments are continually pushed backward from one extremity of the stomach to the other; this motion may be easily observed with a microscope, in a polype which is not too full, and in which the food has been already divided into little fragments. For these observations, it is best to feed the polype with such food as will give a lively-coloured juice; as for example, those worms whose intestines are filled with red substances: for by these means we shall see that the nutritious juices are conveyed not only to the extremity of the body, but also into the arms; from whence it is probable that each of the arms form also a kind of gut, which communicates with that of the body. Some bits of a small black snail that is frequently to be found in our ditches, was given to a polype. The substance of this skin was soon reduced into a pulp, consisting of little black fragments; on examining the polype with the microscope, these particles were perceived to be driven about the stomach, and to pass from head to tail, and into their arms, even where these were as fine as a thread; they were afterwards forced into the stomach, and from thence to the tail, from whence they were again driven into the arms, and so on.

The grains take their tinge from the food which nourishes the polypes; these grains become red or black, if the polype be fed with juices that are either red or black; and they are more or less tinged with these different colours, in proportion to the strength and quantity of the nutritive juices. It is also observable, that they lose their colour if fed with aliments that are not of the same colour with themselves.

The polypes feed on the greater part of those insects that are to be found in fresh water. They may be nourished with worms, the larva of gnats, &c. they will also eat larger animals if they are cut into small pieces, as snails, large aquatic insects, small fish, butcher's meat, &c. Sometimes two polypes seize the same worm, and each begins to swallow its own end, continuing so to do till their mouths meet, Plate XXIV. A. Fig. 8; in this position they remain for some time, at last the worm breaks, and each has its share; sometimes the combat does not end here, for each continuing to dispute the prize, one of the polypes opens its mouth advantageously, and swallows the other with its portion of the worm, Plate XXIV. B. Fig. 14; this combat ends more fortunately for the devoured polype than might be at first expected, for the other often gets the prey out of its stomach, but lets it out again sound and safe, after having imprisoned it above an hour. From hence we learn, that the stomach of the polype, which so soon dissolves the animal substances which are conveyed into it, is not capable of digesting that of another polype.

Plate XXIV. A. Fig. 5, represents a polype with one half a centipe in its mouth, as at a; the other part without, as at m. Fig. 1 represents one suspended in water by a piece of packthread; c n, a centipe seized by it, and drawn partly towards the mouth; i o, the bendings in the arm; p, an arm in search of a small aquatic insect. Fig. 2, a polype stretching itself into a boat-like form, to take or swallow a worm lying sideways. Fig. 4, the same polype with the worm swallowed and bent within it. Fig. 6, is a polype in the situation they generally assume when they have satisfied their voracious appetite. Fig. 7, one that has swallowed a small monoculus. Fig. 9, a, one whose arms are loaded with monoculi. Fig. 10, a polype full of them from head to tail. Fig. 3, one that has only swallowed a few of them. Fig. 8, represents two polypes engaged in combat for a worm, of which both of them have swallowed a part.

Plate XXIV. B. Fig. 11, represents a polype engaged with a very large worm. Fig. 12, a worm seen within the skin of a polype. Fig. 13, a polype disgorging the excrementitious parts of a worm.

Plate XXI. Fig. 12, a polype that has swallowed a small fish, and taken the shape thereof.

OF THE GENERATION OF THE HYDRÆ.

As the hydra fusca and the hydra grisea are considerably larger than the hydra viridis, it is more easy to observe the manner of their producing their young. It is upon these, therefore, that most of the observations here recited have been made. If one of them be examined in summer, when the animals are most active, and more particularly prepared for propagation, it will be found to shoot forth from its side several little tubercles, or knobs, which grow larger and larger every day; after two or three days inspection, what at first appeared but a small excrescence, takes the figure of a small animal, entirely resembling its parent. It does not inclose a young polype, but is the real animal in miniature, united to the parent, as a sucker to the tree.

When a young polype first begins to shoot, the excrescence terminates in a point, as at e, Plate XXIV. B. Fig. 24; so that it is rather of a conical figure, and of a deeper colour than that of the body. This cone soon becomes truncated, and in a little time appears cylindrical. The arms then begin to shoot from the anterior end c i. The tail adheres to the body of the parent, but grows gradually smaller, till at last it only adheres by a point b, Fig. 23, it is then ready to be separated; for this purpose the mother and young ones fix themselves to the glass, or other substance upon which they may be situated. They have then only to give a sudden jerk, and they are divided from each other. There are some trifling differences to be observed now and then in their performing this operation, which it would be too tedious to enumerate here. A polype, a b, Fig. 20, with a young one, c d, places its body in an arch of a circle a d b, against the sides of the glass, the young one being fixed at the top d of the arch, with its head also fixed against the glass; so that the mother, by contracting the body, and thus becoming straight, loosens herself from the young one.

The young ones shoot in proportion to the warmth of the weather, and the nature of the food eaten by the mother; some have been observed to be perfectly formed in twenty-four hours, while others have required fifteen days for the same purpose; the first were produced in the midst of summer, the latter in a cold season.

The tail of the young polype communicates with, and partakes of the food from the parent in the same manner as its own arms do, and the food lies in the same manner as in the arms. When this fœtus is furnished with arms, it catches its prey, swallows, digests, and distributes the juices thereof even to the parent body; every good is common to each. Here then we have evident communication between the fœtus and the mother; this communication was further proved by the following experiment. A large polype, one of the hydra fusca, was placed on a slip of paper, in a little water; the middle of the body of the young one was cut, and the superior part of that end which remained fixed to the parent was found to be open. The parent polype was then cut on each side of the shoot. Thus a short cylinder was obtained, which was open at both ends. This being viewed through a microscope, the light was seen to come through the side slip, or young one, into the stomach of the old one. For further conviction, the cylindrical portion was cut lengthways; on observing these parts, not only the hole t of the communication, Plate XXIV. B. Fig. 17, was distinctly seen, but one might see through the end o of the young one. On changing the situation of these two pieces of prepared polypes, and looking through the opening e, Fig. 18, the day-light was seen through the hole of communication i.

This communication between the parent polype and its young ones may be seen on feeding them; for, after the parent a b, Plate XXIV. B. Fig. 22, has eaten, the bodies of the young ones swell, being filled with the aliments as if they themselves had been eating. In the hydra fusca the young ones do not proceed from the tail part b c, Plate XXIII. B. Fig. 16, but only from the part a c, with this exception, there is no particular part of the body before the rest, on which they produce their young. Some of them have been so closely observed, and have so greatly multiplied, that there would be scarce any impropriety in saying they produced their young ones from all the exterior parts of their body. A polype puts forth frequently five or six young ones at the same time. Trembley has had some that have produced nine or ten at the same time, and when one dropped off another came in its place.

Though this gentleman had for two years thousands of them under his eye, and considered them with the most scrupulous attention, he never observed any thing like copulation. To be more certain on this head, he took two young ones the instant they came from their parent, and placed them in separate glasses; they both multiplied, not only themselves, but their offspring, which were separated and watched in the same manner to the seventh generation; nay, they have even the faculty of multiplying while they adhere to the parent. The arms of the young ones do not sprout till the body has attained some length.

Several excrescences or buds often appear at the same time on a polype, which are so many polypes growing from one trunk; whilst these are developing, they also bud, which buds again put forth little ones, the parent and the young ones forming a singular kind of animal society,. in which all participate of the same life, and the same wants. In this state, the parent appears like a shrub thick set with branches. Several generations are often thus attached to one another, and all to the parent polype; after a time, this tree of polypes or hydræ is decomposed, and gives birth to new generations, or fresh genealogical trees. Here we see a surprizing chain of existence continued, and numbers of animals naturally produced, without any union of sexes; every polype raising a numerous posterity by a kind of animal vegetation.

From Fig. 16, Plate XXIII. B. the reader may form an idea of the promptitude with which these creatures increase and multiply; the whole group formed by the parent and its young was about an inch and an half long, and one inch broad, the arms of the mother and her nineteen little ones hanging down towards the bottom of the vessel; the animal would eat about twelve monoculi per day, and the little ones about twenty among them, or rather more than thirty for the group.

OF THE RE-PRODUCTION OF THE HYDRÆ.

So strange is the nature of this creature's life, that the method by which other animals are killed and destroyed becomes a means of propagating these. When divided and cut to pieces in every direction that fancy can suggest, it not only continues to exist, but each section becomes an animal of the same kind.

A polype cut transversely or longitudinally, in two or three parts, is not destroyed; each part in a little time becomes a perfect polype. This species of fecundity is so great in these animals, that even a small portion of their skin will become a little polype, a new animal rising as it were from the ruins of the old, each small fragment yielding a polype. If the young ones be mutilated while they grow upon the parent, the mutilated parts are re-produced; the same changes succeed also in the parent. A truncated portion will put forth young before it is perfectly formed itself, or has acquired its new head and tail; sometimes the head of the young one supplies the place of that which would grow out of the anterior part of the trunk.

If a polype be slit, beginning at the head, and proceeding to the middle of the body, a polype will be formed with two heads, and will eat at the same time with both. If the polype be slit into six or seven parts, it becomes a hydra with six or seven heads. If these be again divided, we shall have one with fourteen; cut off these, and as many new ones will spring up in their place, and the heads thus cut off will become new polypes, of which so many new hydræ may again be formed; so that in every respect it exceeds the fabulous relation of the Lernean hydra.

As if the wonders already related of the polype were not sufficient to engage our attention to these singular animals, new circumstances, as surprizing as the foregoing, present themselves to convince us of the imperfection of our ideas of animality, and of the greatness of the power of our Lord and Saviour, who is the source and origin of every degree of life, in all its immense gradations, as unity is the origin of number in all its varied series, multiplied proportions and combinations; and as numbers may be considered as recipient of unity, in order to make manifest the wonderful powers thereof, so the universe and its parts are adapted to receive life from the source of all life, and thus become representatives of his immensity and eternity.

The polypes may be as it were grafted together. If the truncated portions of a polype be placed end to end, and then pushed together with a gentle force, they will unite, and form a single one. The union is at first made by a fine thread, and the portions are distinguished by a narrow neck, which gradually fills up and disappears, the food passing from one portion to another. Portions not only of the same, but pieces of different polypes may be thus united together. You may fix the head of one polype to the trunk of another; and that which is thus produced, will grow, eat, and multiply like another.

There is still another method of uniting these animals together, more wonderful in its nature, and less analogous to any known principles of animation, and more difficult to perform. It is effected by introducing one within the other, forcing the body of one into the mouth of the other, and pushing it down so that their heads may be brought together: in this state it must be kept for some time; the two individuals are at last united, and grafted into each other; and the polype, which was at first double, is converted into one, with a great number of arms, and performs all its functions like another.

The hydra fusca furnishes us with another prodigy, to which we know nothing that is similar either in the animal or vegetable kingdom. They may be turned inside out like a glove, and, notwithstanding the apparent improbability of the circumstance, they live and act as before. The lining or coating of the stomach now forms the epidermis, and the former epidermis now constitutes the coating of the stomach. A polype thus turned, may often have young ones attached to its side. If this be the case, after the operation they are of course inclosed in the stomach. Those which have acquired a certain size extend themselves towards the mouth, that they may get out when separated from the body; those which are but little grown, turn themselves inside out, and by these means place themselves again on the outside of the parent polype.

The polype thus turned combines itself a thousand different ways. The fore-part often closes itself, and becomes a supernumerary tail. The polype which was at first straight, now bends itself, so that the two tails resemble the legs of a pair of compasses, which it can open and shut. The old mouth is at the joint as it were of the compasses; it cannot, however, act as one, so that a new one is formed near it, and in a little time a new species of hydra is formed with several mouths.

Plate XXIII. B. Fig. 18, represents the upper part of a polype that has been divided into two parts; a, the upper, c, the lower part, the end c being something larger than that of a common polype, and is sensibly perforated; in the summer time this part often walks and eats the same day it is cut. Fig. 17, the other part of the same polype; the anterior end is very open, and the edges of it turned a little outwards, which afterwards folding inwards, close the aperture. This end now appears swelled, as at c, Fig. 21; the arms shoot out from this end: at first three or four points only begin to shoot, as at c, Fig. 20, and while these increase in size, others appear between them; they can seize their prey and eat before their arms have done growing. In the height of summer the arms will often begin to shoot in twenty-four hours; but in cold weather it will be fifteen or twenty days before the head is formed. Fig. 22, represents a polype that was cut close under the arms; this became also a complete animal in a little time.

The sides of a polype that has been cut longitudinally, roll themselves up in different ways, generally beginning at one of the extremities, rolling itself up in a heap, as in Plate XXIII. B. Fig. 19, with the outside of the skin inwards; it soon unrolls itself, and the cut sides form themselves into a tube, whereof the edges a b and c i, Fig. 15, on both sides meet each other and unite. Sometimes they begin to join at the tail end, at other times the whole sides gradually approach each other. The sides join so close, that from the first moment of their junction no scar can be discovered. Fig. 14, represents a polype partly joined, as at i b, the part c a e not yet closed. Fig. 29, represents a polype, the heads of which have been repeatedly divided, by which means it becomes literally a hydra. Fig. 24, represents a polype that has been turned, endeavouring to turn itself back again, the skin of the anterior part lying back upon the other; the arms varying in their direction, being sometimes turned towards the head, see Fig. 24 and 26, at others, towards the tail. The anterior extremity c, formed by the edges of the reversed part a, remained open for some days, and then began to close; new arms shot out near the old ones, and several mouths were formed at those parts where the arms joined the body. Fig. 23, 25, 27, 28, represent the different changes that took place in another polype that had been turned inside out, and the different revolutions it went through before it acquired a fixed state; a c always shews the part the polype had turned back, and a b the part it could not turn back.

A polype, which has been partly turned back, remains but a little time in that situation. Fig. 28, a, the part where the portion it had turned back joined to the body a b; this became straight, and formed a right angle with a b; the same day another head appeared at e, and several arms, a o, a n, began to shoot from the mouth a; at the other side of this mouth there were the old arms a d. The next day the portion a c was drawn near the body, and formed an acute angle with it, as at Fig. 25. Fig. 27, represents the same swelled, after having swallowed a worm. Four days afterwards its form had varied considerably, as may be seen by comparing Fig. 25 and 28, having now one common mouth, and two small polypes growing on it.

We may now be permitted to make a few reflections on this singular animal. On considering the various properties that have been already described, many particulars will be found in them that are very analogous to others that are continually carrying on around us; we perceive that there is a successive unfolding of new parts. In every organized frame there is a continual effort to extend its sphere of action, and enlarge the operation of that portion of life which is communicated to it. This gradual evolution requires a secret and curious mechanism, to regulate and modify by re-action the continued conatus of the forming principle within it. The polype is an organized whole, of which each part, each molecule, each atom, tends to produce another; it is, if we may so speak, one entire ovary, a compound of germ, or seed. In cutting a polype to pieces, the nourishing juices, which would have been employed in supporting the whole, are made to act upon each portion.

When a polype is divided longitudinally, it forms two half tubes; the opposite edges of these approach, and in a very short time form a perfect tube. The sides are made to touch each other by certain motions and contractions of the piece; but as soon as the edges come in contact, a slight adhesion takes place, the corresponding vessels unite, and new ones are unfolded, as in a vegetable graft; by these means the points of connection and cohesion are multiplied, the motion of the fluids are re-established, and with them the vital œconomy. This is performed with more rapidity than in vegetables, because the polype is nearly gelatinous, and its parts are extremely ductile; this ductility is supported and preserved by the element which it inhabits. The same reasoning applies equally to explain the formation of so many heads to a polype, as constitute it a real hydra.

A new polype is formed out of small portions or fragments, in a very different manner, the operations in nature being always varied, according as the circumstances differ; each fragment is puffed up, the skin separated, and an empty space is formed within it; this part is to become the stomach of the rising polype, which soon sends forth arms, and is formed to the perfection proper to its kind. We learn from this instance that the skin of the polype is not so simple as was at first imagined; for we find it dividing itself into two membranes, and forming thereby a cavity fit to perform all the functions of a stomach; but why these membranes are separated in the small portions, and not in the larger, we cannot tell; but though we are ignorant of this, and many more circumstances relative to the re-production of these little animals, yet the foregoing facts enable us to understand better the nature of the existence of these polypes which have been turned inside out.

For as that part which formed the interior skin of the stomach in the little fragments before-mentioned, became the exterior part of the animal, the inside of the polype is consequently so similar to the exterior skin, that one may be substituted for the other, without injuring the vital functions; from hence we might, in some measure, have inferred the possibility of the polypes living, after they have been turned inside out, independent of the fact itself.

The viscera of the animal are situated in the thickness of the skin, and absorbing pores are placed both on the inside and outside, so that the animal can live whether the skin be turned one way or the other. The Author of nature did not create the polype to be turned as we turn a glove; but he formed an animal whose viscera were lodged in the thickness of the skin, and with powers to resist the various accidents to which it was unavoidably exposed by the nature of its life; and the organization necessary for this purpose was so constructed, that the skin might be turned without destroying life.

Every portion of a divided polype has, like the vegetable bud, all the viscera necessary to its existence; it can, therefore, live by itself, and push forth a head and tail, when placed end to end against another piece. The vegetation consists in uniting the portions, the vessels of each part increase in length, and a communication is soon formed between them, which unites the whole. The ease with which the parts unite, is as has been observed before, probably owing to their gelatinous nature; for we find many similar instances in tender substances. The solid parts of the embryo, as the fingers, unite in the womb; tender fruit and leaves may be also thus united.

A portion of these creatures is capable of devouring its prey almost as soon as it is divided from the rest. In the structure of those animals which are most familiar to us, a particular place is appropriated for the developement and passage of the embryo. But on the body of an animal, which, like a tree, is covered with prolific gems, it is not surprizing that the young ones should proceed from its sides, like branches from a tree. The mother and her young ones form but one whole; she nourishes them, and they contribute to her existence, as a tree supports, and is reciprocally supported by its branches and leaves.

OF THE HYDRA PALLENS.

The hydra pallens has been fully described only by M. Rösel;* it is very seldom to be met with, is of a pale yellow colour, and

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* Insecten Belustigung, 3. Theil. pag. 465. Tab. LXXVI. LXXVII.

grows smaller gradually from the bottom, the tail is somewhat round or knobbed, the arms are about the length of the body, of a white colour, and generally seven in number, apparently composed of a chain of globules; it brings forth the young from all parts of its body. Linnæus defines it as, hydra pallens tentaculis subsenis mediocribus;* Pallas as, hydra attenuata corpore flavescente, sursum attenuato.†

OF THE HYDRA HYDATULA.

Plate XXI. Fig. 1, 2, 3, and 4.

The next in order is the hydra hydatula, which we have already defined from Linnæus as a hydra with four obsolete arms, and a vesicular body: it is spoken of by several medical writers, who are enumerated in the Systema Naturæ, p. 1321. It is described also by Hartman, Misc. Nat. Cur. Dec. I. An. 7, Obs. 206, Dec. II. An. 4, Obs. 73, as hydatis animata; also in the Dissert. de Inf. Viv. p. 50, n. 6, tænia hydatoidea. Pallas defines it as tænia hydatigena rugis imbricata corpore postice bulla lymphaticæ terminato. The following description is extracted from that in the Philosophical Transactions, No. 193, by Dr. Tyson, who names it lumbricus hydropicus.

In the dissection of a gazella or antelope, Dr. Tyson observed several hydatides or films filled with water, about the size of a pigeon's egg, and of an oval form, fastened to the omentum, and some in the pelvis, between the bladder of urine and the rectum; and he then suspected them to be a particular sort of insect, bred in animal bodies, or at least the embryos or eggs of them: 1. Be-

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* System. Nat. p. 1320, No. 4.

† Zoophyt. 4.

cause he observed them included in a membrane, like a matrix, so loosely, that by opening it with a finger or knife, the internal bladder, containing the serum or lympha, seemed no where to have any connection with it, but would very readily drop out, still retaining its liquor, without spilling any of it. 2. He observed that this internal bladder had a neck or white body, more opake than the rest of the bladder, and protuberant from it, with an orifice at its extremity, by which, as with a mouth, it exhausted the serum from the external membrane, and so supplied its bladder or stomach. 3. Upon bringing this neck near the candle, it moved and shortened itself. Fig. 1, represents one of these watery bladders inclosed in its external membrane, its shape was nearly round, being only a little depressed or flatted, as a drop of quicksilver will be by lying on a plane. In Fig. 2, the neck is better seen; the external membrane being taken off, an open orifice is found at its extremity; it consists of circular rings or incisures, which are more visible when magnified, as in Fig. 3; it then appears granulated with a number of little eminences all over the surface; the orifice at the extremity seems to be formed by retracting itself inwards, and upon trial it was found to be so; for in Fig. 4, the neck of this polype is represented magnified and drawn out its whole length; on opening it there were found within the two strings a, a, which probably convey into the stomach the moisture and nourishment, which the animal, by protruding its neck, extracts from the external membrane.*

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* Hydra hydatula habitat in abdomine mammalium, ovium, suum, murium, &c. inter peritoneum et intestina. Vesica lymphatica, pellucida, magnitudine pruni, petiolata corpore cylindrico, in cujus apice os, quod, corpore compresso, movet tentacula vix manifesta. Linn. Syst. Nat. p. 1321. No. 5.

OF THE HYDRA STENTOREA.

Plate XXII. Fig. 27 and 28.

Hydra tentaculis ciliaribus corpore infundibuliformi.

The arms of this hydra are rows of short hairs, the body trumpet-shaped.

This species of hydra is very common, and has been described by almost every writer on these subjects; it is placed by Müller among the vorticellæ.

Vorticella stentorea caudata, elongata, tubæformis limbo ciliato. Müller animalcula infusoria.

Mr. Baker originally named it the funnel-like polype, which Messrs. Trembley and Reaumur changed to the tunnel-like polype, under which name it appears in the Philosophical Transactions, No. 474.

There are three kinds of them, which are of different colours, green, blue, and white. The white ones are the most common. It is necessary to observe them often, and in various attitudes, in order to obtain a tolerable idea of their structure. They do not form clusters, but adhere singly by their tail to whatever comes in their way; their anterior end is wider than the posterior, and being round, gives the animal somewhat of a funnel form, though it is not completely circular, having a sort of slit or gap that interrupts the circle. The edge of this opening is furnished with a great number of fibrillæ, which by their brisk and continual motions excite a current of water; the small bodies that float or swim near this current, are forced by it into the mouth of the little animal. Trembley says, that he has often seen a number of very small animalcula fall one after another into the mouth, some of which were afterwards let out again at another opening, which he was not able to describe.

They can fashion their mouths into several different forms. If any thing touch them, they shrink back and contract themselves. They live independent of each other, swimming freely through the water in search of their prey, and fix to any thing they meet with.

These animals multiply by dividing themselves, not longitudinally, nor transversely, but sloping and diagonal wise; the proceedings in nature continually varying in every new form of life. Of the two polypes produced by the division of one, the first has the old head and a new tail; the other, the old tail and a new head.

To make the description more clear, Trembley called that with the old head the superior polype, that with the new head the inferior one. The first particular that is observable in these polypes, when they are going to divide, is the lips of the inferior one; a transverse and oblique stripe indicates the part where it is going to divide; the new lips are formed at about two-thirds of the length of the polype, reckoning from the head; the division is made in a sloping line, that goes about half way round the parent animal; these lips are at first discerned by a slow motion, which engages the attention of the observer. They then insensibly approach each other and close, whereby a swelling is formed on the side of the polype, which is soon found to be a new head. When the swelling is considerably increased, the two polypes may be plainly distinguished. The superior one being now connected with the inferior one only by its lower extremity, is soon detached from it, and swims away to fix itself on some convenient substance; the inferior one remains fastened to the place where the original polype was fixed before the division.

From the various modes by which different species of polypes are multiplied, we are led to form more exalted ideas of nature, and to see that the little we discover is but an exceeding small part of her contents; we learn also to be more cautious in reasoning from analogy, and laying down the known for a model to the unknown, because we find that the operations in nature are varied ad infinitum.

The growth of the hydra fusca is very quick, but that of the hydra stentorea is much more so. The progress of the fœtus is always more rapid than that of the infant and adult animal; but in these organized atoms the evolution is so rapid, as to appear almost like an immediate creation.

Fig. 28 represents the hydræ stentoreæ, or funnel-polypes, fixed to the under side of a piece of some vegetable substance; they are in this figure of their natural size.

Fig. 27, the same polypes magnified; the different forms they assume are also seen here, sometimes short and thick, as at m m; long, as at n; nearly globular, as at o; extended to the full size, as at k; seen as contracted at i. The fibrillæ or little hairs may be seen in most of the attitudes except those of l.

OF THE HYDRA SOCIALIS.

Plate XXI. Fig. 11.

Hydra socialis mutica torosa rugosa.*

Social hydra, bearded thick and wrinkled.

This species of hydra has been described by many writers. It is the vorticella socialis of Müller, who defines it as vort cella caudata, aggregata, clavata; disco obliquo. Müller Animalcula Infusoria, p. 304. Pallas makes it a brachionus, Pall. Zooph. 53.

In Fig. 11, these animals are represented as considerably magnified; they appear like a circle, surrounded with crowns, or ciliated heads, tied by small thin tails to a common center, from whence they advance towards the circumference, where they turn like a wheel, with a great deal of vivacity and swiftness, till they occasion a kind of whirlpool, which brings into its sphere the proper food for the polype. When one of them has been in motion for a time, it stops, and another begins; sometimes two or three may be perceived in motion together. They are often to be found separate, with the tail sticking in the mud. The body contracts and dilates very much, so as sometimes to have the appearance of a cudgel; at others, to assume almost a globular form. The young polypes of this species have been sometimes taken for the hydra stentorea.

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* Linn. Syst. Nat. p. 1321. No. 7.

OF THE VORTICELLÆ.

We now come to another division of these animals, to which later writers have given the name of vorticellæ; this term I shall therefore adopt, being of opinion that it behoves every man to maintain that order in scientific arrangement which is not inconsistent with truth, except he can produce another arrangement more expressive of the nature of the objects it is designed to discriminate; a process requiring no small degree of attention.

The variety that may be observed in these minute animals confirms a principle, which, the more it is inquired into, the more it will be found to accord with the general operations in nature, namely, that there is always a pre-existent principle of life necessary to the organization both of animals and vegetables; that the alimentary and other particles which are added to, or apparently belong to them, produce nothing of themselves; they are incapable of forming the least fibre, but they are able to become constituent parts of one organical whole, together with the instruments whereby the forming principle is manifested, and rendered capable of acting upon certain orders of creatures.

VORTICELLA.

Animal calyce vasculoso; ore contractili ciliato, terminali. Stirps fixa.

A small animal, with a vascular cup; the mouth is at one end ciliated, and capable of being contracted, the stem fixed.

VORTICELLA ANASTATICA.

Plate XXI. Fig. 13, 14, 15, and 16.*

Vorticella anastatica, composita, floribus campanulatis, stirpe multiflora rigescente.

Vorticella anastatica, compound, with bell-shaped flowers, and a rigid stem.

Cluster polype, second species. Trembley, Philos. Trans. vol. xliv. part. 2. p. 643.

These polypes form a group resembling a cluster, or more properly an open flower; this flower or cluster is supported by a stem, which is fixed by its lower extremity to some of the aquatic plants or extraneous bodies that are found in the water; the upper extremity forms itself into eight or nine lateral branches, perfectly similar to each other; these have also subordinate branches, whose collective form much resembles that of a leaf. Every one of these assemblages is composed of one principal branch or nerve, which makes with the main stem of the cluster an angle somewhat greater than a right one; from both sides of this nerve the smaller lateral branches proceed; these are shorter the nearer their origin is to the principal branch.

At the extremity of the principal branch, and also of all the lateral ones, there is a polype or vorticella. There are others on both sides of the lateral twigs, but at different distances from their extremity. These polypes are all exceeding small, and of a bell-like figure; near their mouth a quick motion may be discerned, though not with sufficient distinctness to convey an adequate idea of its cause; upon the branches of these clusters are round bodies, which will be more particularly described presently.

Every cluster has eight or nine of these branches or leaves; they do not all proceed from the same point, but the points from whence they set out are not far asunder; each of these branches is bent a little inwards, so that all of them taken together form a kind of shallow cup. If the eye be placed right over the base of this cup, the appearance of the whole eight or nine branches is like unto that of a star, with so many rays proceeding from the center. If the cluster be slightly touched, all the branches instantly fold up, and form a small round mass. The stem which supports the cluster contracts also at the same time, folding up like a workman's measuring rule, that consists of three or four joints. This extraordinary assemblage constitutes one organized whole, formed of a multitude of similar and particular ones. A new species of society, in which all the individuals are members of each other in the strictest sense, and all participate of the same life.

A few days after one of these clusters is formed, small round bodies or bulbs may be perceived to protrude in several places from the body of the branch; these grow very fast, and arrive at their greatest growth in two or three days. The bulbs detach themselves from the branches out of which they spring, and go away, swimming till they can settle upon some substance which they meet with in the water, and to which they fix themselves by a short pedicle; the bulbs are then round, only a little flatted on the under side, the pedicle continues to lengthen gradually for about twenty-four hours, during the same time the bulbs also change their figure, and become nearly oval. There are in a cluster but few of these bulbs, compared with the number of the

the vorticellæ, neither do all the bulbs come out at the same time. The bulb then divides lengthways into two smaller ones, but which are still much larger than the vorticellæ themselves. It is not long before these are separated like the first, and thus form four bulbs on the same stalk; these again divide themselves, and form eight; which again subdivide, and consequently make sixteen. They are all connected with the stalk by a proper pedicle, but they are not all of an equal size; the largest continue to divide, and the smallest begin to open, and take the bell-formed shape. Trembley observed from one round bulb, in about twenty-four hours, by repeated divisions, one-hundred and ten vorticellæ to be formed.

It has been asked with propriety, what plant or what animal could have led us to expect an existence and mode of propagation similar to that of the vorticella anastatica?

Fig. 13 represents one branch of the vorticella anastatica; on this branch, besides the vorticellæ which are of a bell-like form, some of those round bodies from which they first spring, and by which they are so remarkably distinguished from any other species, may be seen.

Fig. 14 represents one of the globular bodies after it has parted from the cluster, and has fixed itself to some other body, and after the globule itself and its pedicle have begun to lengthen.

Fig. 15 represents the two bodies that were formed by the parting of that which is shewn at Fig. 14.

Fig. 16* represents four that were formed by the separation of the two bulbs, exhibited in the foregoing figure.

VORTICELLA PYRARIA.

Plate XXII. Fig. 25, 26.

Vorticella composita, floribus muticis obovatis; tentaculis bigeminis, stirpe ramosa. Compound, with beardless oval florets, two double arms, the stem branched.

It is somewhat of a pear shape, the base is pellucid, the top truncated, the lateral arms, which are a pair on each side, cannot be distinguished without some attention; they are sometimes to be seen disengaged from the pedicle, and rolling swiftly in a kind of circle.

VORTICELLA CRATÆGARIA.

Plate XXII. Fig. 40.

Vorticella composita, floribus muticis globosis; tentaculis binis, stirpe ramosa. Compound, with globous naked florets, two tentacules, and a branched stem.

These vorticellæ are to be found in the month of April, both in the mud, and upon the tail of the monoculus quadricornis; they are generally heaped together in the manner in which they are represented in the figure; they are of a spherical form, and united to one common stalk. They are also often to be found without any pedicle. The body is rather contracted; the aperture is circular, and surrounded with a marked margin; it has two small arms. With a deep magnifier, a vehement rotatory motion may be seen. They sometimes separate from the community, and go forwards in a kind of spiral line, and then in a little time come back again to the rest.

The figure represents a parcel of these vorticellæ united together.

Among the other authorities for this animal, Linnæus refers to Baker's description of the mulberry insect, "Employment for the Microscope," p. 348, which, as it differs a little from the preceding account, we shall insert here. That from which his drawing was made, and which he has described, was found in a ditch near Norwich; he called it the mulberry insect, from the resemblance it bore to that fruit; though the protuberances that stand out round it are more globular than those of a mulberry. It is to be seen rolling about from one place to another, and is probably a congeries of animalcula; they are to be met with in different numbers of knobs or protuberances, some having fifty or sixty, others more or less, down to four or five. The manner of moving is the same in all. They are generally of a pale yellow.

VORTICELLA OPERCULARIA.

Plate XXII. Fig. 29.

Vorticella composita floribus muticis ovalibus, stirpe ramosa. Compound, with naked oval florets, and a branched stem.

These vorticellæ are of a lemon shape, and are generally found in clusters, branching out from a stem, which mostly adheres to some convenient substance.

That species of them which is described by Baker had a very short pedicle, and the animals were much longer than those which are represented at Fig. 29. There was no main stem, but all the pedicles were joined in one center, round which the animals extended themselves as so many radii, forming a very pleasing figure.

The mouths of these animalcula are not ciliated, but they are furnished with a round operculum or cover, connected by a long ligament or muscle, which extends downwards through the body, and is affixed withinside of it, near the tail. This ligament may be contracted or dilated, so that the cover can be removed to some distance from the mouth; in this situation several short hairs may be found to radiate from it; these have a vibratory motion, by which they excite a current of water, most probably to draw in the proper nourishment, after which they shut or pull down the cover, which they again extend at pleasure: when the cover is pulled close down, the mouth contracts, and no hairs are to be seen.

Fig. 29 represents the vorticella opercularia; ſ, the operculum removed at some distance from the mouth, at t; it is nearly close at r, the mouth contracted, the cover drawn in, and no hairs to be seen; u, a part of the stalk, from which some of the animalcula are separated.

VORTICELLA UMBELLARIA.

Plate XXII. Fig. 30.

Vorticella composita, floribus ciliatis globosis muticis, stirpe umbellata. Compound, with ciliated globous naked florets and an umbellated stem.

Vorticella acinosa, simplex, globosa, granis nigricantibus, pedunculo rigido. Müller Animal. Infus. p. 319.

We frequently find in divers places, upon water-plants, and other bodies in the water, a whitish substance that looks like mould; plants, pieces of wood, snail shells, &c. are often entirely covered over with this substance. If we examine any of these minute bodies by the microscope, we shall find such motions as will induce us to think them an assemblage of living animals, severally fixed to the extremities of small stems or pedicles, many of which are often so united as to form together a sort of branches or clusters, from whence they have been termed clustering polypes, or des polypes en bouquet.

These clusters are larger or smaller, according to the species of the vorticellæ which form them, as well as owing to the concurrence of many other circumstances. To obtain a clear idea of the figure of these animals, it is best to observe the smaller clusters, as in the larger they are often rendered less distinct on account of the number.

The length of those which are represented at Fig. 30, is about the 240th of an inch; they are of a bell-shape. The anterior part a c generally appears open, the posterior part is fixed to a stem or pedicle, b e; it is by the extremity of this pedicle that the vorticella fastens itself to any substance. It appears in the microscope of a brownish colour, excepting at the smaller end b, where it is transparent, as well as the whole pedicle b e. When the anterior part a c is open, a very lively motion may be perceived about its edges; and when it presents itself in a particular manner, something very much resembling the little wheels of a mill, moving with great velocity, may be discovered on both sides of the edges of this anterior part.

These vorticellæ are able to contract themselves suddenly. They may be made to do this, either by touching them, or moving the substance to which they are fixed. When they contract, the edges of the anterior parts are drawn quite into the body; on resuming their former posture, the edges may be seen to come forth, and put themselves in motion as before. Minute substances that float in the water are often forced down into these openings, and sometimes are thrown out again.

They are capable of swimming about singly, but their form is in that case considerably different from that which they have when they are fixed. To see regularly in what manner the clusters are formed, and in what way these little creatures multiply, it is best to observe one that is fixed by itself.

The pedicle of a single vorticella is at first short, but it soon grows longer, and then begins to multiply, that is, to divide or split itself into two lengthways. To effect this, the lips are first drawn into the body, the anterior part closes and becomes round, and loses its bell shape, the motion about the lips ceases, though a small degree of motion may be perceived within the body. The anterior end flattens gradually, and spreads wider in proportion as it grows smaller. It then gradually splits down the middle, that is, from the middle of the head to the pedicle, so that in a little time two separate round bodies appear to be joined to the end of the pedicle that before supported but one.

The mouth or anterior part of each of these bodies now opens by degrees; and in proportion as they open, the lips of the new vorticella begin to display themselves. The motion before spoken of may then also be perceived. Indeed it is the best time of observing it; it is at first slow, but more rapid in proportion as the mouth opens, when it is as swift as that of the vorticella before it began to divide, and we may now look upon it as completely formed. A vorticella is generally about one hour in dividing itself.

The lower of the three drawings, Fig. 30, represents two vorticellæ joined by their posterior extremity to one pedicle; soon after the division, each vorticella begins to shew a pedicle of its own.

Fig. 30 represents a cluster of eight vorticellæ; by this figure we may form some idea in what manner the pedicles are disposed as their number increases. There were at first only two at b, whose branches lengthened to d, and then each of them was divided into two, now forming four; these again lengthened and reached i; when they were again subdivided, as in the figure.

The reader will join with Bonnet in admiring the group of wonders afforded by a single spot of mouldiness. What unforeseen, varied, and interesting scenes are presented within so small a compass! what a theatre is exhibited to a thinking mind! But our abode is so recluse, that we have but a glimmering view of it: how great would our astonishment be, if the whole spectacle was disclosed to us at once, and we were enabled to penetrate into the interior structure of this wonderful assemblage of living atoms! Our eyes see only the gross parts of the decorations, whilst the machines that execute them remain in impenetrable darkness! Who shall enlighten this profound obscurity, or dive into an abyss where reason is lost; or draw from thence the treasures of wisdom concealed within it? Let us learn to be content with the small portion that is communicated to us, and contemplate with gratitude the first traces of human understanding that are imparted to us in these discoveries.

VORTICELLA BERBERINA.

Vorticella composita, floribus ovalibus muticis, stirpe ramosa. Compound, with oval beardless florets.

This is a species of the vorticellæ, which resembles the preceding one in many respects, particularly in being multiplied in the same manner, that is, by dividing or splitting, according to its length.

They are more slender than the vorticella umbellaria; the branches of the clusters are transparent. When many of them are together, they appear of a changeable violet colour; the clusters are not unlike a sprig of spun glass. The motion of the lips is not so easily distinguished as in the foregoing species, though it may be observed in these whilst they are opening and completing their formation. For at these times the motion is but slow, whereas it becomes afterwards very quick in those that are arrived at a state of perfection.

All the cluster vorticellæ detach themselves from time to time from the stem, and from these they swim about till they fix again upon some convenient substance; the branches, when deserted, bear no more vorticellæ.

VORTICELLA DIGITALIS.

Plate XXII. Fig. 31.

Vorticella composita, floribus cylindricis, unisulcatis semiclausis, stirpe ramosa. Compound, with cilindrical florets.

Vorticella composita, cylindrica, crystallina, apice truncata et fissa, pedunculo fistuloso ramosa. Müller Animal. Infus. p. 327.

This species of the vorticella is very scarce, it seems only to have been seen by Rösel, who found it on the monoculus quadricornis, till it was discovered in the year 1784 by Müller, who had sought for it several years before, but in vain.

The body is cylindrical, crystalline, and appears almost empty; it has three pellucid points disposed lengthways, the apex is truncated in an oblique direction, the margin bent back. The upper part contracts itself, and the margin then assumes a conical shape, with a convex surface; there are in general but few branches from the principal stem, and these are short and thick. It excites an undulatory motion, but no hairs, nor any rotatory motion, have been discovered. Fig. 31, o and n, represents the vorticella adhering to the monoculus quadricornis.

VORTICELLA CONVALLARIA.

Plate XXII. Fig. 39.

Vorticella simplex, gregaria, flore campanulata mutico; tentaculis bigeminis, stirpe fixa. Simple, but gregarious, the florets bell-shaped, with two pair of little arms, and a fixed stem.

Vorticella simplex, campanulata, pedunculo rotortili. Müller Animal. Infus.

These vorticellæ, or bell-animals, as they are termed by Baker, are generally found adhering to some substance in the water; they are represented here as found by Rösel, fixed to a curious cornu ammonis, with points projecting from the back. To the naked eye they appear only as so many little white points, but under the microscope, as little bells, agitating the water to a considerable distance. The stems of these have a particular motion, they draw themselves up and shorten all at once, taking the form of a spiral wire or screw; in a moment after they again resume their former shape, stretching themselves out straight as before. Many of them may be seen at times adhering to each other by their tails; the cilia, which are two on each side of the mouths, are very seldom to be perceived.

VORTICELLA URCEOLARIS.

Plate XXII. Fig. 33, 34, 35, 36, 37, 38.

Vorticella simplex, pedunculata, ore dentato. Single, with a short tail, and toothed mouth.

Brachionus capsularis testa ovata apice sexdentata basi incisa, cauda longa bicuspi. Müller Animal. Infus. p. 356.

To the naked eye it appears as a white moveable point; but when examined by the microscope, a tail projecting from the lower part is discovered, and a double rotatory instrument is seen, which it can conceal or expose at pleasure. It has been seen and described by most microscopical writers; but as Baker's seems to be the most perfect description, I shall principally follow his account of it.

He discovered three species of them, two of which are included under the vorticella urceolaris. Fig. 33, 34, 35, are of the first species; Fig. 36, 37, 38, are of the second kind. The first sort, when extended, is about twice as long as it is broad. It is contained in a shell; the fore part of this is armed with four sharp teeth or points; the opposite side has no teeth, but is waved or bent in two places, like the form of a Turkish bow. At the bottom there is a hole, through which it pushes the tail. It fastens itself by this tail to any convenient substance when it intends to use its rotatory organs; but when it is floating in the water, and at all other times when not adhering to any body, it wags the tail backwards and forwards something like a dog.

We may consider it as divided into a head, thorax, and abdomen; each of which may be extended and contracted considerably: it can, by dilating all three, protrude the head beyond the shell, or by contracting them, draw the whole body within the same.

The head, when extended, divides itself into two branches, between which, another part, a kind of proboscis, is pushed out; at the end of this are two fibrils, that appear when they are at rest like a broad point, but which can be moved to and from each other very briskly with a vibratory motion, see Fig. 33.

The form and situation of the two branches are sometimes changed, the ends thereof becoming more round, and the vibratory motion is altered to a rotatory one: this alteration is represented at Fig. 34: the head also appears in this figure. The thorax is annexed to the lower part of the head; it is muscular: within it there is a moving intestine, which has been supposed to be either the lungs or the heart of the little creature, see b, Fig. 33 and 34.

A communication is formed between the thorax and the abdomen by means of a short vessel c, whose alternate contractions and dilatations occasion the abdomen to rise and fall alternately, having at the same time a sort of peristaltic motion. The food is conveyed through this vessel into the abdomen, where it is digested; it is then discharged by the anus, which is placed near the tail.

The tail has three joints, and is cleft or divided at the extremity, by which means it can better fasten itself to suitable objects. It is in general projected from the lower end of the shell, moving nimbly to and fro, serving the animal as a rudder when it is swimming, to direct its course.

When the water in which the little animal is placed is nearly dried away, or when it has a mind to compose itself to rest, it contracts the head and fore-part of the body, brings them down into the shell, and pulls the tail upwards, so that the whole of this minute creature is contained within the shell, see Fig. 35. The shell is so transparent that the terminations cannot be easily distinguished when the animal is extended; but whatever is transacted within the shell, is as plain as if there was no substance between the eye and the interior parts.

Fig. 36, 37, 38, exhibit the appearance of another species of these animals, which differs from the foregoing kind. This has also a head, a thorax, and abdomen, but then they are not separated by a gut or intermediate vessel, as in the former, but are joined immediately together, and at the place where in the first kind a moveable intestine was seen; in this a muscle, most probably the heart, may be discovered; it has a regular systole and diastole: this part is intended to be shewn at a, Fig. 36, 37, 38. Like the other, it draws the head and tail within the shell, which then appears to have six teeth or spikes on one side, and two on the other. It very seldom protrudes its head so far out as the other; sometimes the fibrillæ may be seen within the margin of the shell.

Both species carry their young in an oval integument or bag, fastened externally to the lower part of the shell, somewhere about the tail; these bags are sometimes opake at one end, and seemingly empty at the other, see d, Fig. 34: sometimes the middle is opake, with a transparent margin, see b, Fig. 36.

It is highly entertaining to see a young one burst its integument, and gradually force its way out; in performing this operation, it is much assisted by the motion of the tail of the parent. The head part comes out first, it then sets its rotatory organ in motion, by which it is completely disengaged, leaving the integument behind, which the vorticella freed itself from by repeated strokes with its tail. A young one almost disengaged is seen at b, Fig. 38; another embryo, c, was left adhering to the shell.

There are four more species of the vorticellæ mentioned by Linnæus, which are, the vorticella encrinus, the vorticella polypina, the vorticella stellata, and the vorticella ovifera; which, being marine animals, do not come properly within our plan. The vorticella polypina will be described hereafter.

TUBULARIA CAMPANULATA.

Plate XXII. Fig. 32.

Tubularia reptans, tubis campanulatis. Creeping, with campanulated tubes.

It is called by Baker the bell-flowered, or plumed animal.

These little creatures dwell in colonies together, from ten to fifteen in number, living in a kind of slimy mucilaginous case, which, when expanded in the water, has some resemblance to a bell with its mouth upwards. These bells or colonies are to be found adhering to the large leaves of duck-weed and other aquatic plants.

The bell or case which these animals inhabit, being very transparent, all the motions of its inhabitants may be discerned distinctly through it. There are several ramifications or smaller bells proceeding from the larger one; in each of these there is an inhabitant. The opening at the top of these bells is just large enough for the creature's head, and a small part of its body to be thrust out from it, the rest remaining in the case, into which it also draws the head on the least alarm.

Besides the particular and separate motions which each of these creatures is able to exert within its case, and independent of the rest, the whole colony has a power of altering the position of the bell, and removing it from one place to another. These animalcula seem not to like to dwell in societies, whose number exceeds fifteen; when the colony happens to increase in number, the bell may be observed to split gradually, beginning from about the middle of the upper extremity, and proceeding downwards towards the bottom, till they at last separate and become two colonies, independent of each other.

The arms are very near each other; sixty may often be counted in one plume, having each the figure of an Italic *ſ*, one of whose hooked ends is fastened to the head; and altogether, when expanded, compose a figure somewhat like a horseshoe, convex on the side next the body, but gradually opening and turning outwards, so as to leave a considerable distance within the outer extremities of the arms.

The plumed polype is of a very voracious disposition, devouring a great number of small animals. If the arms, when extended, be observed attentively with the microscope, they will be found to have a constant vibratory motion, alternately bending withinside of the plume, and then rising up again. When one arm ceases its motion, the same is performed by another; thus by the perpetual agitation of the several arms, such a strong current is produced in the water, as brings the animalcula, and other minute bodies, that are floating near the polype, into its mouth, which is situated between the arms. The food, if agreeable to the creature, is swallowed; if otherwise, it is rejected by a contrary motion.

The animal may be seen very plain when it has retired within the tube. The body is about one-eighth of an inch long, without reckoning the plume, which is about the same length. It is cylindrical, and the skin is very transparent. The plume is only a continuation of this transparent skin, it is very broad in proportion to the body, and of a remarkable figure; the base is of the shape of a horseshoe; from this base the arms project, they bend rather outwards. The plume which they form, gives them a resemblance to some flowers. The arms may be compared, from their fineness and transparency, to very fine threads of glass. The base of the plume is grooved, and is fixed to the animal by the middle of the horseshoe which it forms, and it is here that there is an opening which serves as a mouth to the animal. The intestines are easily distinguished through its transparent skin; when it has just been eating, they are of a deep brown colour. Three principal parts are very visible, the oesophagus, the stomach, and the rectum.

In the inside of these animals a small oblong whitish body is formed, which is carried to the outside, and remains fixed in a perpendicular direction to the body; many of these are formed daily, and of these oval bodies new animals are produced, exactly similar to the parent.

If these minute bodies be eggs, they are of a singular kind, being destitute of any covering, and are neither membranaceous nor crustaceous; we cannot with propriety say the young ones are hatched from them; we can, however, perceive these oviform bodies to unfold themselves gradually. The developement is accomplished in a few minutes, and an animalculum appears like the parent.

Trembley amassed a great number of these eggs, and carried them from England with him, keeping them quite dry; on putting them into water, they gradually developed, and became as perfect as the tubularia from which they proceeded.

There is a very great similarity in the construction of this little creature and many of the marine polypes, who, like it, exist in tubes of the same growth with themselves.

Fig. 32 represents three tubulariæ campanulatæ or plumed polypes very much magnified, namely, one, b f a c d d e h g i, which is out of its cell; e h, the oesophagus; f g, the stomach; a f, the rectum; a c d d e, the plume, consisting of the base a e, which is but little seen, and the arms c d d, which proceed from the edges of this base; a second polype, *A B I*, which is within its cell, and in which the skin containing the plume is reversed. The third polype, s t u u, is a young one exhibited out of its cell; g o o, threads which are fixed at one end to the intestines of the animal, by the other to the bottom of the cell, l k.

CHAP. VIII.

OF THE ANIMALCULA INFUSORIA.

OUR knowledge of the microscopic world is at present very contracted, but we know enough to give us high conceptions of its concealed wonders, and to fill us with profound astonishment at the infinite variety of forms that are made recipient of life. A few of the inhabitants of this minute world have been discovered. The figure and apparent habits of life of these, resemble so little those with which we are more acquainted, that it is often difficult to find terms to express what is represented to the eye.

Animalculum signifies a little animal, and therefore the term might be applied to every animal which is considerably inferior in size to ourselves. It has been customary, however, to distinguish by the name of animalcula only such animals as are of a size so diminutive, that their true figure cannot be discerned without the assistance of glasses; and more especially it is applied to such as are altogether invisible to the naked eye, and cannot even be perceived to exist, but by the aid of microscopes.

By the help of magnifying glasses we are brought into a kind of new world; and numberless animals are discovered, which, from their minuteness, must otherwise for ever have escaped our observation: and how many kinds of these invisibles there may be, is yet unknown; as they are observed of all sizes, from those which are barely invisible to the naked eye, to such as resist the action of the microscope, as the fixed stars do that of the telescope, and with the best magnifiers hitherto invented, appear only as so many moving points.

The smallest living creatures our instruments can shew, are those that inhabit the waters; for, though possibly animalcula equally minute, or perhaps more so, may fly in the air, or creep upon the earth, it is scarce possible to obtain a view of them; whereas, water being transparent, and confining the creatures within it, we are enabled, by applying a drop of it to our glasses, to discover with ease a great part of its contents, and in a space barely visible to the naked eye, often perceive a thousand little creatures, all full of life and vigour.

By the animaleula infusoria are meant, not the larvæ of those insects which in their first state are inhabitants of water, and afterwards become winged insects, as the gnat, &c. Baker, and many other writers on the subject, have often confounded these, and hence entered into a train of reasoning contrary to fact and experience. The animalcula infusoria take their name from their being found in all kinds either of vegetable or animal infusions; if seeds, herbs, or other vegetable substances, be infused in water, it will soon be filled with an indefinite number of these minute beings. There is a prodigious variety in their forms; some perfectly resemble the bell-polype; others are round or oblong, without any, at least apparent, members; some resemble a bulb with a long taper tail; some are nearly spherical; the greater part are vesicular and transparent. Those most generally found in every drop of ditch water are mere inflated bladders, with a small trace of intestines in the center; the next are a flat kind, with a number of legs under the belly.

Motion seems to be their great delight; they pervade with equal ease and rapidity, and in all forms and directions, the whole dimensions of the drop, in which they find ample space for their various progressions, sometimes darting straight forward, at other times moving obliquely, then again circularly: they know how to avoid with dexterity any obstacles that might obstruct their progress. Hundreds may be seen in a drop of water in constant action, yet never striking against each other. If at any time the clusters prove so thick as to impede any of their motions, they roll and tumble themselves over head, creep under the whole range, force their way through the midst, or wheel round the cluster, with surprizing swiftness; sometimes they will suddenly change the direction in which they are moving, and take one diametrically opposite thereto. By inclining the glass on which the drop of water is laid, it may be made to move in any direction; the animalcula in the drop will swim as easily against the stream as with it.

If the water begin to evaporate, and the drop to grow smaller, they flock impetuously towards the remaining part of the fluid; an anxious desire of attaining this momentary respite of life is very visible, as well as an uncommon agitation of the organs by which they imbibe the water. These motions grow more languid as the water fails, till at last they entirely cease.

Animalcula and insects will support a great degree of cold, but both one and the other perish when it is carried beyond a certain point. The same degree of heat that destroys the existence of insects, is fatal to animalcula; as there are animalcula produced in water at the freezing point, so there are insects which live in snow.

If the smallest drop of urine be put into a drop of water where these animalcula are roving about, apparently happy and easy, they instantly fly to the other side, but the acid soon communicating itself to this part, their struggles to escape are increased, but the evil also increasing, they are thrown into convulsions, and soon expire.

Among animalcula, as in every other part of nature, there is constantly a certain proportion preserved between the size of the individuals and their number. There are always fewest amongst the larger kinds, but they increase in number as they diminish in size, till of the last, or lowest to which our powers of magnifying will reach, there are myriads to one of the larger. Like other animals, they increase in size from their birth till they have attained their full growth. When deprived of food, they grow thin and perish; and different degrees of organization are to be discovered in their structure.

The birth and propagation of these microscopic beings is as regular as that of the largest animals of our globe; for though their extreme minuteness prevents us, in most cases, from seeing the germ from which they spring, yet we are well assured, from numerous observations, that the manner in which they multiply is regulated by constant and invariable laws.

It has been shewn that different species of the hydræ and vorticellæ multiply and increase by natural divisions and subdivisions of the parent's body; this manner of propagation is very common among the animalcula in infusions, though with many remarkable varieties. Some multiply by a transverse division, a contraction takes place in the middle, forming a kind of neck that becomes smaller every instant, till they are enabled by a slight degree of motion to separate from each other. These animalcula in general studiously avoid each other; but when they are in the labour of multiplication, and the division is in great forwardness, it is not uncommon to see one of them precipitate itself on the neck of the dividing animalculum, and thus accelerate the separation.

Another species, when it is on the point of multiplying, fixes itself to the bottom of the infusion; it then forms an oblong figure, afterwards becomes round, and begins to turn rapidly, as if upon an internal center, continually changing the direction of its rotatory motion; after some time, we may perceive two lines on the spherule, forming a kind of cross; soon after which the animalculum divides into four distinct beings, which grow, and are again subdivided.

Some multiply by a longitudinal division, which in one kind begins in the fore-part, and others in the hind-part; from another kind a small fragment is seen to detach itself, which very soon acquires the form of the parent animalculum. Lastly, some propagate in the same manner as those we deem more perfect animals.

From what has been said, it appears clearly that their motions are not purely mechanical, but are produced by an internal spontaneous principle, and that they must therefore be placed among the class of living animals, for they possess the strongest marks, and the most decided characters of animation; and consequently, that there is no foundation for the supposition of a chaotic and neutral kingdom, which can only have derived its origin from a very transient and superficial view of these animalcula.

It may also be further observed, that as we see the motions of the limbs, &c. of the more noble animals, viz. the human species, are produced by the mechanical construction of the body and the action of the soul thereon, and are forced by the ocular demonstration arising from anatomical dissection, to acknowledge this mechanism which is adapted to produce the various motions necessary to the animal; and as when we have recourse to the microscope, we find those pieces which had appeared to the naked eye as the primary mechanical causes of the particular motions, to consist themselves of lesser parts, which are the causes of motion, extension, &c. in the larger; when the structure can therefore be traced no further by the eye or glasses, we have no right to conclude, that the parts which are invisible, are not equally the subject of mechanism: for this would be only to assert in other words, that a thing may exist because we see and feel it, and has no existence when it is not the object of our senses.

The same train of reasoning may be applied to microscopic insects and animalcula; we see them move, but because the muscles and members which occasion these motions are invisible, shall we infer that they have not muscles, with organs appropriated to the motion of the whole and its parts? To say that they exist not, because we cannot perceive them, would surely not be a rational conclusion. Our senses are indeed given us, that we may comprehend some effects; but then we have also a mind with reason bestowed upon us, that from the things which we do perceive with our senses, we may deduce the nature of those causes and effects which are imperceptible to the corporeal eye.

Messrs. Buffon, Needham, and Baron Münchhausen, have considered this part of animated nature in so different a light from other writers, that we cannot with propriety entirely pass them over. Needham imagined that there was a vegetative force in every microscopical point of water, and every visible filament of which the whole vegetable contexture consists; that the several species of microscopic animals may subside, resolve again into gelatinous filaments, and again give lesser animals, and so on, till they can be no further pursued by glasses. That agreeable to this idea, every animal or vegetable substance advances as fast as it can in its revolution, to return by a slow descent to one common principle, whence its atoms may return again, and ascend to a new life. That notwithstanding this, the specific seed of one animal can never give another of a different species, on account of the preparation it must receive to constitute it this specific seed.

Buffon asserts, that what have been called spermatic animals, are not creatures really possessing life, but something proper to compose a living creature, distinguishing them by the name of organic particles, and that the moving bodies which are to be found in the infusions either of animal or vegetable substances, are of the same nature.

Baron Münchhausen supposed that the seeds of mushrooms were first animals, and then vegetables; and this, because he had observed some of the globules in the infusions of mushrooms, after moving some time, to begin to vegetate.

It might be sufficient in the first instance to observe, that Messrs. Needham and Buffon, by having recourse to a vegetative force and organic particles, to account for the existence and explain the nature of animalcula, and the difficulties of generation, have substituted words in the place of things; and that we are no gainers by the substitution, unless they explain the nature of these powers. But to this we may add, that all those who have examined the subject with accuracy and attention, as Bonnet, De Saussure, Baker, Wrisberg, Spalanzani, Haller, Ellis, Müller, Ledermüller, Corti, Rofredi, &c. disagree with the foregoing gentlemen, proving that they had deceived themselves by inaccurate experiments, and that one of them, Buffon, had not seen the spermatic animals he supposed himself to be describing, insomuch that Needham was at last induced to give up his favourite hypothesis.

Though we can by no means pretend to account for the appearance of most animalcula, yet we cannot help observing, that our ignorance of the cause of any phænomenon is no argument against its existence. Though we are not, for instance, able to account in a satisfactory manner for the origin of the native Americans, yet we suppose Buffon himself would reckon it absurd to maintain, that the Spaniards on their arrival there found only ORGANIC PARTICLES moving about in disorder. The case is the very same with the eels in paste, to whose animation he objects. They are exceedingly small in comparison with us; but, with the solar microscope, Baker has made them assume a more respectable appearance, so as to have a diameter of an inch and an half, and a proportionable length. They swam up and down very briskly; the motion of their intestines was very visible; when the water dried up they died with apparent agonies, and their mouths opened very wide. Now, were we to find a creature of the size of this magnified eel gasping in a place where water had lately been, we certainly should never conclude it to be merely an ORGANIC PARTICLE, or fortuitous assemblage of them, but a fish. Why then should we conclude otherwise with regard to the eel in its natural state, than that it is a little fish? In reasoning on this subject, we ought ever to remember, that however essential the distinction of bodies into great and small may appear to us, they are not so to the Deity, with whom, as Baker well expresses himself, "an atom is a world, and a world but as an atom." Were the Deity to exert his power a little, and give a natural philosopher a view of a quantity of paste filled with eels, from each of whose bodies the light was reflected as in the solar microscope; our philosopher, instead of imagining them to be mere organic particles, as the paste would appear like a little mountain, he would probably look upon the whole as an assemblage of serpents, and be afraid to come near them. Whenever, therefore, we discover beings to appearance endued with a principle of self-preservation, or whatever we make the characteristic of animals, neither the smallness of their size, nor the impossibility of our knowing how they came there, ought to cause us to doubt of their being animated.

I shall here insert some extracts of the experiments made by Ellis at the desire of Linnæus, and which are a full refutation of those made by Needham and Münchhausen. By those he made on the infusions of mushrooms in water, it appeared evidently that the seeds were put in motion by minute animals, which arose on the decomposition of the mushroom; these, by pecking at the seeds, which are little round reddish bodies, moved them about with great agility in a variety of directions, while the little animals themselves were scarce visible till the food they had eaten discovered them.

The ramified filaments, and jointed or coralloid bodies, which the microscope discovers to us on the surface of most vegetable and animal infusions, when they become putrid, and which were supposed by Needham to be zoophytes, were found by Ellis to be of that genus of fungi called mucor, many of which have been figured by Michelius, and described by Linnæus. Their vegetation is so quick, that they may be seen to grow and seed under the eye of the observer. Other instances of similar mistakes in Needham's experiments may be seen in Ellis's paper, Philos. Trans. vol. lix. p. 138.

A species of mucor arises also from the bodies of insects putrefying in water; this species sends forth a mass of transparent filamentous roots, from whence arise hollow seed vessels; on the top there is a hole, from which minute globules often issue in abundance, and with considerable elastic force, which move about in the water. It will however be found, with a little attention, that the water is full of very minute animalcula, which attack these seeds, and thus prolong their motion; but after a small space of time they rise to the surface, and remain there without any motion; a fresh quantity rises up, and floating to the edge of the water, remains there inactive; but no appearance can be observed of detached and separated parts becoming what are called microscopic animalcula. Indeed, it is surprizing that Needham should ever take the filaments of the moistened grains for any thing else than a vegetable production, a true species of mouldiness.

On the 25th of May, Fahrenheit's thermometer 70°, Ellis boiled a potatoe in the New River water, till it was reduced to a mealy consistence. He put part of it, with an equal proportion of the boiling liquor, into a cylindrical glass vessel, that held something less than half a wine pint, and covered it close immediately with a glass cover. At the same time he sliced an unboiled potatoe, and, as near as he could judge, put the same quantity into a glass vessel of the same kind, with the same proportion of New River water not boiled, and covering it with a glass cover, placed both vessels close to each other. On the

26th of May, twenty-four hours afterwards, he examined a small drop of each by the first magnifier of Wilson's microscope, whose focal distance is reckoned at $\frac{1}{50}$ part of an inch; and, to his amazement, they were both full of animalcula of a linear shape, very distinguishable, moving to and fro with great celerity; so that there appeared to be more particles of animal than vegetable life in each drop. This experiment he repeatedly tried, and always found it to succeed in proportion to the heat of the circumambient air; so that even in winter, if the liquors be kept properly warm, at least in two or three days the experiment will succeed.

The animalcula are infinitely smaller than spermatic animals, and of a very different shape; the truth of which every accurate observer will soon be convinced of, whose curiosity may lead him to compare them, and he is persuaded they will find they are no way akin. Having learnt from M. De Saussure, of Geneva, that he found one kind of these animalcula infusoria that increases by dividing across into nearly two equal parts, and that the infusion was made from hemp-seed, he procured a quantity of this seed, some of it he put into New River water, some into distilled water, and some into very hard pump water; the result was, that in proportion to the heat of the weather, or the warmth in which they were kept, there was an appearance of millions of minute animalcula in all the infusions; and some time after some oval ones made their appearance; these were much larger than the first, which still continued. These wriggled to and fro in an undulatory motion, turning themselves round very quick all the time that they moved forwards.

Ellis found out by mere accident a method to make their fins appear very distinctly, especially in the larger kind of animalcula, which are common to most vegetable infusions, such as the terebella. This has a longish body, with a cavity or groove at one end, like a gimblet. By applying a small stalk of the horseshoe geranium, the geranium zonale of Linnæus, fresh broken, to a drop of water in which these animalcula are swimming, we shall find that they will become instantly torpid, contracting themselves into an oblong oval shape, with their fins extended like so many bristles all round their bodies. The fins are in length about half the diameter of the middle of their bodies. After lying in this state of torpitude for two or three minutes, if a drop of clean water be applied to them, they will recover their shape, and swim about immediately, rendering their fins again invisible. Before he discovered this expedient, he tried to kill them by different kinds of salts and spirits; but though they were destroyed by these means, their fins were so contracted, that he could not distinguish them in the least.*

It is one of the wonders of the modern philosophy to have invented means for bringing creatures so imperceptible as the various animalcula under our cognizance and inspection. One might well have deemed an object that was a thousand times too little to be able to affect our sense, as perfectly removed from human discovery; yet we have extended our sight over animals to whom these would be mountains. The naked eye takes in animal beings from the elephant to the mite; but below this, commences a new order, reserved only for the microscope, which comprehends all those from the mite, to those many millions of times smaller; and this order cannot be said to be exhausted, if the microscope be not arrived at its ultimate state of perfection.

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* The preceding recital of the hypothesis of Messrs. Buffon, Needham, and Baron Münchhausen, may appear superfluous, having been so ably refuted by Mr. Ellis; the consideration, however, that it may afford entertainment to some of my readers, and prove beneficial to others, by cautioning them against too precipitately adopting plausible suppositions, induced me to retain the account. EDIT.

In reality, the greater number of microscopic animalcula are of so small a magnitude, that through a lens, whose focal distance is the tenth part of an inch, they only appear as so many points; that is, their parts cannot be distinguished, so that they appear from the vertex of that lens under an angle not exceeding the minute of a degree. If we investigate the magnitude of such an object, it will be found nearly equal to $\frac{3}{100000}$ of an inch long. Supposing, therefore, these animalcula to be of a cubic figure, that is, of the same length, breadth, and thickness, their magnitude would be expressed by the cube of the fraction $\frac{3}{100000}$, that is, by the number $\frac{27}{1000000000000000}$, that is, each animalculum is equal to so many parts of a square inch. This contemplation of animalcula has rendered the idea of indefinitely small bodies very familiar to us; a mite was formerly thought the limit of littleness, but we are not now surprized to be told of animals many millions of times smaller than a mite; for, "there are in some liquors animalcules so small, as, upon calculation, the whole magnitude of the earth is not found large enough to be a third proportional to these minute floating animals and the whales in the ocean."* These considerations are still further heightened, by reflecting on the internal structure of animalcula, for each must have all the proportion, symmetry and adjustment of that organized texture, which is indispensably necessary for the several functions of life, and each must be furnished with proper organs, tubes, &c. for secreting the fluids, digesting its food, and propagating its species.†

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* Chambers's Cyclopedia by Rees, Art. Animalcule.

† Minute animals proportionably exceed the larger kinds in strength, activity, and vivacity. It has been already observed, p. 212, that the spring of a flea vastly outstrips any thing animals of a greater magnitude are capable of; the motion of a mite is much quicker than that of the swiftest race-horse. M. De L'Isle, Hist. Acad. Scienc. 1711. p. 23, has given the computation of the velocity of a little creature, so small as to be scarcely visible, which he found to run three inches in a second; supposing now its feet to be the fifteenth part of a line, it must make five-

Having thus given a general idea of the properties of animalcula, I now proceed to describe the various individuals, following the arrangements of O. F. Müller,* and giving the discriminating characters by which he has distinguished them; abridging, enlarging, or altering the descriptions, to render them in some instances more exact, in others less tedious, and upon the whole, I hope, more interesting to the reader.

A
METHODICAL DIVISION
OF THE
ANIMALCULA INFUSORIA.

I. THOSE THAT HAVE NO EXTERNAL ORGANS.

1. **Monas**: punctiforme. A mere point.

2. **Proteus**: mutabile. Mutable, or changeable.

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hundred steps in the space of three inches, that is, it must shift its legs five-hundred times in a second, or in the time of the ordinary pulsation of an artery. The rapidity with which many of the water insects skim the surface of the fluid, and others swim in it, is astonishing, nor is the celerity of the various species of animalcula infusoria less deserving of admiration. Edit.

* Müller Animalcula Infusoria, Fluviatilia, et Marina.

3. Volvox: sphæricum. Spherical.

4. Enchelis: cylindraceum. Cylindrical.

5. Vibrio: elongatum. Long.

Membranaceous.

6. Cyclidium: ovale. Oval.

7. Paramæcium: oblongum. Oblong.

8. Kolpoda: sinuatum. Crooked, or bent.

9. Gonium: angulatum. With angles.

10. Bursaria. Hollow like a purse.

II. THOSE THAT HAVE EXTERNAL ORGANS.

Naked, or not inclosed in a shell.

11. Cercaria: caudatum. With a tail.

12. Leucophra: ciliatum undique. Every part ciliated.

13. Trichoda: crinitum. Hairy.

14. Kerona: corniculatum. With horns.

15. Himantopus: cirratum. Cirrated, or curled.

16. Vorticella: ciliatum apice. The apex ciliated.

Covered with a shell.

17. Brachionus: ciliatum apice. The apex ciliated.

I. MONAS.

Vermis inconspicuus, simplissimus, pellucidus, punctiformis. An invisible,* pellucid, simple, punctiform worm.

1. Monas Termo. M. gelatinosa. Gelatinous mona.

Animalcules semblable a des points. Spallanzani Opusc. Phys. I. Bullæ continuo motu. Bonanni Obs. p. 174.

Among the various animalcula which are discovered by the microscope, this is the most minute, and the most simple; a small jelly-like point, eluding the powers of the compound microscope, and being but imperfectly seen by the single; these, and some others of the mona kind, are so delicate and slender, that it is no wonder they often escape the sight of many who have examined infusions with attention; in a full light they totally disappear, their thin and transparent forms blending as it were with the water in which they swim.

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* By invisible, we only mean that they are too small to be discerned by the naked eye.

Small drops of infused water are often so full of these, that it is not easy to discover the least empty space, so that the water itself appears changed into another substance less transparent, but consisting of innumerable globular points, thick sown together; which, though full of life, seem only a kind of inflated bladders. In this a motion may be perceived, something similar to that which is observed when the sun's rays shine on the water, the animalcula being violently agitated, or in a commotion like unto a hive of bees. They are very common in ditch water, and in almost all infusions, both of animal and vegetable substances.

2. Monas Atomus. M. albida puncto, variabili instructa, Plate XXV. Fig. 1. White mona, with a variable point.

This animalculum appears as a white point, which, when it is highly magnified, is somewhat of an egg-shape; the smaller end is generally marked with a black point; the situation of this is sometimes varied, and found at the other end of the animalculum: sometimes two black points are to be seen crossing the middle of the body. It was found in sea water that had been kept the whole winter; it was not, however, very fetid; there were no other animalcula in the same water.

3. Monas Punctum. M. nigra. A black mona.

A very minute point, solid, opake and black, round and long. They are dispersed in the infusion, and move with a slow wavering motion; were found in a fetid infusion of pears.

4. Monas Ocellus. M. hyalina puncto centrali notata. Transparent like talc, with a point in the middle.

The margin black, and a black point in the middle; it moves irregularly, is found in ditches covered with conferva, and frequently with the cyclidium milium, see No. 84.

5. Monas Lens. M. hyalina. Transparent mona of the appearance of talc.

This is among the number of the smaller animalcula, nearly of a round figure, and so pellucid, that it is not possible to discover the least vestige of intestines. Though they may often be seen separate, yet they are more generally collected together, forming a kind of vesicular or membranaceous mass. Contrary to the custom of other animalcula, they seek the edges of the evaporating water, the consequence of which is almost immediate death. When the water is nearly evaporated, a few dark shades are perceived, probably occasioned by the wrinkling of the body. A slow tremulous motion, confined to one spot, may be perceived at intervals; this in a little time becomes more lively, and soon pervades the whole drop. Its motions are in general very quick: two united together may sometimes be seen swimming among the rest; while in this situation, they have been mistaken by some writers for a different species, whereas it is the same generating another by division. It is to be found in all water, though but seldom in that which is pure; they are in great plenty in the summer in ditch water, also in infusions of animal or vegetable substances, made either of fresh or salt water, myriads being contained in a drop; numbers of various sizes are to be found in the filth of the teeth.*

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* The circumstance of animalcula being found in the teeth is mentioned with confidence by various authors; some doubts may, however, still remain of the fact. Mr. Willughby detected a woman, who pretended to take worms out of the teeth with a quill, having forced the quill from her just as she was putting it into his mouth, and found small worms in it; see Birch's History of the Royal Society, vol. iv. p. 387. I am inclined to think that the accounts usually met with in authors have no better foundation. It has also repeatedly happened, that

The animalcula of this, and the first species are so numerous as to exceed all calculation, though they are contained in a very confined space.

6. Monas Mica. M. circulo notata. Mona, marked with a circle.

This lucid little point may be discovered with the third lens of the common single microscope; when the magnifying power is increased, it appears either of an oval or spherical figure, for it assumes each of these at pleasure. It is transparent, and has a small ellipse inscribed as it were within its circumference; this ellipse is moveable, being sometimes in the middle, sometimes a little towards the fore-part, at others, nearer the hind-part. There is a considerable variety in its motions; it often turns round for a long time in the same place; an appearance like two kidneys may sometimes be perceived in the middle of the body, and the animalculum is beautifully encompassed with a kind of halo, arising most probably from invisible and vibrating fibrillæ. They are to be found in the purest waters.

7. Monas Tranquilla. M. ovata, hyalina, margine nigro. Egg-shaped, transparent mona, with a black margin.

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ingenious men, from their anxiety for discovery, have imagined that objects have appeared to their view, which, having related as facts, themselves or others have afterwards found to be nothing more than a deceptio visus; and thus they have been, at least for a time, the unintentional promulgators of error; considerable caution is therefore necessary on these occasions, see p. 132, 133.

Some authors, in support of a favourite system, have made bold assertions on the subject of animalcula; the small-pox, the measles, the epilepsy, &c. have been attributed to them: Langius reduces all diseases in general to the same principle. A writer at Paris, who assumed the title of an English physician, has proceeded still farther; he not only accounts for all diseases, These animated points seem to be nearly fixed to one spot, where they have a fluctuating or reeling motion. They are frequently surrounded with a halo, and differ in their figure, being sometimes rather spherical, at others quadrangular. The black margin is not always to be found, and sometimes one would almost be tempted to think it had a tail. They are found in urine which has been kept for a time. The urine is covered, after it has remained in the vessel, with a dark-coloured pellicle or film, in which these animals live: although the urine was preserved for several months, no new animalcula were observed therein. It has been already shewn, that a drop of urine is in general fatal to other animalcula, yet we find in this instance, that there are animated beings of a peculiar kind, appropriated to, and living in it.

8. MONAS LAMELLULA. M. hyalina compressa. Flat transparent mona.

This is mostly found in salt water. It is of a whitish colour, more than twice as long as it is broad, transparent, with a dark margin, the motion vacillatory; it often appears as if double.

9. MONAS PULVISCULUS. M. hyalina, margini virente. Transparent mona, with a green margin.

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but for the operation of all medicines, from the hypothesis of animalcula. He has peculiar animals for every disorder; scorbutic animalcula, podagrical animalcula, variolous animalcula, &c. all at his service. Journ. des Scav. tom. lxxxvii. p. 535, &c.

It is not at all surprising that the wonderful discoveries relating to animalcula should have been applied, however improperly, to support the most whimsical and chymerical systems. Most of the discoveries in natural philosophy have been subjected to similar abuses, and laid the foundation for the warm imaginations of some men to fabricate visionary theories; these have been of great prejudice to real science, the primary object and ultimate reward of which is the acquisition of truth. EDIT.

Little spherical pellucid grains of different sizes, the circumference green, a green bent line passes through the middle of some, probably indicating that they are near separating or dividing into two distinct animalcula; sometimes three or four, at others, six, seven, or even more, are collected together. They rove about with a wavering motion; and are mostly found in the month of March in marshy grounds.

10. Monas Uva. M. hyalina gregaria. Transparent gregarious mona.

It is not easy to decide on the nature of these little assemblages of corpuscles, which sometimes consist of four, at others of five, and frequently of many more: the corpuscles are of different sizes, according to the number assembled in one group. When collected in a heap, the only motion they have is a kind of revolution or rotatory one. The smaller particles separate from the larger, often dividing into as many portions as there are constituent particles in the group; when separated, they revolve with incredible swiftness. To try whether this was a group of animalcula collected together by chance, or whether this was their natural state, the following experiment was made. A single corpuscle was taken the moment it was separated from the heap, and placed in a glass by itself; it soon increased in size, and when it had attained nearly the same bulk as the group from which it was separated, the surface began to assume a wrinkled appearance, which gradually changed till it became exactly similar to the parent group. This new-formed group was again decomposed, like the preceding one, and in a little time the separated particles became as large as that from which they proceeded. It is found in a variety of infusions.

II. PROTEUS.

Vermis inconspicuus, simplicissimus, pellucidus, mutabilis. An invisible, very simple, pellucid worm, of a variable form.

11. PROTEUS DIFFLUENS. P. in ramulos diffluens, Plate XXV. Fig. 2 and 3. Proteus, branching itself out in a variety of directions.

A very singular animalculum, appearing only as a grey mucous mass; it is filled with a number of black globules of different sizes, and is continually changing its figure. Being formed of a gelatinous pellucid substance, the shape is easily altered, and it pushes out branches of different lengths and breadths. The globules which are within divide and pass immediately into the new formed parts, always following the various changes of form in the animalcula. The changes that are observed in the form of this little creature, do not arise from any extraneous cause, but are entirely dependent on its internal powers. It is to be met with but very seldom; the indefatigable Müller only saw it twice, although he examined such an immense variety of infusions. It is to be found in fenny situations.

12. PROTEUS TENAX. P. in spiculum diffluens, Plate XXV. Fig 4 and 5. Proteus, running out into a fine point.

A gelatinous pellucid body, stored with black molecules; it changes its form like the preceding, but always in a regular order, first extending itself out in a straight line, Fig. 5, the lower part terminating in an acute bright point, a, without any intestines; and the globules being all collected in the upper part, c, it next draws the pointed end up towards the middle of the body, swelling it into a round form. The contraction goes on for some time, after which the lower part is swelled out as it is represented in Fig. 4, d; the point a, is afterwards projected from this ventricose part. It passes through five different forms before it arrives at that which is seen at Fig. 4. It scarcely moves from one spot, only bending about sideways. It is to be found in river water.

III. VOLVOX.

Volvox inconspicuus, simplicissimus, pellucidus, sphæricus. An invisible, very simple, pellucid, spherical worm.

13. VOLVOX PUNCTUM. V. sphæricus, nigricans, puncto lucido. Spherical, of a black colour, with a lucid point.

A small globule; one hemisphere is opake and black, the other has a pellucid crystalline appearance; a vehement motion is observable in the dark part. It moves in a tremulous manner, and often passes through the drop, turning round as if upon an axis. Many may be often seen joined together in their passage through the water; they sometimes move as in a little whirlpool, and then separate. They are found in great numbers on the surface of fetid sea water.

14. VOLVOX GRANULUM. V. sphæricus, viridis, peripheria hyalina. Spherical and green, the circumference of a bright colour.

There seems to be a kind of green opake nucleus in this animalculum; the circumference is transparent. It is to be found generally in the month of June, in marshy places; it moves but slowly.

15. Volvox Globulus. V. globosus, postice subobscurus. Globular volvox, the hind-part somewhat obscure.

This globular animalculum is ten times larger than the monas lens; it verges sometimes a little towards the oval in its form. The intestines are just visible, and make the hinder part of the body appear opake; it has commonly a slow fluttering kind of motion, but if it be disturbed, the motion is more rapid. It is found in most infusions of vegetables.

16. Volvox Pilula. V. sphæricus, interaneis immobilibus virescentibus. Small round volvox, with immoveable green intestines.

This is a small transparent animalculum; its intestines are immoveable, of a green colour, and are placed near the middle of the body, the edges often yellow; a small obtuse incision may be discovered on the edge, which is, perhaps the mouth of the animalculum. This little creature appears to be encompassed with a kind of halo or circle. If this be occasioned by the vibratory motion of any fringe of hairs, they are invisible to the eye, even when assisted by the microscope. It seems to have a kind of rotatory motion, at one time slow, at another quick; and is to be found in water where the lemna minor, or least ducks-meat, grows, sometimes as late as the month of December.

17. Volvox Grandinella. V. sphæricus, opacus, interaneis immobilibus. Spherical and opake, with immoveable intestines.

This is much smaller than the preceding, and is marked with several circular lines; no motion is to be perceived among the interior molecules. It sometimes moves about in a straight line, sometimes its course is irregular, at others it keeps in the same spot with a tremulous motion.

18. Volvox Socialis. V. sphæricus, moleculis crystallinis, æqualibus distantibus. Spherical volvox, with crystalline molecules, placed at equal distances from one another.

When very much magnified this animalculum seems to have some relation to the vorticella socialis, as seen with the naked eye. It consists of crystalline molecules, disposed in a sphere, and filling up the whole circumference; they are all of an equal size. Whether they are included in a common membrane, or whether they are united by one common stalk, as in the vorticella socialis, has not been discovered. We are also ignorant of the exact figure of the little particles of which it is composed; when a very large magnifying power is used, some black points may be discerned in the center of the crystalline molecules. The motion is sometimes rotatory, sometimes from right to left, and the contrary. It is found where the chara vulgaris has been kept.

19. Volvox Sphæricula. V. sphæricus, moleculis similaribus rotundis. Pl. XXV. Fig. 6. Spherical volvox, with round molecules.

This spherule is formed of pellucid homogeneous points of different sizes. It moves slowly about a quarter of a circle from right to left, and then back again from left to right.

20. Volvox Lunula. V. hemisphæricus, moleculis similaribus lunatis. Plate XXV. Fig. 7. An hemispherical volvox, with lunular molecules.

Is a small roundish transparent body, composed of innumerable molecules, homogeneous, pellucid, and of the shape of the moon in its first quarter, without any common margin. It is in a continual two-fold motion; the one, of the whole mass turning slowly round; the other, of the molecules one among the other. They are found in marshy places in the beginning of spring.

21. Volvox Globator. V. sphæricus membranaceus. Spherical membranaceous volvox.

This is a transparent globule, of a greenish colour; the fœtus is composed of smaller greenish globules. It becomes whiter and brighter with age, moves slowly round its axis, and may be perceived by the naked eye. But to the microscope the superficies of this pellucid membrane appears covered with molecules, as if it were granulated, which has occasioned some observers to imagine it to be hairy; the round pellucid molecules that are fixed in the center are generally largest in those that are young. The exterior molecules may be wiped off, leaving the membrane naked. When the young ones are of a proper size, the membrane opens, and they pass through the fissure; after this the mother melts away. They sometimes change their spherical figure, the superficies being flattened in different places. Most authors speak of finding eight lesser globules within the larger; but Müller says, that he has counted thirty or forty of different sizes. This wonderful capsulate situation of its progeny is well known; indeed it often exhibits itself big with children and grand-children.

Leeuwenhoeck was the first who noticed this curious animalculum, and depicted it; a circumstance which has not been mentioned by Baker and other microscopic writers, who have described it. It may be found in great plenty in stagnant waters in spring and summer, and in infusions of hemp-seed and tremella. Baker describes it as follows: This singular minute water animal, seen before the microscope, appears to be exactly globular, without either head, tail, or fins. It moves in all directions, forwards or backwards, up or down, rolling over and over like a bowl, spinning horizontally like a top, or gliding along smoothly without turning itself at all. Sometimes its motions are very slow, at other times very swift; and when it pleases, it can turn round as upon an axis very nimbly, without moving out of its place. The body is transparent, except where the circular spots are placed, which are probably its young. The surface of the body in some is as it were dotted all over with little points, and in others, as if granulated like shagreen. Baker thought also that in general it appeared as if it was set round with short moveable hairs. By another writer they are thus described: These animalcula are at first very small, but grow so large as to be discerned with the naked eye; they are of a yellowish green colour, globular figure, and in substance membranaceous and transparent. In the midst of this substance several small globes may be perceived; each of these are smaller animalcula, which have also their diaphanous membrane, and contain within themselves still smaller generations, which may be distinguished by the assistance of very powerful glasses. The larger globules may be seen to escape from the parent, and then increase in size, as has been already observed.

22. Volvox Morum. V. membranaceus orbicularis, centro moleculis sphæricis viridibus. Membranaceous orbicular, with spherical green molecules in the center.

This animalculum has some resemblance to the volvox uva, but is sufficiently distinguished by the surrounding bright orbicular membrane: the middle part is full of clear green globules. The globules seldom move, though a quivering motion may sometimes be perceived at the center. It has a slow rotatory motion, and is found amongst the lemna, in the months of October and December.

23. Volvox Uva. V. globosus, moleculis sphæricis virescentibus nudis. Globular volvox, composed of green spherical globules, which are not inclosed in a common membrane.

This animalculum seems to be a kind of medium between the volvox pilula, No. 16, and the gonium pectorale, No. 114, being, like the one, composed of green spherules, and in form, resembling the other. It consists of a congeries of equal globules of a greenish colour, with a bright spot in the middle; the whole mass is sometimes of a spherical form, sometimes oval, without any common membrane; a kind of halo may be perceived round it, but whether this is occasioned by the motion of any invisible hairs has not been discovered. The mass generally moves from right to left, and from left to right; scarce any motion can be discovered in the globules themselves. It was found in the month of August, in water where the lemna polyrrhiza was growing. Two masses of these globules have been seen joined together. They contain from four to fifty of the globules, of which a solitary one may now and then be found.

24. Volvox Vegetans. V. ramulis simplicibus et dichitomis, rosula globulari terminatis. A volvox with simple dichitomous branches, terminating in a little bunch of globules.

It consists of a number of floccose opake branches, which are invisible to the naked eye; at the apex of these there is a little congeries of very minute oval pellucid corpuscles. Müller at first thought it to be a species of microscopic and river sertularia; but afterwards he found the bunches quitting the branches, and swimming about in the water with a proper spontaneous motion. Many old branches were found deserted of their globules, while the younger branches were furnished with them. It was found in river water in November 1779 and 1780.

IV. ENCHELIS.

Vermis inconspicuus, simplicissimus, cylindraceus. An invisible, simple, cylindric worm.

25. Enchelis Viridis. E. subcylindrica, antice oblique truncata. Green enchelis, of a subcylindric figure, the fore-part truncated.

This is an opake green, subcylindric animalculum, with an obtuse tail, the fore-part terminating in an acute truncated angle; the intestines obscure and indistinct. It is continually varying in its motion, turning from right to left.

26. Enchelis Punctifera. E. viridis, subcylindracea, antice obtusa, postice acuminata, Plate XXV. Fig. 8. Green enchelis, subcylindric, the fore-part obtuse, the hinder part pointed.

It is an opake animalculum, of a green colour; there is a small pellucid spot in the fore-part *a*, in which two black points may be seen; a kind of double band, *c c*, crosses the middle of the body. The hinder part is pellucid and pointed; an incision is discovered at the apex of the fore-part, which seems to be the mouth. When in motion, the whole of it appears opake and green. It is found in marshes.

27. ENCHELIS DESES. E. viridis, cylindrica, subacuminata gelatinosa. Green, cylindrical, gelatinous, the end somewhat pointed.

The body is round, the colour a very dark green, so that it is quite opake; the fore-part is bluntly rounded off, the hinder-part is somewhat tapering, but finishes with a rounded end. From its opacity, no internal parts can be discovered; there is a degree of transparency near the ends. It is exceeding idle, moving very slowly; to be found, though rarely, in an infusion of lemnæ.

28. ENCHELIS SIMILIS. E. obovato opaca, interaneis mobilibus. Enchelis, of an egg-shape, opake with moveable intestines.

It is an opake body, with a pellucid margin; both extremities are obtuse, but the upper one much more so than the under one; it is filled with moveable spherules. Its motion is generally quick, either to the right or the left; it is probably furnished with hairs, because, when moving rapidly, the margin appears striated. It is found in water that has been kept for months.

29. ENCHELIS SEROTINA. E. ovato cylindracea, interaneis immobilibus. Enchelis partly oval, partly cylindrical, the interior parts immoveable.

An oval animalculum, round the fore-part smaller than the hind-part, the margin of a black colour; it is replete with grey vesicular molecules, and moves slowly.

30. ENCHELIS NEBULOSA. E. ovato-cylindracea, interaneis manifestis mobilibus. Oval and cylindric enchelis, with visible moveable intestines.

The body is shaped like an egg, the fore-part narrow, and often filled with opake confused intestines; in moving, it elevates the fore-part of the body. It is found in the same water as the cyclidium glaucoma, No. 86, but is three times its size, and considerably more scarce.

31. Enchelis Seminulum. E. cylindracea æqualis. Enchelis equally cylindric.

It is a cylindrical animalculum, twice as long as it is broad, the fore and hind-part of the same size; the intestines in the fore-part are pellucid, those in the hinder-part obscure. It moves by ascending and descending alternately. It may be seen sometimes swimming about with the extremities joined together. Found in water that has been kept for some days.

32. Enchelis Intermedia. E. cylindracea, hyalina, margine nigricante. Cylindrical enchelis, transparent, with a blackish margin.

This animalculum forms an immediate kind between the monas punctum, the enchelis seminulum, and the cyclidium milium. It is one of the smallest among the animalcula. The body is transparent, it has no visible intestines, the fore and hind-part are of an equal size, the edge of a deeper colour than the rest of the body; a point is to be seen in the middle of some of them; in others, it is as if a line passed through the middle.

33. Enchelis Ovulum. E. cylindrico-ovato hyalina. Egg-shaped transparent enchelis.

A transparent, round, egg-shaped animalculum; nothing is discovered withinside, even by the third magnifier; but, with an increased power, some long foldings may be seen on the superficies, and here and there a few bright molecules.

34. Enchelis Pirum. E. inverse conica, postice hyalina. Pear-form enchelis, the hinder-part transparent.

This enchelis is lively and pellucid, the fore-part is protuberant, and filled with molecules, the hinder-part smaller and empty; it has moveable molecular intestines. Its motion is rapid, passing backwards and forwards through the diameter of the drop. When at rest, it seems to have a little swelling, or tubercle, on the middle of the body.

35. Enchelis Tremula. E. ovato-cylindracea, gelatina. Oval enchelis, cylindrical, gelatinous.

This is also to be placed amongst the most minute animalcula; the end of it is rather pointed, and has a tremulous motion; it almost induces one to think it has a tail. Two of these little creatures may at times be perceived to adhere together. It was found in an infusion with the paramæcia aurelia, No. 93, and many other animalcula.

36. Enchelis Constricta. E. obovata, crystallina, medio coarctata. Sub-oval enchelis, crystalline, with a stricture in the middle.

An animalculum of an oval shape, the middle part drawn in, as if a string was tied round it. It is of a very small size, and is found in salt water.

37. Enchelis Pulvisculus. E. eliptica, interaneorum congerie viridi. Of an eliptic shape, with a congeries of green intestines.

It is a round animalculum, pellucid, the fore-part obtuse, the hind-part rather sharp, marked with green spots; myriads may sometimes be seen wandering about in one drop; it is found among the green matter on the sides of the vessels in which water has been kept for some time.

38. Enchelis Fusus. E. cylindracea, utraque extremitate angustiore truncata. Cylindrical enchelis, both ends truncated.

The body is round and transparent, the fore and hind-part smaller than the rest of the body, and equally so, the ends a little truncated. In the inside a long and somewhat winding intestine, a sky-coloured bright fluid, and some black molecules transversely situated, may be discerned. The motions of this animalculum are languid; it was found in pure water.

39. Enchelis Fritillus. A cylindric enchelis, the fore-part truncated.

This is one of the most transparent animalcula; the hinder-part of an obtuse convexity, the fore-part truncated. Müller suspects that there is a rotatory organ in the fore-part. No intestines can be seen. It runs backwards and forwards through the drop in a diametrical line, with a wavering motion; sometimes turns round for a moment, but presently enters on its usual course. Is found in an infusion of grass and hay.

40. Enchelis Caudata. E. elongata, antice obtusa, postice in caudam hyalinam attenuata, Plate XXV. Fig. 9. Enchelis with a long body, the fore-part obtuse, the hinder-part diminishing into a kind of tail.

The body is of a grey colour, pellucid, with globular molecules divided from each other, and dispersed through the whole body;

the fore-part a, thick and obtuse, the hind-part b, crystalline and small, the end truncated. It is but seldom met with.

41. Enchelis Epistomium. E. cylindrico-elongata, apice gracili subgloboso. Enchelis with a long cylindric body, the fore-part slender and roundish.

It is among the smaller animalcula, the body is cylindrical and bright, the hinder-part obtuse, the fore-part smaller, and terminating in a globule; a black line may now and then be perceived down the middle of it.

42. Enchelis Gemmata. E. cylindracea, serie globulorum duplici, in collum hyalinum producta. Enchelis with a cylindrical body, the upper part prolonged into a transparent neck, a double series of globules running down the body. Its motion is slow, and generally in a straight line; it is found in ditch-water where the lemna thrives.

43. Enchelis Retrograda. E. hyalina, antice angustata, apice globulari. Plate XXV. Fig. 11 and 12. Transparent enchelis, the fore-part rather smaller, and terminating in a small globule.

It has a gelatinous transparent body; no visible intestines, though a pellucid globule is discoverable near the hinder-part; the body is thickest in the middle, and grows smaller towards each end. It generally moves side-ways, sometimes in a retrograde manner; and if it be obstructed in its motion, draws itself up, as it is represented at Fig. 11.

44. Enchelis Festinans. E. cylindrica oblonga, obtusa, antice hyalina. Oblong cylindrical enchelis; the ends obtuse, the fore-part transparent.

The body is round, of an equal size throughout, and both ends obtuse; more than half the length is without any visible intestines, the lower end full of vesicular, pellucid, minute globules; a large globular vesicle is also to be found in the fore-part; it moves quickly from one side to the other, in a reeling or staggering manner. It was found in sea water.

45. Enchelis Farcimen. E. cylindracea curvata utrinque truncata. A cylindric enchelis, crooked and truncated at both ends.

The body of this is cylindrical, about four times as long as broad, even, truncated at both ends, the intestines opake, and not to be distinguished from one another; it turns the extremities opposite ways, so as to form the figure of an S. It is to be found in water that has stood for some time, though but seldom. Joblot found it in an infusion of corn centaury or blue-bottle; it moves in an undulatory manner, but very slowly.

46. Enchelis Index. E. inverse conica, apicis altero angulo producto. Enchelis in the form of an inverted cone, one edge of the apex produced out so as to form an angle with the other part.

The body rather opake, of a grey colour, and of a long conical figure; the lower end obtuse, the fore-part thick, one side of this part projecting like a finger from the edge; two very small projections proceed also sometimes from the lower end. This animalculum has the power of retracting these projections, and making both ends appear obtuse. It moves about but slowly, and was found in water with the lemna minor, or least ducks-meat.

47. Enchelis Truncus. E. cylindrica, subcapitata. Plate XXV. Fig. 10. Cylindrical enchelis with a kind of head.

This is the largest of this kind of animalcula; the body is cylindrical, mucose, grey, long and rather opake, the fore-part globular, the hind-part obtuse. Something like three-teeth, c, may be sometimes seen to proceed from one of the sides; it can alter its shape considerably. Globules of different sizes may be seen within the body. It rolls about slowly from right to left.

48. Enchelis Larva. E. elongata, medio papillula utrinque notata. A long enchelis, with two little nipples projecting from the middle of the body, one on each side.

It is long, round, and filled with grey molecules; the fore-part is obtuse and pellucid; a kind of neck or small contraction is formed at some little distance from this end. The lower part pointed; about the middle of the body there are two small projections.

49. Enchelis Spatula. E. cylindrica striata, apice hyalino spatulata. A cylindrical striated enchelis, the fore-part transparent, and of the shape of a spatula.

This animalculum is perfectly cylindrical, very pellucid, of a crystalline appearance; it is marked with very fine longitudinal furrows, and has generally two transparent globules, one placed below the middle, the other near the extremity of the body; on the other side are five smaller ones, which are oval. The top is dilated, with the corners rounded like the spatula, or instrument for spreading plaisters. It has a wavering kind of motion, folding the spatula variously, yet retaining its general form.

Müller mentions his seeing it once draw the spatula into the body, and keep it there for two hours, when it again appeared.

50. Enchelis Pupula. A cylindric enchelis, the fore-part papillary.

The fore-part is protuberantly round, and rather opake, the hind-part pellucid, both extremities obtuse, furnished with a papillary finger-shaped head, the hinder part marked with a transparent circle, or circular aperture. The fore-part filled up with moveable molecules, which are more scarce in the hinder-part. It has a rotatory motion on a longitudinal axis, and moves through the water in an oblique direction. It is to be found in dunghill water in November and December.

51. Enchelis Pupa. E. ventricoso cylindrica, apice in papillam producta. Enchelis forming a kind of ventricose cylinder, with a small nipple proceeding from the apex.

It is not unlike the preceding animalculum, but is much larger; the anterior end not so obtuse, the nipple gradually formed from the fore-part, all but this end is opake, and filled with obscure particles: it has no transparent circle, as was observed in the enchelis pupula. Its motion is exceeding slow.

V. VIBRIO.

Vermis inconspicuus, simplicissimus, teres, elongatus. An invisible worm, very simple, round, and rather long.

52. Vibrio Lineola. V. linearis minutissimus. Very small linear vibrio.

This is one of the most minute animalcula, surpassing in slenderness the monas termo, No. 1. The greatest magnifier exhibits little more than a tremulous motion of myriads of little oblong obscure points. In a few days it almost fills the whole substance of the water in vegetable infusions.

53. Vibrio Rugula: V. linearis flexuosus. Vibrio like a bent line.

Myriads of this species may be found; it is between the vibrio lineola, just described, and the vibrio undula, No. 55. It appears as a little line, which is sometimes drawn up in an undulated shape, and moves backwards and forwards in a straight line, often without bending the body at all.

54. Vibrio Bacillus. V. linearis, æqualis utrinque truncata. Linear vibrio, equally truncated at both ends.

This is an exceeding small creature, but visible with the third lens; in a certain position of the light, transparent. It is gelatinous, and not half so large as the monas lens, No. 5, though six, and sometimes ten times longer; it is everywhere of an equal size, and has no visible intestines; its action is languid, the serpentine flexures of the body are with great difficulty perceived. Müller made two infusions of hay in the same water, and at the same time, in the one he put the hay whole, in the other it was cut in small pieces; in the first there were none of the vibrio bacillus, but many of the monas lens and kolpoda cucullus, No. 108; in the latter, many of the vibrio bacillus, and few of the monæ.

55. Vibrio Undula. V. filiformis flexuosus. A filiform flexuous vibrio.

A perfect undulating little line, round, gelatinous, without any visible intestines. It is never straight; when at rest it resembles the letter V, when in motion the letter M, or a bending line like that which geese form in their flight through the air; its motions are so rapid, that the eye can scarce follow them. It generally rests upon the top of the water, sometimes it fixes itself obliquely by one extremity, and whirls itself round. This is the little creature that Leeuwenhoeck says exceeds in slenderness the tail of the animalculum seminale, which he has described in Fig. 5, Epis. Phys. 41, being an hundred times less than a mustard-seed, and on which he makes the following very just observation: That as these very small animalcula can contract and variously fold their little tails, we must conclude that tendons and muscles are as necessary to them as to other animals; if to these we add the organs of sensation, and those of the intestines, the mind is lost in the astonishment which arises from the impression of infinite, in the indefinitely small.

56. Vibrio Serpens. V. filiformis, ambagibus in angulum obtusum productis. A filiform vibrio, the windings or flexures obtuse.

A slender gelatinous little animal, in the form of a long serpentine line, all the bendings being nearly equal in size, and at equal distances; it generally moves in a straight line; an intestine may be discovered down the middle. It is to be found in river water, but is not commonly to be met with.

57. Vibrio Spirillum. V. filiformis, ambagibus in angulum acutum tornatis. Filiform vibrio, twisted something like a spiral wire or cork-screw, the bending acute.

It is an exceeding minute, singular creature, twisted in a spiral form; the shape of these bendings remains the same even when the animal is in motion, not occasioned by any internal force, but are its natural shape. It moves generally in a straight line, vibrating the hind and fore-parts. It was found in 1782, in an infusion of the sonchus arvensis, or corn sow-thistle.

58. Vibrio Vermiculus. V. tortuosus gelatinus. This little vibrio is twisted and gelatinous.

The body is white, or rather of a milky appearance, cylindric, long, the apex obtuse, rather growing smaller, and twisted towards the hind-part. Its motion is languid and undulatory, like that of the common worm; it sometimes moves quicker, but with seeming labour. When it bends itself alternately from one side to the other, a black long line may be discovered, sometimes whole, sometimes broken: when at rest, it occasionally twists into various folds. It may be observed easily with the first lens of the single microscope, and is probably the same animalculum mentioned by Leeuwenhoeck in all his works, as found in the dung of frogs, and in the spawn of the male libellula. It is to be found in marshy water in November, though but seldom.

59. Vibrio Intestinum. V. gelatinosus, teres, antice angustatus. This vibrio is gelatinous, round, the fore-part small.

It is cylindric, milk-coloured, and slender towards the top, both ends obtuse; no traces of intestines to be discovered, though four or five spherical eggs are perceived at the extremity of the hind-part. It can draw the fore-part so much inwards as to give it a truncated and dilated appearance, something like a spatula. Its motion is slow and progressive. It is found in marshy waters.

60. Vibrio Bipunctatus. V. linearis, æqualis, utraque extremitate truncata, globulis binis mediis. Linear vibrio, of an equal size throughout, both ends truncated, and two small globules in the middle of the body.

It is of a small size, and rather less than the following animalculum; the body is of a pellucid talc-like appearance, the fore and hind-part truncated; in the middle are two (sometimes there is only one) pellucid globules, placed lengthwise. It most commonly moves forward in a straight line; its movements are slow. It was found in fetid salt water.

61. Vibrio Tripunctatus. V. linearis, utrinque attenuatus, globulis tribus, extremis minoribus. Linear vibrio, both the ends smaller than the middle, furnished with three globular points, the two which are at the extremities being smaller than that at the middle.

The body is pellucid, talky, each of the ends rather tapering, furnished with three pellucid globules, the middle one is the largest; the space between these globules is generally filled with a green matter; in some there is nothing of the green substance near the extremities, but only about the middle. It seldom moves far, and then its motion is rectilinear, backwards and forwards.

62. Vibrio Paxilifer. V. flavescens paleis gregariis multifariam ordinatis. Plate XXV. Fig. 13, 14, 15. Yellow, gregarious, straw-like vibrio.

This is a wonderful animalculum, or rather a congeries of animalcula. It is invisible to the naked eye, and consists of a transparent membrane, with yellow intestines, and two or three visible points; they are generally found collected together in different parcels, from seven to forty in number, and ranged in a variety of forms, sometimes in a straight line, as in Fig. 14, then forming the concave Figure 13, at others, moving in a zig-zag direction, as in Fig. 15; when at rest they are generally in a quadrangular form, and found in great plenty with the ulva latissima, or brown laver.

As this animalculum seems to have some affinity with the hair-like animal of Baker, I think the reader will be better pleased to see his description of it introduced in this place, than to have it raised into a new and distinct species.

This little animal is extremely slender, and not uncommonly one-hundred and fifty times longer than broad. Its resemblance to an hair induced Baker to call it the hair-like insect. The body or middle part, which is nearly straight, appears in some composed of such parallel rings as the windpipe of land animals consists of, but seems in others scaled, or rather made up of rings that obliquely cross each other. Its two ends are bent or hooked, pretty nearly in the same degree, but in a direction contrary each to the other; and as no eyes can be discerned, it is difficult to judge which is the head or tail. Its progressive motion differs from that of all animals hitherto described; for, notwithstanding the body is composed of many rings and joints, it seems unable to bend them, or move directly forwards; but when it is inclinable to change its quarters, it can move from right to left, or left to right, and proceed at the same time backwards or forwards obliquely; and this it performs by turning upon one end as a center, and describing with the other the quarter of a circle; then it does the same with the other end, and so alternately; whereby its progression is in a diagonal line, or from corner to corner. Of this any one may immediately be satisfied, who will take the trouble of shifting the points of a pair of compasses in that manner. All its motions are extremely slow, and require much patience and attention in the observer. It has neither feet, fins, nor hairs, but appears perfectly smooth and transparent, with the head bending one way, and the tail another, so as to be like a long Italic *S*; nor is any internal motion, or particularly opake part, to be perceived, which may determine one to suppose it either the stomach, or the intestines.

These creatures are so small, that millions of millions might be contained in an inch square. When viewed singly, or separated from one another, they are exceedingly transparent, and of a lovely green; but, like all other transparent bodies, when numbers of them are brought together they become opake, and lose their green colour in proportion as the quantity increases, till at last they appear entirely black.

Notwithstanding the extreme minuteness of these animalcula, they seem to be fond of society; for, on viewing for some time a parcel of them taken up at random, they will be seen to disperse themselves in a kind of regular order. If a multitude of them be put into a jar of water, they will form themselves into a regular body, and ascend slowly to the top, where, after they have remained some time exposed to the air, their green colour changes to a beautiful sky-blue. When they are weary of this situation, they form themselves into a kind of rope, which slowly descends as low as they intend.

A small quantity of the substance containing these creatures having been put into a jar of water, it so happened, that one part descended immediately to the bottom, the other continuing to float on the surface. After some time, each of these swarms of animalcula exhibited a disposition to change its quarters. Both armies, therefore, set out at the same time, the one proceeding upwards, and the other downwards; so that after some hours journey they met in the middle. A desire of knowing how they would conduct themselves on this occasion, engaged the observer to watch them carefully; and to his surprize, he saw the army that was marching upwards open to the right and left, to make room for those that were descending. Thus without confusion or intermixture each held on its way, the ascending army marching in two columns to the top, and the other proceeding in one column to the bottom, as if each had been under the direction of wise leaders.

63. VIBRIO LUNULA. V. arcuatus, utraque extremitate æquali. Plate XXV. Fig. 16. Bow-shaped vibrio, both ends of an equal size.

The body resembles much the shape of the moon at the first quarter; it is of a green colour, and has generally from seven to ten globules disposed lengthwise; the smaller ones are of a very pale colour, a pale green vacuity may sometimes be seen in the middle: some little varieties may be observed amongst them, which are not easily to be described; it will be enough to have given the reader their general and distinguishing characteristics.

64. VIBRIO VERMINUS. V. linearis compressus, antice quam postice angustior. Linear compressed vibrio, the fore-part narrower than the hind-part.

A round transparent animalculum, or rather a long crystalline membrane, the hind-part broader than the fore-part, the apex subtruncated, the base obtuse, no perceptible intestines; in the middle are two spherical vesicules, and a third towards the lower edge. It moves quickly backwards and forwards with an undulatory motion; they seem to be joined in a very singular manner, and were found in great plenty in salt water that had been kept several days, till it became fetid.

65. Vibrio Mallæus. V. linearis basi globuli, apice linea transversa. A linear vibrio, with a globule at the base, and transverse line at the apex.

This is a white pellucid animalculum, resembling the letter T, with a globule affixed to the base. It is in motion and at rest every moment alternately; in the former case, it resembles the letter V; in the latter, the letter T. They are found plentifully in spring water.

66. Vibrio Acus. V. linearis, colli, apice obtuso, cauda setacea. Linear vibrio, with a neck, the upper extremity obtuse, the lower one terminating in a setaceous tail.

This vibrio is of the shape of a sewing needle; the neck round, partly transparent, and marked in the middle with a red point; the trunk cylindrical, the edges obscure, the middle bright, and nearly of a triangular appearance, the tail resembling a fine bristle. A motion may be observed in the inside of this little creature. It does not bend the body when in motion.

67. Vibrio Sagitta. V. sublinearis, colli, apice truncato atra, cauda setacea. Somewhat linear in its appearance, a well-marked neck, the apex truncated and open, the tail setaceous.

The body is very long and flexible, broadest towards the middle, which is also filled with grey molecules; the fore-part is drawn out into a straight transparent neck, the upper end of it thick and black. The motion of this animalculum seems to be produced by the contraction and extension of the neck. It is found in salt water.

68. Vibrio Gordius. V. æqualis, caudæ apice tuberculato. Vibrio of an equal size throughout, the tail terminated by a little tubercle.

A round animalculum; the fore-part for about one-sixth of the whole length is transparent, and furnished with a sky-coloured alimentary tube; the lower part is bright and pointed, the middle full of small globules; a small knob terminates the tail. Found in an infusion made with salt water.

69. Vibrio Serpentulus. V. æqualis utrinque subacuminatus. This vibrio is of an equal size, rather pointed at both ends.

It is very similar to the vibrio anguillula, No. 71, differing principally in the shape of the ends, which in this are furnished with a long row of the most minute points. It does not adhere to objects by the pointed tail. The body is of a whitish colour, frequently convoluted, and drawn into different figures. Its motion is serpentine, sometimes to be met with perfectly straight and still, and is found in infusions of vegetables after some weeks standing.

70. Vibrio Coluber. V. filiformis, seta caudali geneculata. Filiform vibrio, the tail setaceous, and bending up nearly to form a right angle with the body.

In this vibrio, the mouth, the oesophagus, the molecules in the intestines, and the twisting of them, are very conspicuous. The tail is exceeding small, and bent so as to form a considerable angle with the body. It is found in river water.

71. VIBRIO ANGUILLULA. V. æqualis, subrigidus. Vibrio of an equal size throughout, and somewhat hard.

This animalculum may be divided into four varieties, if not distinct species: namely, 1. Anguillula aceti. 2. Anguillula glutinis farinosi. 3. Anguillula aquæ dulcis; and 4. Anguillula aquæ marinæ. These varieties I shall first describe, together with the eels in blighted wheat, and then proceed with the rest of the vibrio.

I. ANGUILLULA ACETI, OR VINEGAR EEL.

Plate XI. Fig. 7.

Chaos redivivum, Linn. Syst. Nat. 1326.* Leeuwenhoeck Opera Omn. p. 3, n. 1, f, l, o. Joblot Observ. Micros. 1, p. 2, pl. 2. Hooke's Micrograph. p. 216, pl. 25, fig. 3. Borelli Observ. Micros. 1, p. 7. Power's Micros. Observ. p. 32. Adams Micrograph. Illustr. 4th edition, p. 125, pl. 38, fig. 197, A, B, C, D. Rozier Journal Physique, Mars 1775, Janv. & Mars 1776. Spallanzani Opusc. Phys. part 1, p. 83.

This eel is both oviparous and viviparous; it is filiform, but in other respects differs considerably from the paste eel. It is longer, not near so large, the tail is smaller and more tapering; it moves with much greater ease, and is more lively. In the tail of this eel we may observe in miniature, what may be seen on a much larger scale in that of the viper, viz. a small projection somewhat resembling a tongue, which occasionally appears as delineated in the figure at *a b*, and at other times adheres close to

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* Linnæus includes this and the paste eel under the same tit'e:—Habitat in aceto et glutine bibliopegorum. He adds,—Reviviscit ex aqua per annos exsiccatum. EDIT.

the body. An alimentary duct may be easily discovered, but no other intestines can be discerned, without deranging altogether the organization of the animalculum. The pungent taste of vinegar was formerly attributed to these animalcula, an opinion which was soon exploded.

2. ANGUILLULA GLUTINIS FARINOSI, OR PASTE EEL.

Plate XI. Fig. 6, 8, 9, and 10.

Chaos redivivum, Linn. Syst. Nat. 1326. Ledermüller Micros. Ergötzungen, p. 33, tab. 17. Baker Micros. made easy, p. 81. Ibid. Empl. for the Micros. p. 244, pl. 10, no. 8 and 9. Rozier Journal Physique, Mars 1775, Mars 1776. Adams Micrograph. Illustr. 4th edition, p. 125, pl. 38, fig. 179.

The eels in paste have been more distinguished than most other animalcula, as well on account of their many curious properties, as the various speculations and theories to which they have given rise. Four different species of eels may be found in paste; of the first, I shall now give a particular description. The body is filiform or like a thread, round, pellucid, replete with little grains in the middle, both extremities very pellucid and empty, the forepart a little truncated, the hind-part terminating in a very short bristly point. It is the same of every age and size. To be certain of procuring this species of eels, boil some flower in water, to which you have added a few drops of vinegar; provide an earthen pot which has an hole at the bottom, and fill it with earth; then put the paste in a piece of coarse cloth, and bury it in this earth; the pot is to be exposed to the sun in the summer, or kept in a warm place in the winter; by these means in ten or twelve days you will very seldom fail of finding a large quantity of eels in the paste.

This eel, when at its full growth, is about one-tenth of an inch long, and rather less than one-hundredth of an inch in diameter. Fig. 6 represents one of these eels magnified about one-hundred and twenty times, only compressed so much between two plates, by means of an adjusting screw, as not only to prevent it from moving, but to lengthen and flatten it in a small degree. At the upper part there are two little moveable pieces or nipples, *a a*, between which an empty space *b* is formed, that terminates in the mouth; the hinder-part is round, but there projects from it a short setaceous tail *w*; in the young eels the termination of the tail is not so abrupt as in the present specimen, but it finishes by a gradual diminution. There is probably a vent near *z*, for the passage of the excrements; because when that part has been gently pressed, two or three jets of a very subtile substance have been observed to issue from it. If the pressure be increased, a small bladder will be forced out, a further compression bursts the bladder, and the intestines are forced through the opening.

A greater degree of magnifying power is necessary to obtain an exact idea of the viscera of these eels. Fig. 10 represents the alimentary duct further magnified, from its origin to the belly. It is shewn here as separated from the animal, which is easily effected; for nature, assisted by very little art, performs the operation. The oesophagus, *b c*; Fig. 6 and 10, at its origin *a a*, is very small, but soon grows larger, as at *c*, and forms a kind of oblong bag, *c d*; the diameter of this increases till it comes to *d*, where it swells out as at *d e f*; it then grows smaller till it comes to *g*, when it again swells out at *g k l*. The part *k l* is the stomach. M. Becli has shewn, that the alimentary duct of many species of worms is formed of two bags, one of which is inclosed within the other. It is the same with this animalculum; the little vessel *b c*, that we have called the oesophagus, which is the origin of the bag *c d*, enters into the same bag, and preserves its form within it till it comes to *m*, from whence it is prolonged in the form of a black line *m n*, which passes by the axis of the duct *e*, and apparently terminates itself at the beginning of the abdomen *l*. To this tube, near the center of the swelling *g k l*, are fixed two small transparent bodies; that end of these which is connected with the tube is round, the other end is pointed; these small pieces cannot be discerned in every position of the eel.

I shall now shew how this duct is to be forced out of the eel. The body, when compressed, generally bursts either at the head or tail, and always at that part which is least pressed; hence when the mass of fluids contained in the body is forced towards the anterior part, they meet with a resistance in passing from the abdomen to the duct already described; the abdomen, being forced by the fluids which are made to act against it, bursts at the upper end, and the fluids, striking against the neck, force it, with all its contents, out of the body, through an opening at the anterior part; on lessening the pressure, the intestine thus discharged will float in the water between the two plates of glass.

Not to enter into a detail of those parts which have been supposed by some writers to constitute the heart, &c. of these minute animalcula, it will be sufficient here to describe those in which motion may be discovered, and to leave the rest to future observations on the subject. The parts which may be seen in motion within these minute creatures are, 1. the small tube or duct, from its origin at *m*, to the two appendages; 2. these appendages themselves, *h*; 3. the remainder of the tube, from the appendages to the insertion at the ventricle *k*; 4. in the swelling *g k l*. The rest of this duct, from the beginning by the oesophagus *b c*, to the second swelling, has no motion. There is a variety in the motions of the first part of this duct, sometimes it dilates and contracts, at other times it has an oscillatory motion. It is difficult to gain a good view of the appendages; but when the position of the little creature is favourable, they seem to have a twofold motion, by which the pointed ends approach to, and then separate from each other, and another by which they move up and down. The part *g k l* moves backwards and forwards alternately; the motion of each of these parts is independent of the rest. These are the principal parts, whose motion is connected with the life of the animal.

The other viscera that are contained in the body of the eel, and which may be observed by the aid of the microscope, are, the vessels which contain the food, those which are filled with a transparent substance, and the womb or ovary. The first form the abdomen and intestines; these are filled with a black substance, which prevents their being properly and clearly distinguished; these vessels, in their passage through the posterior part of the body, form an empty space, in which we may perceive that one side of the animalculum is occupied by the ovary *q q q*, which runs from *j* to *u x*; it is at these two extremities of the ovaries that the eggs begin to be formed, for the largest eggs are always to be found in the middle, and the smallest at the ends, as may be seen at *j f* and *u x*.

All the eels which bear eggs have two protuberances, *y y*, formed on the exterior part near the center of the ovary; it appears like a transparent semicircular membrane, but is really a kind of hernia or bag, in which one or two eggs may be sometimes seen; all the larger eels have this appendage, which also bears the marks of having been burst. Now, as the younger eels have not this appendage, nor any marks of a rupture, we may reasonably conclude that it is from hence that the little eels issue from the parent.

In the latter part of the year, and during the winter, these eels are oviparous, and the young eels may be seen to proceed from the egg; at other times they are viviparous; six live eels have been seen at one time in the belly of the parent, twenty-two eggs have been counted in the ovary. Müller suspected that there was a difference of sex in some of these animalcula, but it was left to M. Roffredi to afford the proof, and it was only from a variety of repeated observations that he could allow himself to be convinced of this truth. He continued his researches upon the same subject on other microscopic eels, and has since been able to distinguish the sexual parts of the vinegar eels.

The second species of paste eel is oviparous. It is easily distinguished from the first kind by being much smaller; in Fig. 8, is exhibited a magnified view of this eel. The conformation of the alimentary duct and the intestines are in general nearly the same, though an intelligent observer will find out some specific differences. By the flexion of the intestines *c c c*, a void space is left a little beyond the middle of the body, where the ovary, *d d*, is situated. There is no exterior protuberance near this ovary, as in the preceding one.

We meet with another eel in paste, which may with propriety be called the common eel. It is often to be found in grains placed in the earth, in which the germ is destroyed, in the roots and stems of farinaceous plants, in the tremella of Adanson, and in several species of conferva, as well as in several infusions. This eel, when at its full growth is rather longer than the common eel of blighted wheat; one of them is represented at Fig. 11.

They are easily distinguished from the eels of blighted wheat, because they have no ranges of globules like it, by the two little protuberances which are near the middle of the body, and by the regular diminution of the tail. It is oviparous.

A very small species, represented at Fig. 9, may also be found in paste; they may be distinguished from the young eels of the larger sort by their vivacity and slenderness.

As the eels in paste are objects which are so often exhibited in the microscope, it will be proper, before we leave this subject, to inform the reader how he may procure the young eels from the parent animalcula; a discovery which was originally made by Mr. Sherwood, but more particularly pursued and described by Baker. Take up a very small quantity of paste where these eels abound on the point of a pin, or with a sharpened quill; lay it on a slip of glass, and dilute it well with water; by these means, many of them will become visible to the naked eye; then with the nib of a pen cut to a very fine point, and shaved so thin as to be extremely pliable, single out one of the largest eels, and insinuate the point of the pen underneath it; remove it into a very small drop of water, which you must have ready prepared on another slip of glass. When thus confined, it may easily be cut asunder transversely, by the help of a good eye and steady hand, with a lancet or sharp penknife; or if the eye be deficient, a hand-magnifier will enable almost any person to perform the operation. As soon as the parts are separated, apply your object to the microscope; and if the division has been made about the middle of the animal, several oval bodies of different sizes will be seen to issue forth. These are young anguillulæ of different degrees of maturity, each of which is coiled up, and included in its proper membrane, of so exquisite a fineness, as to be scarce discernible by the greatest magnifier while it incloses the embryo animal. The largest and most forward break immediately through this delicate integument, unfold themselves, and wriggle about nimbly in the water; others get out, uncoil, and move about more slowly; and the least mature continue entirely without motion. The uterus or vessel that contains all these oval bodies is composed of many annula or ringlets, not unlike the aspera arteria of land animals, and it seems to be considerably elastic; for as soon as the operation is performed, the oval bodies are thrust out with some degree of violence by the spring or action of this bowel. An hundred or upwards of young ones have been seen to issue from one single eel, whereby the prodigious increase of them may be accounted for, as probably several such numerous generations are produced in a short time. Hereby we also learn that these creatures are not only like eels in shape, but are likewise viviparous, as eels are generally supposed to be.

Few experiments are to be found more entertaining, or in which there is so little risk of being disappointed; for they seem, like earth-worms, to be all prolific, and you may be sure of success, unless by accident you cut one that has already brought forth all its young, or make your trials when the paste has been kept a very long time, in which cases they have been found unfruitful.

3. ANGUILLULA AQUÆ DULCIS, OR FRESH WATER EEL.

Coreulum vermiculo simile, Linn. Amæn. (Mund. Invis.) Anguille Vulgaire, Rozier Journal Physique, 1775. Mars, Nov. 1776. Ibid. Anguille du Bled Rachitique. Ibid. Anguille du Faux Ergot. Spallanz. Opusc. Phys. part 2, p. 354, pl. 5, fig. 10.

The body of this is exceedingly transparent, with no visible entrails, though a few transverse lines may be discovered on the body. It is sometimes, though rarely, furnished with a long row of little globules, and often with two small oval ones; the tail terminates in a point. Müller says he found these eels in the sediment which is formed by vegetables on the sides of vessels in which water had been kept for some time.

4. ANGUILLULA AQUÆ MARINÆ, OR SALT WATER EEL.

This, when pressed between two plates of glass, appears to be little more than a crystalline skin, with a kind of clay-coloured intestines. The fore-part of the body is truncated, the lower part drawn out to a fine point, the rest of the body is of an equal size throughout. The younger ones are filled with pellucid molecular intestines.

OF THE EELS IN BLIGHTED WHEAT.

Plate XI. Fig. 4 and 5.

These animalcula were discovered by Needham, and described by him in a work entitled, New Microscopical Discoveries, and afterwards more fully treated upon by Baker. They are not lodged in those blighted grains which are covered externally with a soot-like dust, whose inside is often also little more than a black powder; but abundance of ears may be observed in some fields of corn, which have grains that appear blackish, as if scorched: these, when opened, are found to contain a soft white substance, that when attentively examined looks like a congeries of threads or fibres lying as close as possible to each other in a parallel direction, and much resembling the unripe down of some thistles. This fibrous matter does not discover any signs of life or motion, unless water be applied to it; the fibres then separate, and prove themselves to be living creatures.

These eels are in general of a large size, and may be seen with a common magnifying glass, being about one-thirtieth of an inch in length, and one-hundred and fortieth broad. Fig. 5 represents one of them magnified about one-hundred and twenty times; they are in general of a bright chesnut colour, the extremity *a b* is whiter and more transparent than the rest of the body. The end *a* is rather round; the end *c* is pointed. A distinguishing mark of these little creatures is a row of transparent globules, which are placed at intervals through the whole length of the body, beginning at *b*, where the transparency of the fore-part ceases, and going on towards the extremity *c*. They are in diameter rather less than one-third of the body. Another peculiar mark is a small lunular space *d*, near the middle of the body. This part is transparent, and is free from the coloured matter of the intestines; there is a neck in the intestines near this space, which confines them to one part of the body.

Great care should be taken by the observer, not to burst the skin of the eels in disengaging them from the grain, for they never break or burst of themselves; but if broke, visible intestines, filled with a black matter, rush out of the body, from which little black globules are disengaged; if the observation be made immediately after these globules proceed from the eel, they swim slowly about the water, though divested of any principle of internal motion; but if the eels that are broke be left long in the water, the same phænomena will take place, as in other animal and vegetable infusions. The want of due attention to these circumstances has been productive of many of the fanciful positions of Needham, which were deduced from ill-conducted experiments; and, consequently, when properly examined, are found to be in a great measure false.

M. Roffredi sowed some of the grains of this wheat, which sprang up; but the ear was either wholly or in a great measure spoiled, being filled with these eels. He also found them in other parts of the plant; in order to disengage them, the plant must be soaked in water, and then compressed a little. At first sight these eels seem to resemble the foregoing, but a more accurate inspection shews that they have neither the same curious disposition of the internal globules, nor the transparent place in the middle of the body. The intestinal bag leaves indeed in these an empty space, but it is of an undetermined form. The animalcula from the plant are much more lively than those which are procured from the dried grains.

The principal phænomena in this kind of blighted wheat is probably owing to these animalcula, who prevent the regular circulation of the sap. They increase in size in a certain proportion to the plant, so that at last they may be observed with great ease by the naked eye, being two-tenths of an inch long, and nearly one-tenth in diameter. Fig. 4 represents one of these magnified nearly in the same proportion as Fig. 5; *a a a a*, the ovary, which may be traced almost from the lower extremity to the middle of the body, where the body becomes so opake as to prevent its being seen any further. The eggs, when arrived at their full growth, are nearly of a cylindric shape, both ends rounded; towards the extremity *b* there are two little protuberances *d d*, through which the eggs are most probably extruded; these protuberances are not always visible. The eggs are formed of a fine transparent membrane; it covers the young eel, which is folded curiously therein; these eggs may be frequently found in the plant.

A most satisfactory view of these eels is obtained by examining them with the solar microscope; it affords one of the most surprizing and magnificent spectacles; two generations may be often seen, one, which draws near the allotted period of its existence, and another which only begins to enjoy the blessings of life: some arrived at their full growth, and others quite small. In some we may perceive the young animalcula in motion in the eggs, in others, no such motion can be observed; with a variety of other circumstances too tedious to enumerate, though they afford great pleasure to the spectator.

One of the most remarkable circumstances in these animalcula is the faculty they have of receiving again the powers of life, after having lost them for a considerable time; for instance, when some of these blighted grains, that have been preserved for many years, have been soaked in water for ten or twelve hours, living eels of this species have been found in it; if the water evaporate, or begin to fail, they cease to move, but, on a fresh application, will be again revived.*

It may be proper to notice here, that according to the observations of Roffredi, those eels which have done laying of eggs are incapable of being resuscitated upon being moistened; the same seems to be also the case with those that are very young; it is probable they must attain a certain age and degree of strength before they are endowed with this wonderful faculty.

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* The property of revivification is not confined to this species, being common to other kinds of worms, and it is not improbable that the hydræ may possess the same faculty. Edit.

In the month of August, 1743, a small parcel of blighted wheat was sent by Mr. Needham to Martin Folkes, Esq. President of the Royal Society, with an account of his then new discovery; which parcel the president was pleased to give to Mr. Baker, desiring him to examine it carefully. In order so to do, he cut open some of the grains that were become dry, took out the fibrous matter, and applied water to it on a slip of glass, but could discern no other motion than a separation of the fibres or threads, which separation he imputed wholly to an elasticity in the fibres; and perceiving no token of life, after watching them with due care, and repeating the experiment till he was weary, an account thereof was written to Needham, who, having by trials of his own, found out the cause of this bad success, advised him to steep the grains before he attempted to open them; on doing which he was very soon convinced of his veracity, and entertained with the pleasing sight of this wonderful phænomenon. At different times after this, Baker made experiments with grains of the same parcel, without being once disappointed. He soaked a couple of grains in water for the space of thirty-six hours, when, believing them sufficiently moistened, he cut one open, and applying some of the fibrous substance to the microscope in a drop of water, it separated immediately, and presented multitudes of the anguillulæ without the least motion or sign of life; but being taught by experience that they might notwithstanding possibly revive, he left them for about four hours, and then examining them again, found much the greatest number moving their extremities pretty briskly, and in an hour or two after they appeared as lively as these creatures usually are. Mr. Folkes and some other friends were witnesses of this experiment. We find an instance here that life may be suspended and seemingly destroyed; that by an exhalation of the fluids necessary to a living animal, the circulations may cease, all the organs and vessels of the body may be shrunk up, dried, and hardened; and yet, after a long while, life may begin anew to actuate the same body, and all the animal motions and faculties may be restored, merely by replenishing the organs and vessels with a fresh supply of fluid. Here is a proof that the animalcula in the grains of blighted wheat can endure having their bodies quite dried up for the space of four years together, without being thereby deprived of the property of resuscitation.

It appears plainly from the foregoing experiments, that when the blighted grains of wheat have been kept a long time, and the bodies of these animalcula are consequently become extremely dry, the rigidity of their minute vessels requires to be relaxed very gently, and by exceeding slow degrees; for we find that, on the application of water immediately to the bodies of these animalcula, when taken from the dry grains, they do not so certainly revive, as they do if the grains themselves be either buried in earth, or steeped in water for some time before they are taken out: the reason of which most probably is, that too sudden a relaxation bursts their delicate and tender organs, and thereby renders them incapable of being any more employed to perform the actions of life; and, indeed, there are always some dead ones amongst the living, whose bodies appear bursten, or lacerated, as well as others that lie extended and never come to life.

Some discretion is needful to adapt the time of continuing the grains in water or earth to the age and dryness of them; for if they be not opened before they have been too much or too long softened, the animalculum will not only seem dead, but will really be so. Of the two grains mentioned to have been four years old when put to soak, one was opened after it had lain thirty-six hours, and the event proved as already related; the other was suffered to lie for above a week, on opening which, all the anguillulæ near the husk were found dead, and seemingly in a decayed condition; but great numbers issued alive from the middle, and moved themselves briskly. Unless the husks be opened to let these creatures out after being steeped, they all inevitably perish; and when taken out and preserved in water, if the husks be left with them, they will die in a few days; but otherwise, continue alive in water for several months together; and, should the water evaporate, may be revived again by giving them a fresh supply.

72. Vibrio Linter. V. ventricoso-ovatus, collo brevissimo. Ventricose oval vibrio, with a short neck.

This is one of the larger animalcula, of an egg-shape, pellucid, inflated, somewhat depressed at top; the apex is prolonged into a moveable crystalline neck, the belly is replete with pellucid molecules. It is not very common, though occasionally to be found among the lemnæ.

73. Vibrio Utriculus. V. teres, antice angustatus truncatus, postice ventricosus. Round vibrio, the fore-part narrow and truncated, the lower ventricose.

It does not ill resemble a bottle in shape; the belly is replete with molecular intestines, the neck bright and clear, the top truncated; in some a pellucid point is visible at the bottom of the belly. It is in an unceasing, vehement, and vacillatory motion, the neck moving from one side to the other as fast as possible.

74. Vibrio Fasciola. V. antice attenuatus, medio latiusculus, postice acutus. Vibrio with a small fore-part, the middle a little bigger, the hind-part acute.

This is a pellucid animalculum, in the middle are the intestines in the form of points; an alimentary pipe, which lessens gradually in size, is also perceptible. The motion of it is quick, darting itself up and down in the water with great velocity. It is found in water just loosened from the frost, and seldom elsewhere.

75. Vibrio Colymbus. V. crassus, postice accuminatus, collo subfalcato. Thick vibrio, sharpened at the end, the neck a little bent.

It is larger than most of the vibrios, and not unlike a bird in shape. The neck is round, shorter than the trunk, of an equal size throughout, and of a bright appearance, the apex obtuse. The trunk is thick, somewhat triangular, full of yellow molecules; the fore-part broad, the hinder-part acute, the motion slow.

76. Vibrio Strictus. V. elongatus linearis, anticem versus attenuatus, apice obtuso. Vibrio lengthened out almost to a line, small towards the fore-part, the apex obtuse.

The body linear, being a bright membranaceous thread, without any flexure; the hind-part somewhat thicker, round, and filled with molecules, excepting just at the end, where there is a small pellucid empty space. The apex is obtuse, and rather globose; it has a power of contracting and drawing in the filiform part.

77. Vibrio Anas. V. oblongus, utroque fine attenuatus, collo cauda longiore. Oblong vibrio, both ends attenuated, the neck longer than the tail.

The trunk is oblong, opake, and filled with molecules. Both the fore and the hind-part is prolonged into a pellucid talky membrane, which the animalculum has a power of retracting at pleasure. The tail is more acute than the neck. It is most generally found in salt water; a species of them have been found in river water, with a longer neck.

78. Vibrio Cygnus. V. ventricosus, collo adunco. Corpulent vibrio, with a crooked neck.

This animalculum is little more than a most pellucid line, crooked at top, prominent in the middle, and sharp at the end; the fore-part, or neck, is equal in length to the rest of the body, and three times longer than the hind-part or tail; the intermediate part swelling out, is full of dark-coloured molecules and pellucid intestines. It is very small, and the most slothful of all those which move and advance their necks.

79. Vibrio Anser. V. ellipticus, collo longo, tuberculo dorsali. Plate XXV. Fig. 27 and 29. Elliptical vibrio, with a long neck, and a little lump on the back.

It is between the vibrio proteus and vibrio falx, and is distinguished by the lump *b*, Fig. 29, on the back, placed behind the neck; from this an even long neck, *a*, proceeds. The trunk, *d*, is elliptic, round, and without any lateral inequality; full of molecules, the hind-part, *e*, sharp and bright, the fore-part produced into a bending neck that is longer than the body; the apex even and whole, with blue canals passing between the marginal edges, occupying the whole length of the neck; in one of them a vehement descent of water to the beginning of the trunk is perceivable. The motion of the body is slow, that of the neck is more lively and flexuous, sometimes spiral. It is found in water where duck-weed grows.

80. VIBRIO OLOR. V. ellipticus, collo longissimo, apice nodoso. Plate XXV. Fig. 28. Elliptical, with a very long neck, and a knob on the apex.

The form of the body is elliptical and ventricose, the hind-part somewhat sharp. It is membranaceous, dilatable, winding variously; the hind-part is sometimes replete with darkish molecules. The neck, *d,* is three or four times longer than the body, of an equal size throughout, except a small degree of thickness at the apex, *f,* very pellucid. The motion of its neck is very lively, that of the body slow. It is found in water that has been kept for a long time, and which has acquired a vegetable greenness.

81. VIBRIO FALX. V. gibbosus, postice obtusus, collo falcato. A gibbous vibrio, the hind-part obtuse, the neck crooked.

The body is pellucid, elliptical, the fore-part lessening into a little round bright neck, nearly of the same length as the trunk, the hind-part obtuse. The trunk itself is rather rounding or tending to the gibbous, and filled with very small molecules; there are also two bright globules, one within the hind extremity, the other in the middle of the body. The neck being immoveable, the motions of the animalculum somewhat resemble those of a scythe.

82. VIBRIO INTERMEDIUS. V. membranaceus, antice attenuatus, postice subacutus. Membranaceous vibrio, the fore-part small, the hinder part somewhat acute.

It seems to be an intermediate species between the preceding vibrio and the fasciola, No. 74; it is a thin membrane, constantly folded. The whole of it has a crystalline talky appearance, the middle replete with grey particles of different sizes; it has all round a distinct bright margin; the apex of the neck is truncated, the tail obtuse.

VI. CYCLIDIUM.

Vermis inconspicuus, simplicissimus, pellucidus, complanatus, orbicularis vel ovatus. A simple, invisible, flat, pellucid, orbicular or oval worm.

83. Cyclidium Bulla. C. orbiculare hyalinum. Orbicular bright cyclidium.

A very pellucid white animalculum, or orbicular skin, the edges a little darker than the rest. By the assistance of the compound microscope, some globular intestines of a very crystalline appearance are just perceptible. Its motion is slow and semicircular. It is found occasionally in an infusion of hay.

84. Cyclidium Milium. C. ellipticum crystallinum. Elliptic and clystalline cyclidium.

It is very pellucid, of a crystalline splendour, membranaceous and elliptical; a line may be perceived through the whole length of it, a point in the fore-part, the hinder-part getting darker. Its motion is swift, fluttering, and interrupted; probably both extremities are ciliated.

85. Cyclidium Fluitans. C. ovale crystallinum. Oval crystalline cyclidium.

This is one of the smallest animalcula. The body of an oval, or rather suborbicular shape, depressed, crystalline; two small blue spaces may be discovered by the assistance of the microscope at the sides of this little creature.

86. Cyclidium Glaucoma, C. ovatum, interaneis ægre conspicuis. Oval cyclidium, the intestines perceived with difficulty.

A pellucid oval body, with both ends plain, or an oval membrane, with a distinct well-defined edge; the intestines are so transparent that they can scarce be discerned, when it is empty; when full, they are of a green colour, and there are dark globules discoverable in the middle.

In plenty of water it moves swiftly in a circular and diagonal direction; whenever it moves slowly it seems to be taking in water, the intestines are then also in a violent commotion. Two of the smaller ones may often be perceived cohering to each other, and drawing one another by turns; nor are they separated by death, for they remain united even when the water is evaporated. Those who are not familiar with these kinds of observations, may easily mistake the shade in a single one for a junction of two, or the junction of two for a copulation, for they generate by division.

87. Cyclidium Nigricans. C. oblongiusculum, margine nigricans. Oblong cyclidium, with a black margin.

It is very small, pellucid, and flat. With a small magnifier, it may be mistaken for an enchelis.

88. Cyclidium Rostratium. C. ovale, antice mucronatum. An oval cyclidium, the fore-part pointed.

This is an oval, smooth, and very pellucid animalculum, with the fore-part running out into an obtuse point; with this it seems to feel and examine the bodies which it approaches. It is probably ciliated, though the hairs have not been discovered.

The intestines are filled with a blue liquor, forming in a tube, which, from the aperture to the middle of the body, is divided into two legs or branches; beyond the middle there are two little transverse blue lines. This colour sometimes vanishes, and then they seem to be composed of vesicles.

89. Cyclidium Nucleus. C. ovale, postice acuminatum. An oval cyclidium, the hind-part pointed.

The body is pellucid, depressed, the fore-part obtusely convex, the hind-part acute, the intestines vesicular, the fore and hind-part on each side dark. It resembles a grape-seed.

90. Cyclidium Hyalinum. C. ovatum, postice acutum. Oval cyclidium, the hind-part acute.

This cyclidium is oval, flat, and bright, without any visible intestines, the hinder-part somewhat smaller than the fore-part; it has a tremulous kind of motion.

91. Cyclidium Pediculus. C. ovale convexum, subtus planum. An oval convex cyclidium, the bottom even. Trembley Polyp. 1, p. 282.

This is a gelatinous white animalculum, the bottom gibbous over the back, the extremities depressed and truncated, with one end sometimes apparently cloven into two; perhaps this is the aperture of the mouth. It is scarce ever seen but on the arms and the body of the hydra pallida, upon which it runs as if it had feet.

92. Cyclidium Dubium. C. ovale, supra convexum, subtus cavum. Oval cyclidium, the upper part convex, the under part concave.

This is one of the larger species, the margin is pellucid, and the inner part contains a great number of black molecules.

VII. PARAMÆCIUM.

Vermis inconspicuus, simplex, pellucidus, membranaceus, oblongus. An invisible, simple, membranaceous, flat, and pellucid worm.

93. Paramæcium Aurelia. Volvox Terebella. Ellis. P. compressum, versus anticem plicatum, postice acutum. Compressed paramæcium, oblong, folded towards the fore-part, the hinder-part acute.

This is rather a large animalculum, membranaceous, pellucid, and four times longer than it is broad; the fore-part obtuse, transparent, without intestines; the hind-part replete with molecules of various sizes; the fold which goes from the middle to the apex is a striking characteristic of the species, forming a kind of triangular aperture, and giving it somewhat the appearance of a gimblet. Its motion is rectilinear, reeling or staggering, and generally vehement.

They are frequently found cohering lengthwise; the lateral edges of both bodies appear bright. They may also sometimes be seen lying on one another alternately, at others, adhering by the middle. They will live many months in the same water without its being renewed. They are to be found in June in ditches where there is plenty of duck-weed.

94. Paramæcium Chrysalis. P. cylindraceum, versus anticam plicatum, postice obtusum. Plate XXV. Fig. 26. Cylindrical paramæcium, folded towards the fore-part, the hinder-part obtuse.

It differs very little from the preceding, only the ends, *a b,* are more obtuse, and the margins filled with black globules. It is an inhabitant of salt water.

95. Paramæcium Versutum. P. cylindraceum, postice incrassatum, utraque extremitate obtusum: Cylindrical paramæcium, the lower part thick, and both ends very obtuse.

An oblong, green, and gelatinous body, filled with molecules; the lower-part thick, the fore-part smaller, both ends obtuse, and may be seen to propagate by division. It is found in ditches.

96. Paramæcium Oviferum. P. depressum, intus bullis ovalibus. Plate XXV. Fig. 25. Depressed paramæcium, with large oval molecules withinside.

A membranaceous, oval, oblong animalculum, grey and pellucid, having many oval very pellucid corpuscles, *a,* dispersed about the body, and many black grains towards *b.*

97. Paramæcium Marginatum. P. depressum, griseum, margine duplici. Plate XXV. Fig. 24. Depressed paramæcium, grey, with a double margin.

This is one of the largest of the class, flat, elliptical, every part filled with molecules, except in the lower end, *b*, where there is a pellucid vesicle; this animalculum is surrounded by a broad double margin; when expiring, a bright spiral intestine is observable. *a*, the apex; *b*, the vesicle; *c*, the spiral intestine.

VIII. KOLPODA.

Vermis inconspicuus, simplicissimus, pellucidus, complanatus, sinuatus. An invisible, very simple, pellucid, flat and crooked worm.

98. KOLPODA LAMELLA. K. elongata, membranacea, antice curvata.

This animalculum resembles a long, narrow, and pellucid membrane, the hind-part obtuse, narrower, and curved towards the top; no intestines discoverable, only a ridge or fold going through the middle. Its motion is reeling or staggering, and very singular, moving to and fro on its edge, not on the flat side, as is usual with most microscopic animals. It is found in water, but is very seldom to be met with.

99. KOLPODA GALLINULA. K. oblonga, dorso antico membranaceo hyalino. Oblong kolpoda, the back towards the fore-part bright and membranaceous.

The apex rather bent; the belly oval, convex and striated. It is found in fetid salt water.

100. KOLPODA ROSTRUM. K. oblonga, antice uncinata. Oblong, the fore-part hooked.

The fore-part is bent into a kind of hook; the hind-part is obtuse, and everywhere filled with black molecules. One of the edges from the fore-part to the middle, is often so blunted and dilated, that the rest of the body appears quite smooth, and that part thick and triangular. It has a slow and horizontal motion. It is to be found, though but seldom, in water where the lemnæ grow.

101. KOLPODA OCHREA. K. elongata, membranacea, apice attenuato, basi in angulum rectum producta. Long kolpoda, membranaceous, the apex attenuated, the base bent in a right angle to the body.

A large animalculum, long, and of a singular figure, depressed, membranaceous, flexible; one edge nearly straight, the other somewhat bent, filled with obscure molecules, and a few little bladders dispersed here and there; the apex bright and small, the base projecting like the human foot from the leg.

102. KOLPODA MUCRONATA. K. membranacea dilatata, antice angustata, altero margine incisa. Membranaceous, dilated kolpoda, the fore-part smaller than the hind-part, with a small incision at one side.

This animalculum is a dilated bright membrane; the apex an obtuse point, with a broad marked border running entirely round it; within the margin it is filled with grey molecules, a fleshy disc on one side, which terminates in a splendid little point on the other side the disc. It has a truncated appearance.

103. KOLPODA TRIQUETRA. K. obovata depressa, altero margine retuso. Kolpoda nearly of an egg-shape, one edge turned back.

This animalculum appears to consist of two membranes; the upper side flattened, the lower convex; the apex is bent so as to form a kind of shoulder. It was found in salt water.

104. Kolpoda Striata. K. oblonga, subarcuata depressa, candida, antice acuminata, postice rotundata. Oblong, somewhat of a pear-shape, white, the fore-part pointed, the hind-part round.

It is very pellucid and white, the upper part rather bent, and terminating in a point, the lower part obtusely round; at the apex or mouth there is a little black pellucid vesicle; when a very great magnifying power is used, the body appears covered with long streaks; the lower extremity is furnished, like many other animalcula, with very small globules. It is to be found in salt water.

105. Kolpoda Nucleus. K. ovata, vertice acuto. Egg-shaped kolpoda, with an acute vertex.

It is of an oval shape, the vertex pointed, of a brilliant transparency, which renders the viscera visible; they consist of a number of round diaphanous vesicles.

106. Kolpoda Meleagris. K. mutabilis, antice uncinata, postice complicata. Plate XXV. Fig. 22. Changeable, with the fore-part like a hook, the hind-part folded up.

A most singular animalculum of the larger species; it has a dilated membrane, with the finest folds, which it varies and bends in a moment; the fore-part of the body to the middle is clear and bright, the hind-part variously folded in transverse elevated plaits, and full of molecules; the apex turned into a hook, the margin sinuous, and beneath the apex denticulated with three or four teeth; but in some which are more beautifully wrought, the edge is obtusely notched, and set with still smaller notches; in the hind-part there are twelve or more equal pellucid globules. It moves sometimes in a straight, at other times in a crooked line. *a*, the hooked apex; *b*, the denticulated margin; *c*, the series of globules; *d*, the folded part at bottom.

107. Kolpoda Assimilis. K. depressa, non plicatilis apice uncinato, margine antico ad medium, usque crenulato postice, dilatato acutiusculo. Depressed kolpoda, the apex turned in the form of a small hook; the margin of the fore-part notched from the top to the middle, the lower part swells out, then diminishes again into a short point. It has an elliptic mass in the middle, but is never folded like the preceding. It was found on the sea coast.

108. Kolpoda Cucullus. K. ovata, ventricosa, infra apicem incisa. Plate XXV. Fig. 23. Egg-shaped, ventricose, with an incision in the fore-part.

It is very pellucid, with a well-defined margin, filled with little bright vesicles, differing in size, and of no certain number. Its figure is commonly oval, the top bent into a kind of beak, seldom an acute one, sometimes oblong, but most usually obtuse. Its intestines are formed of from eight to twenty-four bright little vesicles, not conspicuous in such as are young. Some have supposed these to be animalcula which the kolpoda had swallowed, but Müller is of opinion that they are its offspring. In some only one crystalline vesicle occupies the middle of the body. It moves in general with great vivacity, and in all directions. When this creature is near death in consequence of the evaporation of the water, it protrudes its offspring with violence. It is found in infusions of vegetables, and in fetid hay. In some few a transparent membranaceous substance may be perceived projecting beyond the beak, and resembling an exuvia; the same may also be observed in the enchelis and vibrio: it is, therefore, possible that these animalcula cast their skin, as is the case with many of the class of insects. *a* shews the cap or hood, *b* the incision.

109. Kolpoda Cucullulus. K. oblonga, infra apicem oblique incisa. Oblong kolpoda, with an oblique incision a little below the apex.

A very pellucid crystalline animalculum; it is furnished with several pellucid globules; there is a bending a little beneath the top, which in some positions is very distinctly seen, in others not. It was observed in an infusion of the sonchus arvensis.

110. Kolpoda Cucullio. K. ovalis depressa, infra apicem tantillum sinuata. Flat oval kolpoda, with a small degree of bending beneath the apex.

This is an oval, or rather an elliptical kolpoda, membranaceous and bright; flat on the upper side, and convex on the under; the fore-part is clear, and from the middle to the hinder-part it is filled with silver-like globules. It frequently stretches out the fore-part, and folds it in different positions.

111. Kolpoda Ren. K. crassa medio sinuata. This kolpoda is thick, and curved in the middle.

The body is yellow, thick, and rather opake; curved a little, in the middle, so as to have the appearance of a kidney; the whole body is filled with molecules. Its motion is quick, fluctuating, and interrupted. When the water in which it swims is about to fail, it assumes an oval form, is compressed, and at last bursts. It is found in an infusion of hay, generally about thirteen hours after the infusion is made.

112. Kolpoda Pirum. K. convexa, ovalis, apice in rostrum producta. Plate XXV. Fig. 20 and 21. Convex kolpoda, oval, the apex formed into a kind of beak.

The body is uniform and transparent, without any sensible inequality; the neck rather long and a little bent; it is of a pale colour, and furnished with obscure little globules. It propagates by division. Fig. 20 represents this animalculum; Fig. 21, the same dividing to form another; *a*, the fore-part; *b*, the hind-part; *c*, where it is dividing.

113. Kolpoda Cuneus. K. clavata, teres, apice dentata. Clavated kolpoda, round, the apex dentated.

This is a large animalculum, the body white, gelatinous, without any distinct viscera. It has a pellucid, bright, striated pustule on one side of the fore-part; the apex is distinguished by three or four teeth, the hinder-part is smaller than the fore-part, with an obtuse termination, which it can bend into a spiral form.

IX. GONIUM.

Vermis inconspicuus, simplicissimus, complanatus, angulatus. An invisible, simple, smooth, angular worm.

114. Gonium Pectorale. G. quadrangulare, pellucidum moleculis sedecim sphæricis. Plate XXV. Fig. 17. This gonium is quadrangular, pellucid, with sixteen spherical molecules.

These sixteen little oval bodies are nearly equal in size, of a greenish colour, pellucid, and set in a quadrangular membrane, like the jewels in the breast-plate of the high-priest, reflecting light on both sides. Its animality is evinced by its spontaneous motion, advancing alternately towards the right and left; these little bodies seem oval when in motion, round when at rest; the four interior ones are a little larger than the rest. It is found in pure water.

115. GONIUM PULVINATUM. G. quadrangulare, opacum pulvillis quatuor. Quadrangular, opake, with four little pillows.

This appears like a little quadrangular membrane, plain on both sides; with a large magnifier it looks like a bolster, formed of three or four cylindric pillows, flattened or sunk here and there. Thus it appeared to Müller on the first examination; some days after all the sides were plain, without any convexity, and divided into little square spaces by lines crossing each other. It is found upon dunghills.

116. GONIUM CORRUGATUM. G. quadrangulare, albidum, medio correptum. Quadrangular gonium, white, sunk a little in the middle.

It is somewhat of a square shape, very minute, without any visible viscera, a little depressed in the middle. It is found in various infusions; in some positions it appears streaked.

117. GONIUM RECTANGULUM. G. rectangulum, dorso arcuato. This gonium is rectangular, the hind-part arched.

This differs but little from the preceding; the angle at the base is a right one, the larger vesicle is transparent, the rest green.

118. Gonium Truncatum. G. obtusangulum, postice arcuatum. Gonium with obtuse corners, the hind-part arched.

Much larger than the foregoing, the fore-part is a straight line, with which the sides form obtuse angles, the ends of the sides being united by a curved line; the internal molecules are of a dark green, there are two little bright vesicles in the middle; its motion is languid. It is found chiefly in pure water, and that but seldom.

X. BURSARIA.

Vermis simplicissimus, membranaceus, cavus. A very simple, hollow, membranaceous worm.

119. Bursaria Truncatella. B. ventricosa, apice truncata. Ventricose bursaria, the top truncated.

An animalculum that is visible to the naked eye, white, oval, and truncated at the top, where there is a large aperture descending towards the base; most of them have four or five yellow eggs at the bottom. It moves itself at pleasure from right to left, and from left to right, ascending to the surface of the water in a right line, and sometimes rolling about while descending.

120. Bursaria Bullina. B. cymbæformis, antice labrata. Boat-shaped bursaria, the fore-part formed into a lip.

A pellucid crystalline animalculum, furnished with splendid globules of different sizes swimming about within it; the under-side convex, the upper side hollow, the fore-part forming a kind of lip. .

121. Bursaria Hirundinella. B. utrinque laciniata, extremitatibus productis. Plate XXV. Fig. 19.

Bursaria with two small projecting wings, which give it somewhat of the appearance of a bird, and it moves something like a swallow. It is invisible to the naked eye, but by the microscope appears to be a pellucid hollow membrane; no intestines are visible. *a*, the head; *b*, the tail; *c*, one of the wings.

122. Bursaria Duplella. B. elliptica, marginibus inflexis. Plate XXV. Fig. 18. Elliptic bursaria with the edge bent in and out.

A crystalline membrane folded up, without any visible intestines, if we except a little congeries of points under one of the folds. It was found among duck-weed.

123. Bursaria Globina. B. sphærica, medio pellucentissima. Spherical bursaria, very pellucid in the middle.

A subspheric hollow animalculum, the lower end furnished with black molecules of various sizes, the fore-part with obscure points, the rest entirely empty, and the middle very pellucid; it moves slowly from right to left.

XI. CERCARIA.

Vermis inconspicuus, pellucidus, caudatus. An invisible pellucid worm with a tail.

124. CERCARIA GYRINUS. C. rotundata, cauda acuminata. Round cercaria, with a sharp tail.

It has a white gelatinous body, without any traces of intestines; the fore-part somewhat globular, the hind-part round, long, and pointed; sometimes it appears a little compressed on each side. When swimming, the tail is in a continual vibration, like that of a tadpole. It seems very similar to the spermatic animalcula.

125. CERCARIA GIBBA. C. subovata, convexa, antice subacuta, cauda tereti. Somewhat of an oval shape, convex, the fore-part rather acute, the tail round.

It is a small animalculum, gelatinous, white, opake, and without any visible intestines; the upper part convex or gibbous; many of them were found in infusions of hay, as well as of other vegetables.

126. CERCARIA INQUIETA. C. mutabilis, convexa, cauda lævi. Plate XXV. Fig. 31 and 32. Changeable convex cercaria, with a smooth tail.

This animalculum so often changes the form of its body, that it is not easy to describe it; it is sometimes spherical, sometimes like a long cylinder, at other times of an oval figure, white and gelatinous; the tail is filiform and flexible, the upper part vibrating vehemently, no visible viscera; a pellucid globule may be observed at the base, and two very small black points placed near the top at *d*, Fig. 32; whether they be eyes to the animalculum is not known. It was found in salt water. *a*, Fig. 31, the body; *b*, the tail.

127. Cercaria Lemna. C. mutabilis, subdepressa, cauda annulata. Plate XXV. Fig. 33, 34, and 35. Mutable cercaria, somewhat flattened, with an annulated tail.

This animalculum varies its form so much, that it might be mistaken for the proteus of Baker, though, in fact, it is totally different. The body sometimes appears of an oblong, somtimes of a triangular, and sometimes of a kidney shape. The tail is generally short, thick, and annulated, but sometimes long, flexible, cylindric, and without rings; vibrating, when stretched out, with so much velocity, that it appears as it were double. The intestines are not very distinct; a small pellucid globule, which Müller supposes to be its mouth, is observable at the apex; and two black points not easily discovered, he thinks are its eyes; sometimes it draws the tail entirely into the body. It walks slowly after taking three or four steps, and extends the tail, erecting it perpendicularly, shaking and bending it; in which state it very much resembles a leaf of the lemna. Fig. 33, *a*, the body rather spherical; *b*, the tail. Fig. 34, *c*, the triangular body; *b*, the tail. Fig. 35, the body extended; *e e*, the eyes; *f f*, the intestines; *g*, a large vesicle; *h*, a smaller one.

128. Cercaria Turbo. C. globulosa, medio coarctata, cauda uniseta. Plate XXV. Fig. 30. Globular cercaria, the middle contracted, with a tail like a bristle.

Partly of an oval, and partly of a spherical shape, pellucid, and of a talky appearance. It seems to be composed of two globular bodies, the lowermost of which is the smallest; this figure is occasioned by the contraction at the middle. There are two black points, like eyes, even with a transverse line which crosses the upper part of this little creature; several large globules may also be discerned; the tail is sometimes quite straight, sometimes turned back on the body. It is to be found among duck-weed.

129. Cercaria Poduria. C. cylindracea, postice acuminata subfissa. Plate XXV. Fig. 36 and 37. Cylindric cercaria, the hind-part sharp and somewhat cloven.

It resembles the young ones of the podura* which live among the lemnæ, is pellucid, and appears to consist of a head, trunk, and tail; the head resembles that of a herring; the trunk is cylindric, replete with black spiral intestines, and appears more or less extended, at the will of the animal; nothing is to be discovered in the hinder-part. The tail most commonly appears to be divided into two bristles. The intestines are in a continual motion when the body moves, and by reason of their various shades give it a very rough appearance; some lateral hairs or cilia are likewise to be perceived. When it moves, it revolves at the same time as upon an axis. It is to be found in November and December, in marshy places that are covered with the lemna. Fig. 36, *a*, the head; *b*, the trunk; *c*, the tail; *d*, with one point; it is seen at *e*, Fig. 37, with two points; *f*, the hairs on the side.

130. Cercaria Viridis. C. cylindracea mutabilis, postice accuminata fissa. Cylindrical cercaria, mutable, the lower end sharp, and divided into two parts.

This animalculum in some of its states considerably resembles the last, but has a much greater power of changing its shape. It is naturally cylindrical, the lower end sharp, and divided into two parts; but it sometimes contracts the head and tail so as to assume a spherical figure, at other times it projects outwards. It is found in the spring, in ditches of standing water.

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* A genus of insects of the order of aptera. Linn. Syst. Nat. p. 1013.

131. CERCARIA SETIFERA. C. cylindracea, antice angustior, postice acuminata. Cylindric cercaria, the fore-part smallest, the hind-part pointed.

This is a small cercaria, the body rather opake, and of a round figure. The upper part is bright, and smaller than the rest; the trunk is more opake; the tail sharp, and near it a little row of short hairs. It has a slow rotatory motion. It is found in salt water, though but seldom.

132. CERCARIA HIRTA. C. cylindrica, antice subtruncata, postice obtusa, bimucronata. Cylindrical cercaria, the fore-part somewhat truncated, the lower part obtuse, finishing with two small points.

A cylindrical opake animalculum, with two small points at the lower end, moveable, yet rigid, and placed at some distance; when in motion, the body appears to be surrounded with rows of small hairs separated a little from each other. It was observed in salt water.

133. CERCARIA CRUMENA. C. cylindraceo-ventricosa, antice oblique truncata, cauda lineari bicuspidata. Cylindrical, ventricose cercaria, the fore-part obliquely truncated, the tail linear, terminating with two diverging points.

The body is ventricose, cylindrical, thick, and wrinkled; the lower part small, the upper part terminates in a small, straight neck, like that of a pitcher; the tail terminates in two diverging points.

134. CERCARIA CATELLUS. C. tripartita, cauda bisecta. Three-parted cercaria, the tail divided into two parts.

This animalculum is more complex in its form than many others; it has a moveable head, which is affixed to the body only by a point; an abdomen, which is not so wide, but twice as long as the head, replete with intestines; and a tail which is shorter than the head, narrower than the belly, and terminating in two bristles, which it can unite and separate at pleasure. It moves with vivacity, though without going far from its own place.

135. Cercaria Catelina. C. tripartita, cauda bicuspidata. Cercaria distinguished into three parts, with a short forked tail.

It differs from the preceding in several respects, being larger, the body thicker, and more cylindrical; the lower part truncated, with two short diverging points projecting from the middle. It was found in a ditch containing plenty of duck-weed.

136. Cercaria Lupus. C. cylindrica, elongata, torosa cauda spinis duabus. Plate XXV. Fig. 39. Cylindric cercaria, long, the tail furnished with two spines.

This animalculum is larger than most of the cercarias, and in some particulars resembles the vorticella. It is full of muscles, capable of being contracted or extended; cylindric, composed of a head, a trunk, and a tail; the head is larger than the body, the apex turned down into a little hook; the tail is like the body, but narrower, terminating in two very bright spines, which it extends in different directions; sometimes it contracts itself into one half its common size; and again extends itself as before. It was found in water among duck-weed. *a* the head, *b* the trunk, *c* the tail, *d d* the spines thereof.

137. Cercaria Vermicularis. C. cylindrica annulata, proboscide exsertili, cauda spina duplici. Plate XXV. Fig. 40. Cy-

lindrical, annulated, with a projecting proboscis, two small spines for the tail.

It is a long, cylindrical, fleshy, mutable animalculum, divided into eight or nine rings, or folding plaits; the apex either obtuse or notched into two points; the hind-part rather acute, and terminating in two pellucid thorns, between which a swelling is sometimes perceived. It often projects a kind of cloven proboscis. It is found in water where duck-weed grows. *d d* the points of the fore-part, *e* the proboscis.

138. CERCARIA FORCIPATA. C. cylindrica, rugosa, proboscide forcipata exsertili, cauda bicuspidata.

Cylindrical cercaria, wrinkled, with a forked proboscis, which it can extend, or retract. It is found in marshy situations.

139. CERCARIA PLEURONECTES. C. orbicularis, cauda uniseta. Orbicular, the tail consisting of one bristle.

It is membranaceous, rather round, and white. In the fore-part are two blackish points; the hind-part is furnished with a slender sharp tail: it has orbicular intestines of different sizes in the middle; the largest of them are bright. Its motion is staggering or wavering; in swimming it keeps one edge of the lateral membrane upwards; the other folded down. It is found in water which has been kept for several months.

140. CERCARIA TRIPOS. C. subtriangularis, brachiis deflexis, cauda recta. Plate XXV. Fig. 38. Cercaria somewhat of a triangular form, two bent arms, and a straight tail.

The body is flat, pellucid, and triangular, having each angle of the base or fore-part bent down into two linear arms; the apex of the triangle is prolonged into a tail. It was found in salt water; *b*, the tail; *a a*, the bent arms.

141. Cercaria Cyclidium. C. ovalis, postice subemarginata, cauda extersili. This is oval, the hind-part somewhat notched, with a tail that it thrusts out at pleasure.

It has an oval, smooth, membranaceous, and pellucid body, with a black margin. The tail is not fixed to the edge, but concealed under it, and comes out from it at every motion, but in such a manner, as to project but little from the edge. There is also a kind of border to the hinder-part. Its intestines are very pellucid vesicles. It is frequently found in pure water.

142. Cercaria Tenax. C. membranacea, antice crassiuscula, truncata, cauda triplo breviore. Membranaceous, the fore-part rather thick, truncated, the tail three times shorter.

It is an oval, pellucid membrane, something larger than the monas lens. The fore-edge is thick and truncated, the hinder-part acute, and terminating in a short tail. It whirls about in various directions with great velocity.

143. Cercaria Discus. C. orbicularis, cauda curvata. A small orbicular animalculum, with a bent tail.

144. Cercaria Orbis. C. orbicularis, seta caudali duplici longissima. Orbicular cercaria, with a tail consisting of two very long bristles.

145. Cercaria Luna. C. orbicularis, cauda lineari duplici brevi. This is likewise orbicular, with two short spines for a tail; the fore-part hollowed, so as to form a kind of crescent.

XII. LEUCOPHRA.

Vermis inconspicuus, pellucidus, undique ciliatus. An invisible worm, pellucid, and everywhere ciliated.

146. Leucophra Conflictor. L. sphærica, subopaca, interancis mobilibus. Spherical opake leucophra, with moveable intestines.

This animalculum, or rather a heap of animalcula, is larger than most species of the vorticella; it is perfectly spherical, and semi-transparent, of a yellow colour, the edges dark. It rolls at intervals from right to left, but seldom removes from the spot where it is first found. It is filled with a number of the most minute molecules, which move as if they were in a violent conflict. In proportion to the number of these little combatants, which are accumulated either on one side or the other, the whole mass rolls either to the right or left, the molecules going in the same direction; it is then tranquil for a short time, but the conflict soon becomes more violent, and the sphere moves the contrary way in a spiral line. When the water begins to fail, they assume an oblong, oval, or cylindric figure; the hind-part of some being compressed into a triangular shape, and the transparent part escaping as it were from the intestines, which continue to move with the same violence till the water wholly fails, when the molecules are spread into a shapeless mass, which also soon vanishes, and the whole shoot into a form, having the appearance of crystals of sal ammoniac, as figured by Baker. Empl. for the Micros. Plate III. No. 3.

147. Leucophra Mamilla. L. sphærica, opaca, papilla exsertili. Sphærical opake leucophra, with a small papillary projection.

It is of a dark colour, and filled with globular molecules, the short hairs are curved inwards; and it occasionally projects and retracts a little white protuberance. It is not uncommon in marshy water.

148. Leucophra Virescens. L. cylindracea, opaca, postice crassiore. Cylindrical, opake leucophra, the lower part much thicker than the upper part.

This is a large, pear-shaped, greenish coloured animalculum, filled with opake molecules, and covered with short hairs; generally moving in a straight line. It is found in salt water.

149. Leucophra Viridis. L. ovalis opaca. Oval, opake leucophra.

Though at first sight it may be taken for a variety of the leucophra virescens; yet, on a further examination, it differs in many particulars; it cannot lengthen and shorten itself as that does. It is also much smaller. Sometimes it appears contracted in the middle, as if it were about to be divided in two.

150. Leucophra Bursata. L. viridis, ovalis, antice truncata. Green oval leucophra, the fore-part truncated.

This is similar in many respects to the foregoing leucophra; it is of a long oval shape, bulging in the middle, and filled with green molecules; every where ciliated, except at the apex, which is truncated, and shaped somewhat like a purse; the hairs larger, and sometimes collected in minute fasciculi. It is to be found in salt water.

151. Leucophra Posthuma. L. globularis, opaca, reticulo pellucenti. This is globular and opake, covered as it were with a pellucid net. It was found in fetid salt water.

152. Leucophra Aurea. L. ovalis, fulva, utraque extremitate æquali obtusus. Oval yellow leucophra, both ends of it equally obtuse.

The little hairs are discovered with difficulty; it has, in general, a vehement rotatory motion.

153. Leucophra Pertusa. L. ovalis, gelatinosa, apice truncato obtusa altera latera suffossa. Oval gelatinous leucophra, the apex obtusely truncated, one side sunk down.

Gelatinous, yellow, and small, without any molecules; the fore-part is truncated, the hind-part brought nearly to a point, with a kind of oval hole on one side. It was found in salt water.

154. Leucophra Fracta. L. elongata, sinuato angulata subdepressa. Leucophra long, with sinuated angles, rather flat.

The body is white, gelatinous, and granulated; it changes its form considerably.

155. Leucophra Dilatata. L. complanata, mutabilis, marginibus sinuatis. Smooth changeable leucophra, with a sinuated edge.

A gelatinous membrane, with a few grey molecules in the fore-part, and a great number in the hinder-part; it is sometimes dilated into a triangular form, with sinuated sides; at other times the shape is more irregular and oblong.

156. LEUCOPHRA SCINTILLANS. L. ovalis, teres, opaca, viridis. Oval, round, opake, green leucophra.

This animalculum is supposed to be ciliated, from its bright twinkling appearance, which probably arises from the motion it gives the water; it is nearly of an egg-shape. It was found in December among the lemna minor.

157. LEUCOPHRA VESICULIFERA. L. ovata, interaneis vesicularibus. Plate XXV. Fig. 41. Oval leucophra, with vesicular intestines.

An animalculum that is a kind of mean between the orbicular and oval, very pellucid, with a defined dark edge and inside, containing some very bright vesicles, or bladders. The middle frequently appears blue, and the vesicles seem as if set in a ground of that colour. Müller could never perceive any of those rays which are mentioned by Spallanzani; he confesses, however, that he once saw an individual like this environed with very small unequal shining rays.

158. LEUCOPHRA GLOBULIFERA. L. crystallina, ovato-oblonga. Crystalline leucophra, of an oblong oval shape.

The body is round, very pellucid, without molecular intestines, though at one edge it has three little pellucid globules; it is everywhere set with short hairs. It was found in a ditch where the lemna minor grew.

159. LEUCOPHRA PUSTULATA. L. ovato oblonga, postice oblique truncata. An oblong oval leucophra, the lower end obliquely truncated.

The body is white, gelatinous, and somewhat granulated; the lower part truncated, as if an oblique section were made in an egg near the bottom. It is covered with little erect shining hairs; at the lower extremities a few bright pustules may be discovered. It is found in marshy waters.

160. LEUCOPHRA TURBINATA. L. inverse conica, subopaca. Leucophra in shape like an inverted cone, and rather opake.

It is a round pellucid body, somewhat of the shape of an acorn, with a pellucid globule at the lower end. It was found in fetid salt water.

161. LEUCOPHRA ACUTA. L. ovata, teres, apice acuto, mutabilis, flaviscans. Oval leucophra, round, with the apex acute, mutable, yellow.

This is gelatinous, thick, and capable of assuming different shapes; the apex bright, and the rest of the body filled with innumerable little spherules; sometimes it draws itself up into an orbicular shape, at other times one edge is sinuated. It was found in salt water.

162. LEUCOPHRA NOTATA. L. ovata, teres, puncto marginali atro. Oval leucophra, round, with a black point at the edge.

163. LEUCOPHRA CANDIDA. L. hyalina, oblonga, altera extremitate attenuata, curvata. Leucophra of a talky appearance, oblong, one end smaller than the other, and bent back.

The body membranaceous, flat, very white, with no visible intestines, except two oval bodies which are with difficulty perceptible; the whole edge is ciliated. Found in an infusion with salt water.

164. LEUCOPHRA NODULATA. L. ovato-oblonga, depressa, serie nodulorum duplici. An oblong oval species of leucophra, with a double row of little nodules.

165. LEUCOPHRA SIGNATA. L. oblonga, subdepressa. Oblong, subdepressed leucophra, with a black margin, filled with little molecular globules, but more particularly distinguished by a curved line in the middle, something in the shape of a long S; one end of which is at times bent into the form of a small spiral. It is common in salt water, in the months of November and December.

166. LEUCOPHRA TRIGONA. L. crassa, obtusa, angulata, flava. Thick, obtuse, angular, and yellow leucophra.

A yellow, triangular mass, filled with unequal pellucid vesicles, one of which is much larger than the rest, and the edge surrounded with short fluctuating hairs. It was found in a marshy situation, but is not common.

167. LEUCOPHRA FLUIDA. L. subreniformis, ventricosa. Leucophra somewhat of a kidney shape, but ventricose.

168. LEUCOPHRA FLUXA. L. sinuata reniformis. Reniform, sinuated leucophra.

169. LEUCOPHRA ARMILLA. L. teres annularis. Round annular leucophra.

170. Leucophra Cornuta. L. inverse conica, viridis opaca. Plate XXV. Fig. 42 and 43. An inverted cone, green, opake.

It bears some resemblance to the vorticella polymorpha, No. 290, and the vorticella viridis, No. 283, and requires to be observed for some time before its peculiar characters can be ascertained; the body is composed of molecular vesicles, of a dark green colour; for the most part it is like an inverted cone, the fore-part being wide and truncated, with a little prominent horn or hook on both sides; the hind-part conical, everywhere ciliated, the hairs exceedingly minute; those in the fore-part are three times longer than the latter, and move in a circular direction. The hinder-part is pellucid, and sometimes terminates in two or three obtuse pellucid projections. The animalculum will at one moment appear oval, at another reniform, and ciliated at the fore-part; but at another time the hairs are concealed. When the water evaporates, it breaks or dissolves into molecular vesicles.. It is found late in the year in marshy grounds. Fig. 42, *a*, the hinder-part pointed; *g*, the cilia; *h h*, the sides. Fig. 43, *b*, the hinder-part obtuse; *e*, the fore-part; *f*, the horns.

171. Leucophra Heteroclita. L. cylindrica, antice obtusa, postice organo cristato duplici exsertili. Plate XXV. Fig. 44 and 45. Cylindrical leucophra, the fore-part obtuse, the hind-part furnished with a double-tufted organ, which it can thrust in or out at pleasure. To the naked eye it appears like a white point; in the microscope, as a cylindrical body, the fore-part obtusely round, the middle rather drawn in, the lower-part round, but much smaller than the upper-part. With a large magnifying power the whole body is found to be ciliated. The intestines are very visible. It is represented in Fig. 44 as it generally appears; *a*, the fore-part; *b*, the hind-part; *d*, the hooked intestines:

in Fig. 45, with the plumed organs; *i i*, the plumes; *g g*, the sheaths from which they are projected.

XIII. TRICHODA.

Vermis inconspicuus, pellucidus, crinitus. An invisible, pellucid, hairy worm.

172. **Trichoda Grandinella.** T. sphærica, pellucida, superne crinata. Spherical, pellucid, the upper-part hairy.

A most minute pellucid globule, the intestines scarce visible, the top of its surface furnished with several short bristles, which are not easily distinguished, as the animalculum has a power of extending and withdrawing them in an instant. It is found in pure water, and in infusions of vegetables.

173. **Trichoda Cometa.** T. sphærica, antice crinita, globulo appendente. Plate XXV. Fig. 46 and 47. Spherical, the fore-part hairy, with an appendant globule.

It is a pellucid globule, replete with bright intestines, the fore-part furnished with hairs, the hind-part with a pellucid appendant globule.

174. **Trichoda Granata.** T. sphærica, centro opaco peripheria crinita. Plate XXV. Fig. 48. Spherical, with an opake center, the periphery hairy.

It resembles the trichoda grandinella and trichoda cometa just described. It has a darkish nucleus in the center; its intestines are imperceptible; short hairs on the edge.

175. Trichoda Trochus. T. subpiriformis, pellucida, antice utrinque crinita. Trichoda somewhat of a pear-shape, pellucid, each side of the fore-part distinguished by a little bunch of hairs.

176. Trichoda Gyrinus. T. ovalis, teres, crystallina, antice crinita. Oval, round, crystalline trichoda, the front hairy.

It is one of the smallest among the trichoda, the body smooth and free from hairs, except at the fore-part, where there are a few. It is found in salt water.

177. Trichoda Sol. T. globularis, undique radiata. Plate XXV. Fig. 65 and 66. Globular trichoda, everywhere radiated.

This splendid creature constitutes a new genus, but as we know of no more of the same kind, it is introduced here. It is a little crystalline round corpuscle, the upper part convex; it is beset with innumerable diverging rays, which are longer than the diameter of the body, proceeding from every part of its surface: the inside is full of molecules. The body contracts and dilates, but the animalculum remains confined to the same spot. It was found with other animalcula in water which had been kept for three weeks. It propagates by division, and is represented as dividing in Fig. 66.

178. Trichoda Solaris. T. sphæroidea, peripheria crinita. Spheroidal trichoda, with a few hairs round the circumference.

The body is orbicular, bright, and filled with globular intestines; in many, a moveable substance, something like the letter S, may be discovered; it has hairs, seldom exceeding seventeen in number, which are disposed round the circumference, each of them nearly equal in length to the diameter of the animalculum.

179. Trichoda Bomba. T. mutabilis, antice pilis sparsis. Plate XXV. Fig. 67 and 68. Changeable, with a few hairs dispersed on the fore-part.

It is a thick animalculum, larger than the trichoda granata, No. 174, and of a yellow colour; pellucid, and replete with clay-like molecules; it is very lively, moving about with so much velocity, as to elude the sharpest sight and most pertinacious observer, and assuming various shapes, sometimes appearing spherical, sometimes reniform, or kidney-shaped, sometimes as at Fig. 67.

180. Trichoda Orbis. T. orbicularis, antice emarginata crinita. Orbicular, the fore-part notched and hairy.

It in some respects resembles the former, but is larger. It is composed of vesicular molecules; is of a spherical figure, smooth, pellucid, and a little notched in the fore-part. The notched part is filled with long hairs, but there are none on the rest of the body.

181. Trichoda Urnula. T. urceolaris, antice crinita. Plate XXV. Fig. 64. This trichoda is in the form of a water pitcher, the fore-part hairy.

A membranaceous pellucid animalculum, the hind-part obtuse, the middle something broader, the fore-part truncated, filled with vesicular black molecules; the hairs in the fore-part are even and short. Its motion is slow.

182. **Trichoda Diota.** T. urceolaris, antice angustata, ora apicis utrinque crinita. Pitcher-shaped trichoda, the fore-part smallest; the upper part of the mouth hairy at the edges.

The body is of a clay-colour, and filled with molecules; the upper-part cylindrical and truncated, the lower part spherical.

183. **Trichoda Horrida.** T. subconica antice latiuscula, truncata postice obtusa, setis radiantibus cincta. Trichoda somewhat of a conical form, the fore-part rather broad and truncated, the lower-part obtuse, and the whole covered with radiating bristles.

184. **Trichoda Urinarium.** T. ovata, rostro brevissimo crinito. Egg-shaped, with a short hairy beak.

185. **Trichoda Semiluna.** T. Semiorbicularis, antice subtus crinita. Semiorbicular, the fore-part hairy underneath.

A smooth pellucid animalculum, and shaped like a crescent.

186. **Trichoda Trigona.** T. convexa, antice ciliata, postice erosa. Plate XXV. Fig. 63. Convex, the fore-part ciliated, the hind-part as it were gnawed off.

This is a triangular animalculum, a little convex on both sides, the fore-part acute, the hind-part a little broader. A notch is seen at *a*, in the hind-part; *b*, the ciliated fore-part; *c*, a tube.

187. **Trichoda Tinea.** T. clavata, antice crinita, postice grossa. This is clubbed, the fore-part hairy, the hind-part large.

This animalculum is round, not very pellucid, narrow in the fore-part, and resembling an inverted club; it is also like some of the tinea.

188. Trichoda Nigra. T. ovalis compressa, antice latior crinita. Oval, compressed trichoda, the fore-part broader and hairy.

The body is opake, when in violent motion it is black, when at rest one side is pellucid; the middle of the fore-part is furnished with little moveable hairs. It was found in salt water.

189. Trichoda Pubes. T. ovato-oblonga gibba, antice depressa. Plate XXV. Fig. 61 and 62. An egg-shaped oblong bunch, the fore-part depressed.

An animalculum with a bunch above the hind-part, marked with black spots, depressed towards the top, a little folded, and somewhat convex underneath; at least this is its appearance when in motion. Very minute hairs occupy the apex, but they are seldom visible till the creature is in the agonies of death, when it extends and moves them vehemently from an arched chink at top, apparently endeavouring to draw in the last drop of water. It is found in water where the duck-weed grows, chiefly in December. *b*, the hairs; *c*, the black globules; *a*, the projecting bunch.

190. Trichoda Floccus. T. membranacea, antice subconica, papillis tribus crinitis. Membranaceous trichoda, the fore-part rather conical; three small papillæ project from the base, which are set with hairs.

191. Trichoda Sinuata. T. oblonga depressa, altero margine sinuato crinita, postice obtusa. An oblong depressed trichoda, one margin hollow and hairy, the lower end obtuse.

The intestines seem to be more lymphatic than molecular; it is of a yellow colour, and the hollow edge ciliated. It was found in river water.

192. Trichoda Præceps. T. membranacea, sublunata, medio protuberante, extorsum crinita. Membranaceous trichoda, somewhat lunated, protuberant in the middle, a row of hairs on the outside.

A pellucid membrane, the fore-part formed into a kind of neck, one edge rising into a protuberance like a hump-back, the other edge convex.

193. Trichoda Proteus. T. ovalis, postice obtusa, collo elongata retractile, apice crinito. Plate XXV. Fig. 56, 57, 58, 59, 60. Oval trichoda, the lower-part obtuse, with a long neck, which it has a power of contracting or extending.

Baker in his Employment for the Microscope, p. 260---266, dignifies this animalculum with the name of proteus, on account of its assuming a great number of different shapes, so as scarce to be known for the same animal in its various transformations; and, indeed, unless it be carefully watched while passing from one shape to another, it will often become suddenly invisible.

When water, wherein any kinds of vegetables have been infused, or animals preserved, has stood quietly for some days or weeks in a glass or other vessel, a slimy substance will be collected about the sides, some of which being taken up with the point of a penknife, placed on a slip of glass in a drop of water, and viewed through the microscope, will be found to harbour several kinds of little animals that are seldom seen swimming about at large. The insect we are treating of is one of these, and was discovered in such slime-like matter taken from the side of a glass jar, in which small fishes, water-snails, and other creatures had been kept. Its body in substance and colour resembled that of a snail; the shape thereof was somewhat elliptical, but pointed at one end, whilst from the other proceeded a long, slender, and finely proportioned neck, terminated with a head, of a size perfectly suitable to the other parts of the animal.

194. Trichoda Versatilis. T. oblonga, postice acuminata, collo retractili, infra apicem crinito. Oblong trichoda, the hind-part acute, with a neck that it can extend or contract at pleasure, the under-part of the extremity of the neck hairy.

It resembles in some measure the trichoda proteus just described, but the neck is shorter, the apex less spherical, and the hinder part of the trunk acute. It lives in the sea.

195. Trichoda Gibba. T. oblonga, dorso gibbera, ventre excavata, antice ciliata, extremitatibus obtusis. Plate XXV. Fig. 55. Oblong trichoda, with a bunch on the back, the belly hollowed out, the fore-part ciliated, both ends obtuse.

The body is pellucid, the upper part swelled out, within it are numerous obscure molecules, and three large globules, the ends rather incline downwards; when the water begins to fail, a few minute hairs may be discovered about the head and at the abdomen; the body then becomes striated longitudinally.

196. TRICHODA FOETA. T. oblonga, dorso protuberante, antice ciliata, extremitatibus obtusis. Oblong trichoda, with the back protuberant, the fore-part ciliated, both ends obtuse.

The body is round and long, and when extended somewhat resembles a rolling-pin in shape; both ends are obtuse, and one shorter than the other; it can draw in the ends and swell out the sides, so as to appear almost spherical.

197. TRICHODA PATENS. T. elongata, teres, antice foveata, foveæ marginibus ciliata. Plate XXV. Fig. 54. This trichoda is long, round, in the fore-part it has a long hole, the edges of which are ciliated.

It is a long cylindrical animalculum, filled with molecules; the fore-part bright and clear, with a long opening, *a*, near the top, which tapers to a point, and is beset with hairs. It is found of different lengths in salt water.

198. TRICHODA PATULA. T. ventricosa, subovata, antice canaliculata, apice et caniculo crinito. Big-bellied, rather inclining towards an oval figure, with a small tube at the fore-part, the upper-end of which is covered with hairs.

199. TRICHODA FOVEATA. T. oblonga, latiuscula, antice corniculis micantibus, postice mutica. Oblong trichoda, rather broad, three little horns on the fore-part, the hinder-part beardless.

200. TRICHODA STRIATA. T. oblonga, altero margine cursum, sinuata et ciliata, utraque extremitate obtusa. Oblong trichoda, one edge rather curved, and also furnished with a row of hairs; both extremities obtuse.

It is a splendid animalculum, of a fox colour, and at first sight might be taken for a kolpoda. The body is oblong, the lower end somewhat larger than the other, the body becoming smaller at that part where the hairs commence; it has a set of streaks which run from one end to the other, and at the abdomen a double row of little eggs, lying in a transverse direction. It was found in river water in December.

201. TRICHODA UVULA. T. planiuscula elongata, æqualis, antice crinita. Plate XXV. Fig. 53. Rather flat and long, of an equal size throughout, the fore-part hairy.

This animalculum is six times longer than broad, round, flexuous, and of an equal size; the greater part filled with obscure molecules; the fore-part, *a*, rather empty, distinguished by an alimentary canal, and lucid globules near the middle, *c*; short hairs occupy the margin of the fore-part, some are dispersed into a chink near the canal. It is found in an infusion of hay and other vegetables.

202. TRICHODA AURANTIA. T. subsinuata, ovata, antice patula, apice ad medium crinita. Trichoda somewhat sinuated, oval, the fore-part broad, the apex hairy to the middle.

It is of a gold colour, pellucid, and filled with a variety of vesicles.

203. TRICHODA IGNITA. T. ovata, apice acuminata, subtus fulcata, fulco crinito. Oval trichoda, the apex rather acute, the under-part furrowed, the furrows hairy.

It is of a fine purple gold colour, somewhat of a reddish cast, pellucid, splendid, with a number of globules of different sizes;

the fore-part small, the hind-part obtuse, and having a very large opening, which appears to run through the body.

204. TRICHODA PRISMA. T. ovata, subtus convexa, supra in carinam compressa, antice angustior. Oval trichoda, the under part convex, the upper part compressed into a kind of keel, the fore-part small.

It is very small, and so transparent that it cannot easily be delineated; its form is singular, and no hairs can be observed.

205. TRICHODA FORCEPS. T. ovalis, antice forcipata, cruribus inæqualibus crinitis. Oval trichoda, with a pair of forceps at the fore-part, with unequal hairy legs.

A large animalculum, somewhat depressed, of a pellucid yellow colour, and filled with molecules; in the lower part there is a black opake globule, the fore-part is divided into long lobes, one of which is falciform and acute, the other dilated, and obliquely truncated; both the apex and the edge of these are furnished with hairs of different lengths; it can open, shut, or cross these lobes at pleasure; by this motion of them it appears to suck in the water. It was found about the winter solstice in water, covered with lemnæ.

206. TRICHODA FORFEX. T. ventrosa, antice forcipata, postice papilla duplici instructa. Round and prominent trichoda, the fore-part formed into a kind of forceps, and two small protuberances.

One of the forceps of this animalculum is twice as long as the other, hooked, and ciliated. It was found in river water.

207. TRICHODA INDEX. T. obovata, margine antico subtus crinito, alteroque apicis in degitum producto. Obovated trichoda, the under part of the front of the margin hairy, the apex is formed by the fore-part, projecting like the finger on a direction-post. It was found in salt water.

208. TRICHODA S. T. striata, antice ciliata, extremitatibus in oppositum flexis. Striated trichoda, the fore part ciliated, the extremities bent in opposite directions.

A yellow animalculum, formed of two pellucid membranes, striated longitudinally; the lower end is obliquely truncated.

209. TRICHODA NAVICULA. T. triquetra, antice truncata ciliata, postice acuta prominula. Three-cornered trichoda, the fore-part truncated and ciliated, the hind-part acute, and bent a little upwards.

It has a crystalline appearance, rather broad, the under side towards the hinder-part convex, the fore-part broad, the apex nearly a straight line, the bent end pointed and turned upwards; and a kind of longitudinal keel running down the middle.

210. TRICHODA SUCCISA. T. ovalis depressa, margine crinito, postice in crura inæqualia erosa. Flattened oval trichoda, the edge hairy, the hinder part hollowed out so as to form two unequal legs.

211. TRICHODA SULCATA. T. ovato-ventricosa, apice acuminata, fulco ventrali, utrinque crinito. Ovated ventricose trichoda, the apex acute, with a furrow at the abdomen, and both sides of it ciliated.

212. TRICHODA ANAS. T. elongata, apice colli subtus crinito. Plate XXV. Fig. 49. Long, the apex of the neck underneath hairy.

A smooth animalculum, five times broader than it is long, filled with darkish molecules; it has a bright neck, *b c*; under the top of the neck at *d* a few unequal hairs are perceptible. Its motions are languid. It is found in pure water.

213. TRICHODA BARBATA. T. elongata, teres, subtus ab apice ad medium crinita. Long trichoda, round, the under part from the apex to the middle hairy.

This animalculum is round, somewhat linear, with both ends obtuse; the fore-part narrower, forming as it were a kind of neck, under which is a row of fluctuating hairs. The trunk is full of grey molecules.

214. TRICHODA FARCIMEN. T. elongata, torulosa, setulis cincta. Plate XXV. Fig. 50 and 52. Long and thick trichoda, surrounded with small bristles.

The body is long, round, pellucid, and covered with very minute hairs; it has also a great number of mucid vesicles about the body.

215. TRICHODA CRINITA. T. elongata, teres, undique ciliata, subtus ad medium usque crinita. Long trichoda, round, everywhere ciliated on the upper part, and the under part likewise hairy as far as the middle.

216. TRICHODA ANGULUS. T. angulata, apice crinita. Angular, the apex hairy.

This animalculum is long, more convex than most of the genus, divided by a kind of articulation into two parts equal in breadth, but of different lengths, the fore-part being shorter than the hind-part; the apex furnished with short waving hair, indistinct molecules withinside, no hair on the hind-part.

217. Trichoda Linter. T. ovato oblonga, utraque extremitate prominula. Plate XXV. Fig. 51. The shape of an oblong egg, with prominences at both extremities.

Both extremities of the body are raised, so that the bottom becomes convex, and the upper part depressed like a boat. It varies in shape at different ages, and sometimes has a rotatory motion. It is found in an infusion of old grass.

218. Trichoda Paxillus. T. linearis depressa, antice truncata crinitaque, postice obtusa. Linear flat trichoda, the fore-part truncated and hairy, the hinder-part obtuse.

A long animalculum, full of grey molecules; the fore-part rather smaller than the hind-part, and furnished with minute hairs. It was found in salt water.

219. Trichoda Vermicularis. T. elongata, cylindracea, collo brevi, apice crinito. Plate XXVII. Fig. 1. Long cylindrical trichoda, with a short neck, the apex hairy.

Gelatinous, the fore-part pellucid, the hind-part full of molecules. It was found in river water. It is represented in different appearances in the figure; *a*, the neck; *b*, the hairs; *c*, a little vesicle in the hinder-part.

220. Trichoda Melitœa. T. oblonga, ciliata, colli dilatabilis, apice globoso, pilifero. Plate XXVII. Fig. 3. Oblong ciliated trichoda, with a dilatable neck, the apex globular, and surrounded with hairs, the edge is ciliated, and a kind of peristaltic motion perceivable in it. It is found in salt water, though but very rarely. *a*, the neck; *b*, the globular apex; *c*, the body ciliated.

221. Trichoda Fimbriata. T. obovata, apice crinita, postice oblique truncata, serrata. Plate XXVII. Fig. 2. Obovated trichoda, the apex hairy, the hinder-part obliquely truncated and serrated.

222. Trichoda Camelus. T. antice crinita, crassiuscula medio utrinque emarginata. Thick, and the fore-part hairy, with notches on the middle and each side.

The fore-part of the body is ventricose; the back divided by an incision in the middle into two tubercles; the lower part of the belly sinuated; its motions are languid. It is found, though not often, in vegetable infusions.

223. Trichoda Augur. T. oblonga, vertice truncata, antico corporis margine, superne pedata, inferne setosa. The body is oblong, depressed, pellucid, and filled with molecules; the vertex truncated, the fore-part forming a small beak; underneath are three feet; beyond these, towards the hinder-part, it is furnished with bristles.

224. Trichoda Pupa. T. cucullata, fronte crinita, cauda inflexa, This trichoda is hooded, the front hairy, the tail inflected.

The body is rather round, pellucid and consists of three parts; the head, which is broad, appears to be hooded, the top being furnished with very small hairs; a transparent vesicle occupies the lower region of the head; and over the breast from the base of the head is suspended a production resembling the sheath of the feet in the pupa of the gnat.

225. Trichoda Lunaris. T. arcuata, teres, apice crinita, cirro, caudali inflexo. Arched trichoda, round, the apex hairy, the tail bent.

This animalculum is round and crystalline; the hind-part somewhat smaller than the fore-part; the intestines are with difficulty distinguished. The edge of the back and the part near the tail are bright and clear. It bends itself into the form of an arch.

226. Trichoda Bilunis. T. arcuata, depressa, apice crinita, cauda biseta. Arched flattened trichoda, the apex hairy, and two little bristles proceeding from the tail.

227. Trichoda Rattus. T. oblonga, carinata, antice crinita, postice seta longissima. Plate XXVII. Fig. 4. Oblong trichoda, with a kind of keel; the fore-part hairy, and a very long bristle proceeding from the hinder-part. *a*, the mouth; *b*, a small knob at the bending of the tail; *c*, the tail.

228. Trichoda Tigris. T. subcylindrica, elongata, apice crinita, cauda setis duabus longis. This trichoda is long, and somewhat cylindrical, the apex hairy, the tail divided into two long bristles.

It resembles the former, but differs in the form of the tail, which consists of two bristles, and likewise in having a kind of incision in the body, at some little distance from the apex.

229. Trichoda Pocillum. T. oblonga, antice truncata, crinita, cauda articulata, biseta. Plate XXVII. Fig. 5 and 6. Oblong trichoda, the fore-part truncated and hairy, the tail articulated, and divided into two bristles.

The body is cylindrical, pellucid, muscular, and capable of being folded up; it appears double; the interior part is full of molecules, with an orbicular muscular appendage which it can open and shut, and this forms the mouth. The external part is membranaceous, pellucid, dilated, and marked with transverse streaks; the animalculum can protrude or withdraw the orbicular membrane at pleasure. Some have four articulations in the tail, others five; and it has two pair of bristles, or projecting parts, one placed at the second joint, the other at the last. It has been frequently found in marshes. In Fig. 6 it is seen with the mouth open; in Fig. 5, with it shut. *a a*, the jaws; *b b*, the first bristles; *c c*, the second pair; *d*, the spine at the tail.

230. Trichoda Clavus. T. antice rotundata, crinita, postice acuminato-caudata. The fore-part round and hairy, the hind-part furnished with a sharp tail. This animalculum has a considerable resemblance to a common nail.

231. Trichoda Cornuta. T. supra convexa, subtus plana, apice crinita, cauda lineari simplici. Trichoda with the upper part convex, the under side plain, the apex hairy, the tail linear and simple.

To these characters we may add, that the body is membranaceous, elliptical, closely filled with molecules; the fore-part lunated, the hinder-part round, and terminating in a tail as long as the body.

232. TRICHODA GALLINA. T. elongata, antice sinuata, fronte crinita, cauda pilosa. Long trichoda, the fore-part sinuated, the front hairy, the tail formed of small hairs.

It is of a grey colour, flat, with seven large molecules and globules within it, the front obtuse, and set with hairs; the hinder-part terminating in a tail formed of very fine hairs. It was found in river water.

233. TRICHODA MUSCULUS. T. ovalis, antice crinita, postice subtus caudata. Plate XXVII. Fig. 7. Egg-shaped, the fore-part hairy, the tail projecting from the under part.

A smooth egg-shaped animalculum, with a double margin or line drawn underneath it; the fore-part narrow, and furnished with short hairs, which are continually playing about; underneath the hind-part is a small tail. It has molecular intestines, and moves slowly. It is found in infusions of hay which have been kept for some months. *a*, the head; *b*, the tail.

234. TRICHODA DELPHIS. T. clavata, fronte crinita, cauda acuminata, subreflexa. Clubbed trichoda, the front hairy, the tail small and rather bent upwards.

It is smooth and pellucid, having the fore-part dilated into a semicircle, gradually decreasing in breadth towards the tail; the front is hairy, the hairs standing as rays from the semicircular edge; one of these edges is sometimes contracted. It is to be found in river water.

235. Trichoda Delphinus. T. oblonga, antice crinita, postice cauda reflexa truncata. Plate XXVII. Fig. 8. Oblong, the fore-part hairy; in the hind-part is the tail, which is turned back, the end of it truncated.

A pellucid, smooth, egg-shaped animalculum; the hind-part terminating in a tail about half the length of the body, dilated at the upper end, truncated, and always bent upwards.

In the inside are vesicles of an unequal size; it moves sometimes on its belly, sometimes on its side; the tail seldom varies its position. It was found in hay which had been infused for some months. *a*, the hairs on the fore-part; *b*, the tail.

236. Trichoda Clava. T. clavata, fronte crinita, cauda reflexili. Club trichoda, the fore-part hairy, the tail turned back.

The fore-part is thick, the hind-part narrow; both extremities obtuse, pellucid, and replete with molecules; the hind-part bent down towards the middle.

237. Trichoda Cuniculus. T. oblonga, antice crinita, postice subacuminata. Oblong, the fore-part hairy, the hind-part rather acute, filled with molecules and black vesicles.

238. Trichoda Felis. T. curvata, grossa, antice angustior, postice in caudam attenuata, subtus longitudinaliter crinita. Plate XXVII. Fig. 9. Curved trichoda, large, the fore-part small, the hinder-part gradually diminishing into a tail; the under part

set longitudinally with hairs. *a*, the head; *b*, the tail; *c*, the hairs.

239. TRICHODA PISCIS. T. oblongata, antice crinita, postice in caudam exquisitam attenuata. Plate XXVII. Fig. 13 and 14. Oblong, the fore-part is hairy, the hind-part terminating in a very slender tail. It is smooth, pellucid, much longer than broad, but of nearly an equal breadth throughout, and filled with yellow molecules; the fore-part obtuse, the hind-part exquisitely slender and transparent; the upper side is convex. *a*, the fore-part; *b*, the tail.

340. TRICHODA LARUS. T. elongata, teres, crinita, cuspidi caudali duplici. Long, round trichoda, surrounded with hairs, the tail divided into two points. See Zoologia Danica.

241. TRICHODA LONGICAUDA. T. cylindracea, antice truncata et crinita, cauda elongata, biarticulata et biseta. Plate XXVII. Fig. 10. Cylindrical trichoda, the fore-part truncated and surrounded with hairs, the tail long, furnished with two bristles, and having two joints. *a*, the hairs at the mouth; *d*, the oesophagus; *e*, the articulation of the tail; *f*, the bristles.

242. TRICHODA FIXA. T. sphærica, peripheria crinita, pedicello solitario. Spherical trichoda; this has the circumference set with hairs, and a little solitary pedicle projecting from the body.

243. TRICHODA INQUILINUS. T. vaginata, folliculo cylindrico hyalino, pedicello intra folliculum retortili. Sheathed trichoda, in a cylindrical transparent bag, having a little pedicle bent back within the bag. See Zool. Dan. prodr. addend. p. 281.

244. Trichoda Ingenita. T. vaginata, folliculo depressa, basi latiore sessilis. Sheathed trichoda, the bag depressed, the base broadest.

The animalculum that is contained in this sheath is funnel-shaped, with one or more hairs, proceeding from each side of the mouth of the funnel. It can extend or contract itself freely in the bag, fixing its tail to the base, without touching the sides. It was found in salt water.

245. Trichoda Innata. T. vaginata, folliculo cylindrico, pedicello extra folliculum. Plate XXVII. Fig. 11. Trichoda sheathed in a cylindrical bag, with a pedicle passing through and projecting beyond it. These characters distinguish it sufficiently from the preceding one. *b*, the animalculum in the sheath; *d*, the tail.

246. Trichoda Transfuga. T. latiuscula, antice crinita, postice setosa, altero latere sinuata, altero mucronata. Broad trichoda, the fore-part hairy, the hinder-part full of bristles; one side sinuated, and the other pointed. See Zool. Dan. prod. addend. p. 281.

247. Trichoda Ciliata. T. ventricosa, postice crinibus pectinata. Ventricose, the hinder-part covered with hair. See Zool. Dan. Icon. Tab. 73, Fig. 13, 15.

248. Trichoda Bulla. T. membranacea, lateribus inflexis, antice et postice crinita. Membranaceous trichoda, the sides bent inwards; the fore and hind-part are both furnished with hairs.

249. TRICHODA PELLIONELLA. T. cylindracea, antice crinita, postice setosa. Cylindrical, the fore-part hairy, the hinder-part furnished with bristles.

This trichoda is rather thick in the middle, and pellucid, with a few molecules here and there, the sides obtuse, the fore-part ciliated with very fine hairs, the hind part terminating in a kind of bristles.

250. TRICHODA CYLLIDIUM. T. ovata, apice hiante, basique crinita. Plate XXVII. Fig. 15. Egg-shaped, the apex gaping, the base hairy.

Pellucid, the hinder extremity filled with globules of various sizes, the fore-part narrower, without any appearance of an external organ. It vacillates upon the edge, commonly advancing on its flat side, and continually drawing in water; it then gapes, and opens into a very acute angle, almost to the middle of the body; but this is done so instantaneously, that it is scarcely perceptible. *a*, the mouth; *b*, the hairs or bristles, which it extends when nearly expiring.

251. TRICHODA CURSOR. T. ovata, antice crinita, postice duplici pilorum strictorum et curvorum fasciculo. Oval trichoda, the fore-part hairy, and the hinder-part also furnished with some straight and curved hairs in two fascicles.

The body is flat and filled with molecules; in the fore-part is an oblong empty space, into which we may sometimes see the water sucked in.

252. TRICHODA PULEX. T. ovata, antice incisa, fronte et basi crinita. Plate XXVII. Fig. 12. Egg-shaped, with an incision in

the fore-part; the front and base hairy. *a*, the anterior part; *b*, the posterior part; *c*, the incision.

253. Trichoda Lynceus. T. subquadrata, rostro adunco, ore crinito. Plate XXVII. Fig. 16. Nearly square, with a crooked beak, the mouth hairy.

At first sight it does not seem very dissimilar to some of the monoculi. The body is membranaceous, and appears compressed, stretched out into a beak above, the lower part truncated; under the beak is a little bundle of hairs; the lower edge bends in and out, and is surrounded with a few bristles. The intestines are beautifully visible, and a small bent tube goes from the mouth to them in the middle of the body; these, as well as the tube, are in frequent agitation. There is likewise another tube between the fore and hind edge filled with a blue liquor. *a*, the beak; *b*, the mouth; *c*, the base.

254. Trichoda Erosa. T. orbicularis, antice emarginata, altero latere crinita, postice setosa. Orbicular trichoda, the fore-part notched; one side furnished with hairs, the hinder-part with bristles.

255. Trichoda Rostrata. T. depressa, mutabilis, flavescens, ciliis longis setisque pediformibus. Depressed trichoda, mutable, yellow, with long ciliated hairs, and feet tapering to a point.

The figure of the body is generally triangular; the apex formed into an obtuse beak, which the animalculum sometimes draws in, so that it appears quite round; the feet are four in number, one of them is longer than the rest; both feet and hairs are within the margin. It is found in water where duck-weed has been kept.

256. Trichoda Lagena. T. teres, ventricosa, rostro producta, postice setosa. Round ventricose trichoda, with a long neck, and the lower end set with bristles.

257. Trichoda Charon. T. cymbiformis fulcata, antice et postice crinita. Plate XXVII. Fig. 17 and 18. Boat-shaped trichoda with furrows, the fore and hind-parts both hairy.

The body is oval; it resembles a boat as well in its motion as shape; the upper part is hollowed, the under part furrowed and convex; the stern round, with several hairs proceeding from it. It was found in salt water. Fig. 17, *a*, the head; *b*, the tail. Fig. 18, *d*, a pellucid bubble that is sometimes to be perceived.

258. Trichoda Cimex. T. ovalis, marginibus lucidis, antice et postice crinita. Plate XXVII. Fig. 19. Oval trichoda, with a lucid margin, both the fore and hind-part hairy.

It is about the size of the trichoda lynceus, No. 253, has an oval body, with a convex back, flat belly, and an incision in the margin of the fore-part, the edges of which incision appear to be in motion. Its intestines are pellucid and ill-defined. When it meets with any obstacles in swimming, it makes use of four small bristles, which are fixed to the under side, as feet. *a*, the hairs in the fore-part; *b*, the bristles at the hind-part; *d*, the back; *e*, two small projecting hairs; *f*, the substance to which the animalculum has affixed itself.

259. Trichoda Cicada. T. ovalis, marginibus obscuris, antice et subtus crinita, postice mutica. Oval trichoda, with an obscure margin, the fore-part covered with hairs on the under side, and the hinder-part beardless.

It does not differ considerably from the preceding, though Müller has pointed out some shades by which they may be discriminated.

XIV. KERONA.

Vermis inconspicuus corniculatus. An invisible worm with horns.

260. **Kerona Rastellum.** K. orbicularis membranacea, nasuta, corniculis in tota pagina. Membranaceous, orbicular kerona, with one projecting point, the upper surface covered with small horns. There are three rows of horns on the back, which nearly occupy the whole of it. It was found in river water.

261. **Kerona Lyncaster.** K. subquadrata, rostro obtuso, disco corniculis micantibus. This species of kerona is rather square, and its disc furnished with shining horns. See Zool. Dan. prod. add. p. 281.

262. **Kerona Histrio.** K. oblonga, antice punctis mucronatis nigris, postice pinnulis longitudinalibus instructa. Plate XXVII. Fig. 20.

It is an oblong membrane, pellucid, with four or five black points in the fore-part, which are continually changing their situation, thick set with small globules in the middle, among which four larger ones are sometimes perceived, these are probably eggs; in the middle space of the hind-part are some longitudinal strokes resembling bristles, which, however, do not seem to project beyond the body. *b*, the horns; *c*, some hairs; *d*, a solitary horn; *e*, a large globule; *f*, some bristles.

263. Kerona Cypris. K. obovata, versus postica superne sinuata, antice crinita. Plate XXVII. Fig. 21. Egg-shaped, towards the hind-part sinuated, the fore-part hairy.

This animalculum is compressed, and somewhat of a pear-shape; the fore-part broad and blunt; the front is furnished with short hairs or little vibrating points inserted under the edge *a*, shorter in the hind-part *e*, partly extended straight, and partly bent down, having a retrogade motion. It is found in water which is covered with lemna.

264. Kerona Haustrum. K. orbiculata, corniculis mediis, antice membranacea ciliata, postice setosa. Orbicular kerona, with the horns in the middle, the fore-part membranaceous and ciliated, and several bristles at the hinder-part.

265. Kerona Haustellum. Differs from the preceding only in having the hinder-part without any bristles.

266. Kerona Patella. K. univalvis, antice emarginata corniculata, postice setis flexilibus pendulis. Plate XXVII. Fig. 22 and 23. Kerona with a univalved shell, orbicular, crystalline; the fore-part somewhat notched; the fleshy body lies in the middle of the shell; above and below are hairs or horns of different lengths jutting out beyond the shell, and acting instead of feet and oars, some of which are bent; the superior ones constitute a double transverse row. *a*, the fore-part; *b*, the horns; *d*, a lunated figure in the shell; *c*, a pulpous body; *f*, bristles at the hinder-part.

267. Kerona Vannus. K. ovalis subdepressa, margine altero flexo, opposito ciliato, corniculis anticis, setisque posticis. Oval and rather flat kerona, with one edge bent, the opposite one

ciliated, the front furnished with horns, and the hind-part with bristles.

268. Kerona Pullaster. K. ovata, antice sinuata, fronte crestata, basi crinita. Plate XXVII. Fig. 24 and 25. Oval, the fore-part sinuated, a crest on the front, the base hairy.

It agrees in many respects with the trichoda pulex, No. 252; but the upper part is pellucid, without any black molecules; the front truncated, the whole surface of the head covered with hair, and the fore-part sinuous. *a*, the horns; *b*, the hairs at the hinder-part; *c*, the cilia of the front.

269. Kerona Mytillus. K. subclavata, utraque extremitate latiori, hyalina ciliata. Plate XXVII. Fig. 29. Rather clubbed, broad at both extremities, clear and ciliated.

A large animalculum, the fore and hind-part rounded, very pellucid and white, dark in the middle, with black intestines, intermixed with a few pellucid vesicles; both extremities appear as if composed of two thin plates. The fore-part is ciliated, the hairs short, lying within the margin; it is also ornamented with two small horns, erected from an obscure mass; with these it agitates the water, forming a little whirlpool. The hind-part is likewise ciliated, and furnished with two bristles, extending beyond the margin. *a*, the horns; *b*, the fore-part ciliated; *c*, the hind-part; *d*, projecting bristles.

270. Kerona Lepus. K. ovata, apice crinito, basi setosa. Egg-shaped, the fore-part hairy, the base furnished with bristles.

The body is egg-shaped, compressed, pellucid, and crowned with short waving hairs, the base terminating with bristles.

271. Kerona Silurus. K. oblonga, antice et postice crinita, dorso ciliato. Oblong, the fore and hind-part hairy, the back ciliated.

An oval smooth animalculum, somewhat crooked and opake, with a fascicle of vibrating hair on the fore-part; it has a sharp tail, furnished with unequal rows of moveable hairs, producing a rotatory motion; in the inside are some partly lucid, and partly opake points. The figure varies from oval to oblong, the filaments of the conferva are often entangled in the tail.

272. Kerona Calvitium. K. latiuscula, oblonga, antice corniculis micantibus. Rather broad, oblong, with glittering horns on the fore-part.

The body is rather broad and flat, both sides obtuse, filled with black molecules, and there is a dark spot near the hinder-part, where there are likewise a few short bristles. The interjacent vesicles are pellucid; no hairs on the fore-part, but instead thereof two little moveable horns, and from three to five moveable black points. It is found in the infusions of vegetables.

273. Kerona Pustulata. K. ovalis convexa, postice altero margine sinuata, utraque extremitate crinita, corniculisque anticis. Oval, convex, kerona, one edge of the hinder-part sinuated, both ends set with hairs, and some horns placed on the fore-part. This animalculum was found in salt water.

XV. HIMANTOPUS.

Vermis inconspicuus, pellucidus, cirratus. A pellucid, invisible, cirrated* worm.

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* That is, furnished with a tuft or lock of hair.

274. HIMANTOPUS ACARUS. H. ventrosus, postice cirratus, antice acuminatus. Plate XXVII. Fig. 27. Round and prominent himantopus, the hinder-part cirrated, the fore-part sharp.

It is a lively, conical, ventricose animalculum, full of black molecules, the fore-part bright and transparent. The apex, which has long hairs on the under part set like rays, is more or less attenuated, at the will of the little creature; four locks of long and crooked hair, or feet, proceed from the belly; and it is continually moving these and the other hairs in various directions. It is found, though seldom, where the lemna grows. *a*, the apex; *b*, the ciliated part; *c*, the feet.

275. HIMANTOPUS LUDIO. H. cirrata, supra crinita, cauda sursum extensa. Plate XXVII. Fig. 26. Curled himantopus, the upper part hairy, the tail extended upwards.

This is a lively and diverting animalculum, smooth, pellucid, full of small points, the fore-part clubbed and a little bent, the hind-part narrow; the base obliquely truncated, and terminating in a tail stretched out transversely. The top of the head, and the middle of the back *b*, are furnished with long vibrating hairs; three moveable and flexible curls *a*, are suspended from the side of the head, at a distance from each other. When the animalculum is at rest, its tail is curled; but when in motion, it is drawn tight, and extended upwards, frequently appearing as if it were cleft, as at *f*.

276. HIMANTOPUS SANNIO. H. incurvata, supra ciliata, infra crinita. Crooked himantopus, the upper part ciliated, the under part hairy.

This very much resembles the himantopus ludio, the cilia are longer than the hairs, and are continually vibrating; it has two moveable curls hanging on the side of the head. Is found, though seldom, in water where the lemna grows.

277. HIMANTOPUS VOLUTATOR. H. lunatus, antice cirratus. Lunated himantopus, the fore-part hairy.

A very lively animalculum, often turning round in a circular direction. Its shape is that of a crescent, with some crystalline points; the convex part is furnished with a row of hairs, which are longest towards the tail, and underneath are four feet.

278. HIMANTOPUS LARVA. H. elongatus, medio cirratus. Long himantopus, cirrated in the middle.

The body is rather depressed and long; the hinder-parts acute, and generally curved, pellucid, and filled with granular molecules. Its motion resembles that of the himantopus ludio, No. 275, but its figure, and the situation of its parts are different.

279. HIMANTOPUS CHARON. H. cymbæformis fulcata, in fovea ventrali cirrata. Boat-shaped furrowed himantopus, the hollow part of the belly cirrated.

An oval pellucid membrane, the fore-part hairy, furrowed longitudinally, each side bent up, so as to form an intermediate hollow place, or belly, filled with grey molecules; beneath the middle it has several bent diverging rows of hairs; no hairs on the hinder-part. It is found in sea water, but rarely.

280. HIMANTOPUS CORONA. H. semiorbiculata, depressa, in utraque pagina cirrata. Semiorbicular himantopus, flattened, both sides cirrated.

A membranaceous lamina, very thin, pellucid, crystalline, and semilunar; the edge of the base is thick set with molecular intestines; the fore-part furnished with short hairs, or a kind of mane; towards the hind-part are three equal curved hairs, or spines.

XVI. VORTICELLA.

Vermis contractilis, nudus, ciliis rotatoriis. A naked worm, with rotatory cilia, capable of contracting and extending itself.

281. Vorticella Cincta. V. trapeziformis, nigro-viridis, opaca. Plate XXVII. Fig. 30. This vorticella is in the form of a trapezium, of a blackish green colour, and opake.

It is of an irregular shape, sometimes assuming an oval figure, and appearing as if girt round with a transverse keel, *a*. It is invisible to the naked eye, ciliated on every side; the hairs all moveable, and longer on one side than the other.

282. Vorticella Sphæroida. V. cylindrico-globosa, uniformis, opaca. A globous cylinder, uniform and opake.

To the naked eye this appears also little more than a point, but the microscope exhibits it as a globular mass of a dark green colour. It occasions a vehement motion in the surrounding water, which is probably effected by some very short hairs, which are perceptible.

283. Vorticella Viridis. V. cylindracea, uniformis, viridis opaca. Plate XXVII. Fig. 31. Cylindrical, uniform, green, and opake.

This vorticella is visible to the naked eye, appearing like a minute green point; but the microscope discovers it to be nearly cylindrical, of a dark green colour, a little thicker at the fore-part *a*, than the hinder-part *b*, and both extremities obtuse. It appears to be totally destitute of limbs; notwithstanding which, it keeps the water in constant motion; so that it has probably some invisible rotatory instrument. It does not change its figure. Its motion is sometimes circular, at others, in a straight line. At *c*, some short hairs are visible.

284. VORTICELLA LUNIFERA. V. viridis, postice lunata, medio margine mucronato. Green vorticella, the hinder part lunated, with a point in the middle projecting from the edge.

The fore-part obtuse, the base broad, and hollowed away like a crescent, with a protuberance in the middle of the concave part shorter than the horns or points of the crescent; the fore-part is ciliated. It is found in salt water.

285. VORTICELLA BURSATA. V. viridis, apertura truncata, papillaque centrali. Plate XXVII. Fig. 32. Green vorticella, the aperture truncated, with a central papillary projection.

Round and prominent, filled with molecules; the fore-part truncated, and both sides of it pellucid; in the center of the aperture there is a prominent papilla or nipple, which when the animalculum is at rest, appears notched; the edge of the aperture is surrounded with cilia; these are sometimes all erect, shining, and in motion, or part bent back and quiescent, and part in motion; sometimes a few of them are collected together, and turned back like little hooks, one on each side. It is found in salt water. *a*, the cilia; *b*, the projecting papilla; *c*, the pellucid space at the fore-part.

286. Vorticella Varia. V. cylindrica, truncata, opaca, nigricans. Cylindrical, truncated, opake, blackish-coloured vorticella, the fore-part ciliated.

287. Vorticella Sputarium. V. ventrosa, apertura orbiculari, ciliis longis raris excentricis. Round and prominent, with an orbicular aperture, and long hairs radiating as from a center.

This is one of the most singular of the microscopic animalcula; when viewed sidewise, it is sometimes nearly cylindrical, but somewhat tapering towards the hinder-part, and having a broad pellucid edge; viewed from the top, it has sometimes a broad face or disc furnished with radiating hairs, the under part contracted into a globular shape, of a dark green colour, and filled with small grains. It was found in October with the lesser lemna.

288. Vorticella Nigra. V. trochiformis nigra. Plate XXVII. Fig. 36 and 37. Top-shaped black vorticella.

This may be seen with the naked eye, appearing like a black point swimming on the surface of the water; the microscope exhibits it as a minute conical body, opake, obtuse, and ventricose at one extremity, and acute at the other. When it extends the extremities, two small white hooks become visible; by the assistance of these it moves in the water, and it is probable from some circumstances that they inclose a rotatory organ. It moves continually in a vacillating manner on the top of the water. It is found in August, in meadows that are covered with water. *a*, the rotatory organ; *b*, the two small hooks; *c*, the acute end.

289. Vorticella Multiformis. V. viridis, opaca, varia,

vesiculis sparsis. Green, opake, variable vorticella, with vesicles scattered about the body.

The vesicles of this vorticella are larger; in other respects it so much resembles the preceding one, that a further description is unnecessary. It is found in salt water.

290. VORTICELLA POLYMORPHA. V. multiformis, viridis, opaca. Plate XXVII. Fig. 33, 34, 35. Many-shaped vorticella, green, opake.

To the naked eye it appears like a green point, moving with great agility; but, when viewed through a microscope, it assumes such a variety of forms, that they can neither be exhibited to the eye by drawings, nor described by words; it is truly one of the wonders of nature, astonishing the mind, fatiguing the eye, and continually exciting the beholder to ask,

> "Quo teneam vultus mutantem protea nodo?"

The body is granulous, and a series of pellucid points is sometimes to be observed, as at *b b*.

Fig. 33, 34, 35, represent this vorticella in three different forms; *a*, the fore-part; *g*, the hind-part; *c*, the fore-part simple; *d*, the fore-part turned in or doubled.

291. VORTICELLA CUCULLUS. V. elongata, teres, apertura oblique truncata. This vorticella is long, round, the aperture or mouth obliquely truncated.

This being visible to the naked eye, may likewise be ranked among the larger vorticellæ. The body is somewhat conical, of a dingy red colour; its shape has been compared to that of a grenadier's cap.

292. VORTICELLA UTRICULATA. V. viridis, ventricosa, productilis, antice truncata. Green vorticella, the belly round and prominent, capable of being lengthened or shortened; the fore-part truncated, much in the shape of a common water-bottle; the neck is sometimes very long, at others, very short, and filled with green molecules.

293. VORTICELLA OCREATA. V. subcubica, infra in angulum obtusum producta. This vorticella is somewhat of a cubical figure, the under part bent in an obtuse angle.

It is a very singular animalculum, in shape somewhat resembling the lower part of a boot; the apex of the upper part or leg is truncated and ciliated, the heel pointed, and the foot round. It is to be found in rivers, though very rarely.

294. VORTICELLA VALGA. V. cubica, infra divaricata. Cubical vorticella, the lower part divaricated.

This is as broad as long, and filled with grey molecules, the apex truncated and ciliated; both angles of the base projecting outwards, one somewhat like a wart, the other like a finger. It is found in marshy waters.

295. VORTICELLA PAPILLARIS. V. ventricosa, antice truncata, papilla caudali et laterali hyalina. Big-bellied vorticella, the fore-part truncated, with a papillary tail, and a splendid papillary excrescence on the side. It is found in marshes where the conferva nitida grows.

296. VORTICELLA SACCULUS. V. cylindracea, apertura repanda, margine reflexo. Cylindrical vorticella, the aperture broad and flat, the edge turned down.

A thick animalculum, of an equal diameter everywhere, and filled with molecules; the edge of the mouth is bent back, the hinder-part obtuse, sometimes notched and contracted, with cilia on both sides of the mouth.

297. VORTICELLA CIRRATA. V. ventrosa, apertura sinuata, cirro utrinque ventrali. Big-bellied vorticella, the aperture sinuated, two tufts of hair on each side of the belly. It is found in ditch water.

298. VORTICELLA NASUTA. V. cylindracea, crateris medio mucrone prominente. Plate XXVII. Fig. 38, 39. Cylindrical, with a prominent point in the middle of the cup.

An animalculum that is invisible to the naked eye; but the microscope discovers it to be furnished with a rotatory organ, which encompasses the middle of the body.

It is pellucid, cylindrical, of an unequal size; the fore-part, *a*, truncated and ciliated, and a triangular prominence, *e*, in the middle of the aperture; the hind-part is obtuse, with a point on each side of the middle of the body. This is the appearance of the little creature when in motion; but when the water is nearly exhaled, some further parts of its structure are rendered visible; two rotatory organs are now observable; one on the fore-part, and the other encompassing the middle of the body, *h h*; the hairs of the latter are in vehement motion. Other fascicles of moving hair may likewise be observed, and the variegated and quick motion of this apparatus is very surprizing, especially if the animalculum be big with young, moving at the same time within the mother.

299. Vorticella Stellina. V. orbicularis, disco moleculari, peripheria ciliata. Orbicular vorticella, with a molecular disc, and ciliated margin.

300. Vorticella Discina. V. orbicularis, margine ciliato, subtus convexo-ansata. Plate XXVI. Fig. 8, 9, 10. Orbicular vorticella, the edge ciliated, with a kind of convex handle on the under-side.

301. Vorticella Scyphina. V. craterformis, crystallina, medio spærula opaca. Bowl-shaped vorticella, crystalline, with an opake spherule in the middle.

302. Vorticella Albina. V. cylindrica, postice acuminata. The fore-part cylindrical, the hinder-part tapering, and ending nearly in a point.

303. Vorticella Fritillina. V. cylindrica vacua, apice truncata, ciliis prælongis. Empty cylindrical vorticella, the apex truncated.

304. Vorticella Truncatella. V. cylindrica, differta, apice truncata, cyliis breviusculis. Cylindrical vorticella, stuffed or filled, the apex truncated, with very short cilia.

This is one of the larger kind of animalcula; the body is crystalline, and replete with black molecules; the skin is perfectly smooth and colourless, the hinder extremity rounded, and the anterior truncated; at this extremity there is a large opening thickly ciliated, which serves as a mouth.

305. VORTICELLA LIMACINA. V. cylindrica, truncata, ciliis bigeminis. Plate XXVII. Fig. 60. Cylindrical truncated vorticella, with two pair of cilia.

306. VORTICELLA FRAXININA. V. gregaria, cylindracea, oblique truncata, ciliis bigeminis, apice margine fissa. Gregarious cylindrical vorticella, obliquely truncated, with two pair of cilia, and a fissure or notch at the upper edge.

The greater part of the body is cylindrical; the hinder-part rather tapering, and filled with opake molecules; towards the upper end it is transparent; within the edge at the top are two small tubercles, from each side of which proceed a pair of small hairs.

307. VORTICELLA CRATEGARIA. V. composita, floribus muticis globosis; tentaculis binis, stirpe ramosa, Plate XXII. Fig. 40. Compound, with globous naked florets, two tentacules, and a branched stem. For an ample description of this animalculum, see page 400.

308. VORTICELLA HAMATA. V. bursæformis, margine aperturæ aculeis rigidis. Plate XXVII. Fig. 40. Purse-formed; the edge of its aperture or mouth set with rigid points.

It is not ciliated, nor have any hairs been discovered upon it; the body is granulated, the fore-part broad and truncated, the hinder-part obtuse, and capable of being contracted or extended. *a*, the rigid points.

309. VORTICELLA CRATERIFORMIS. V. subquadrata, ciliorum fasciculis etiam postice. Plate XXVII. Fig. 40, 41. Ap-

proaching somewhat to a square figure, with fascicles of cilia even at the hinder-part.

A lively animalculum, pellucid, round, longer than it is broad, with convex sides; the head is situated at the large end, the skin smooth, and some traces of intestines may be discovered with difficulty. There is a considerable opening surrounded with hair at the larger end, and the filaments composing it are in continual motion. Two of them are somtimes seen joined together, as at Fig. 41, and full of small spherules; in this state they draw each other alternately different ways, the surface is smooth and the hairs invisible. *e*, moveable cilia.

310. Vorticella Canaliculata. V. dilatata, pellucida, latere inciso. Dilated, pellucid, with an incision in the side.

To the naked eye it appears as so many white points adhering to the sides of the glass; when magnified, the anterior part is narrower than the hind one; in the side a kind of incision may be perceived, and the hind-part is a little notched towards the middle; it is furnished with a rotatory organ, with which it excites a continual whirling motion in the water.

311. Vorticella Versatilis. V. elongata spiculiformis, mox urceolaris. Long spear-formed vorticella, but which often changes its shape into a pitcher-like form.

A pellucid, gelatinous animalculum, of a greenish colour, furnished with small radii, particularly about the circumference, which gives it the appearance of a minute water hedge-hog.

312. Vorticella Ampulla. V. folliculo ampulaceo, pellucido, capite bilobo. Plate XXVI. Fig. 4 and 5. This vorticella

is contained in a pellucid bottle-shaped bag, the head divided into two lobes.

Little more need be said to enable the reader to know this animalculum, if he should meet with it, than to observe that the bag is nearly in the shape of the common water-bottle, and that the animalculum is sometimes to be observed at the bottom of it, sometimes nearly filling it.

313. Vorticella Folliculata. V. oblonga, folliculo cylindraceo hyalino. Oblong vorticella, in a bright cylindrical bag.

This animalculum is gelatinous and cylindrical; when at its greatest extension, the base appears attenuated, and the apex truncated.

314. Vorticella Larva. V. cylindrica, apertura lunata, spinis caudalibus binis. Cylindrical, the aperture somewhat in the shape of a crescent, two small thorny points projecting from the hinder-part.

The head, the trunk, and the tail, may be easily distinguished from each other. It is of a clay-colour, the aperture ciliated; with a globular projection at times appearing to proceed from it.

315. Vorticella Sacculata. V. inverse conica, apertura lunata, trunco postice bidentato, cauda elongata biphylla. Plate XXVII. Fig. 42 and 43. This vorticella is in the shape of an inverted cone, with an aperture the figure of a crescent; the lower part of the trunk is notched, forming as it were two teeth; the tail biphyllous.

Each of these parts is surrounded with a loose bright skin, the head is divided from the trunk by a deep incision. *a a a*, small points projecting from the head; *b*, the cilia; *c* and *d d*, the interior parts; Fig. 42, *l*, the little horn at the bottom of the trunk.

316. VORTICELLA AURITA. V. cylindrico-ventrosa, apertura mutica, ciliis utrinque rotantibus cauda, articulata biphylla. Cylindrical and big-bellied, the aperture destitute of hairs, both sides of it are furnished with rotatory cilia, the tail biphyllous.

317. VORTICELLA TREMULA. V. inverse conica, apertura lobata spinulosa, cauda brevi unicuspi. Somewhat of a conical shape; the mouth being divided into two parts which are set with small spines, and a point projects from the tail.

It is a pellucid crystalline ventricose animalculum, within the body on one side, there is a large clay-coloured oval mass, and a pellucid oval substance adjacent to it; the tail is articulated and very short.

318. VORTICELLA SERITA. V. inverse conica, apertura spinosa integra, cauda brevi bicuspi. Somewhat of the shape of a cone, the aperture set with spines, the tail short and divided into two points.

The body is muscular, pellucid, folding variously; the fore-part truncated; round the margin of the aperture are rows of hairs, but it has also stiffer hairs or spines continually vibrating, with which it draws in both animate and inanimate substances. It has some resemblance to the larger vorticella rotatoria, but is easily distinguished from it by its horned spiny aperture, and simple rotatory organ.

319. Vorticella Lacinulata. V. inverse conica, apertura lobata, setis binis caudalibus. Plate XXVII. Fig. 45. Shaped like an inverted cone, the aperture lobated, the tail small and furnished with two bristles, *d*.

The body is pellucid, cylindrical, and muscular; the apex about a third part down, drawn into a little neck; in the middle is a little lamina or triangular point; another of these is discovered when the aperture faces the observer, which makes it appear like a small flower. The hind-part, when in motion, is a little bent; it terminates in two minute bristles, which are seen sometimes united, at other times diverging. When the animalculum is swimming, its rotatory organ, *a*, may be seen; molecular intestines are visible; it moves with velocity in an oblique direction. It is found in pure water.

320. Vorticella Constricta. V. elliptico-ventricosa, apertura integra, cauda annulata biphylla. Elliptical ventricose vorticella, the aperture or mouth undivided, the tail annulated and forked.

There are two kinds of this vorticella; viz. one of a pale yellow, the other of a white colour; the head, the tail, and the trunk, are fully distinguished; a substance in motion has been perceived, which has been supposed to be the heart; they move by fixing their tail to the glass upon the stage of the microscope, and extending their body as much as possible; they then fix the fore-part to the place where they intend to move, and draw the hinder-part to it, proceeding thus alternately. They sometimes turn round about upon one of the points of their tail, at other times they spring forwards with a jerk. When at rest they open their mouths very wide; the lips are ciliated, in some of them two black globules are discovered.

321. VORTICELLA TOGATA. V. subquadrata, apertura integra, spinis caudalibus binis, plerumque unitis. Square vorticella, the aperture not divided, the tail consisting of two long spines, which are sometimes so united as to appear as one.

The body is convex, of a dark colour, and filled with molecules; the middle part is pellucid, the hinder-part rather broader than the fore-part; the latter is ciliated, and the tail formed of two very thin pellucid spines, which are somewhat curved and much longer than the body.

322. VORTICELLA LONGISETA. V. elongata, compressa, setis caudalibus binis longissimis. Long vorticella, flat, the tail formed of two very long bristles.

The fore-part sinuated, and set with minute cilia; the two bristles which constitute the tail are long, but one is longer than the other.

323. VORTICELLA ROTATORIA. V. cylindrica, pedicello collari, cauda longa quadracuspi. Plate XXVI. Fig. 1, 2, 3, 6, 7, 11, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, and Plate XXVII. Fig. 46, 47, 48, and 49. Cylindrical vorticella, with a little foot projecting from the neck, a long tail furnished with four points.

Brachionus corpore conico subæquali. Hill Hist. Anim. Brachionus corpore conico toruloso. Ibid. Brachionus. Pallas Zooph. 50. Joblot Micros. part 2, p. 77, pl. 10, fig. 18; and p. 96, pl. 5, A B C D E K. Adams's Micrógr. Illustr. p. 148, pl. 40, fig. 255. Leeuwenhoeck Contin. Arc. Nat. p. 386, fig. 1, 2. Baker's Micros. made easy, p. 91---93, pl. 8, fig. 6, 7, 8. Ibid. Empl. for the Micr. p. 267---294, pl. 11, fig. 1 to 13. Spallanz.

Opusc. Phys. 2, p. 301, 345, pl. 4, fig. 3, 4, and 5. Rozier Journal Physique, 1775, p. 220.

This animalculum has long been known by the name of the wheel animal; in the description of which no person appears to have succeeded so well as Baker; and to him every writer has since referred for an ample account of this curious little being. What I shall now say on the subject will be chiefly extracted from the same source of information, with such alterations and additions as appear to be necessary to render his account more complete.

I shall begin with observing, that Müller's wheel animal differs in some respects from that of Baker's; first, with regard to the rotatory organs which are extended on the back like ears; secondly, the two little splendid substances within the body; and thirdly, the two black points near the top of the head, which are probably the creature's eyes.

This little animal is found in rain water that has stood for some days in leaden gutters; in the hollows of lead on the tops of houses; or in the slime and sediment left in rain water; they are also sometimes to be met with in ditches and amongst duckweed.

It has been called the wheel animal, because it is furnished with a pair of instruments, which in figure and motion resemble wheels. It appears only as a living creature when immersed in water; notwithstanding which, it may be kept for many months out of water, and in a state of perfect dryness, without losing the principle of life. When dry, it is of a globular form, about the size of a grain of sand, and without any apparent signs of life.

If it be put into water, in the space of half an hour a languid motion begins, the globule turns itself about, lengthens itself by slow degrees, and becomes very lively; in a short time it protrudes its wheels, and swims about in search of food; or else, fixing itself by its tail, brings the food to it by its rotatory organs, which throw the whole circumjacent fluid into a violent commotion; when its hunger is satisfied, it generally becomes quiescent, and sometimes resumes its globular form.

If the water that is found standing in gutters of lead, or the sediment it has left behind, has any appearance of a red or a dark brown colour, little doubt need be entertained of its containing these animalcula. In the summer season, if a small quantity of this dust be put into water, and placed under a microscope, it seldom fails of discovering a great number of minute reddish globules, which are, in fact, the animals themselves. It will be best to view them first with the third or fourth magnifiers, and afterward apply those possessing greater powers.

The motions of this little creature somewhat resemble those of a caterpillar; like many of those insects, removing itself from place to place by first fixing the tail to some substance, then extending the whole body, fixing the head, and afterward drawing the tail to it; by these alternate actions it moves with some degree of swiftness.

This animal frequently changes its appearance, and assumes a very different form; for, th snout being drawn inwards, the fore-part becomes clubbed, and immediately dividing, exhibits to our view two circular instruments set with minute hairs, that move very briskly, sometimes in a rotatory, at other times in a kind of trembling or vibratory manner. An aperture or mouth is also perceived between the two semicircles; whilst in this state, the animal may often be perceived swimming about in pursuit of food.

The most distinguishing parts of this animalculum are, the head, the thorax, and the abdomen. It differs from any other creature hitherto described in the wonderful form and structure of its head; the sudden changes of which from one form to another are equally surprizing and singular; from being of a very taper form, it becomes almost instantaneously as broad as any part of its body, and protrudes an amazingly curious machinery formed to procure its food.

The circular bodies which project from the animal have much the resemblance of wheels, appearing to turn round with considerable velocity, by which means a very rapid current of water is brought from a great distance to its mouth. As these wheels are very transparent, the edges excepted, which are set with fibrillæ, as cogs to a wheel, it is difficult to determine how the rotatory motions are performed, or whether their figure be flat, concave, or conical; be this as it may, they are protruded from a couple of tubular cases, into which they can be again withdrawn, at the will and pleasure of the animal. They do not always turn the same way, nor with the same degree of velocity, sometimes moving in opposite directions, at other times both one way. The figure varies according to the degree of their protrusion, as well as from other circumstances. They appear occasionally like minute oblong squares, rising from the periphery of a circle; at other times they terminate in sharp points, and sometimes they are curved, bending the same way like so many hooks; now and then the ends appear clubbed, or in resemblance like a number of small mallets.

When the fore-part of this creature is first seen to open or divide, the parts, which when fully protruded resemble wheels, seem only like a couple of semicircles, the edges of which are set with little spiculæ, having a nimble, and continually vibrating motion upwards and downwards, for the purpose of agitating the water, each wheel being in this case doubled, or like a round piece of paper folded in the middle.

When the wheels are in motion, the head appears very large in proportion to the size of the animal; and though it is then everywhere transparent, yet a ring or circle, more particularly distinguished by its brightness, may be perceived about the middle of the forehead, from whence many vessels are seen to originate.

The thorax or breast is united to the head by a short annular circle or neck; the size of the thorax is nearly one-sixth part of the whole animalculum. In it the heart is distinctly seen; being placed nearly in the center, the diastole and systole cannot fail to attract the eye of every attentive observer; the alternate dilatation and contraction is very perceptible through the back of the animal, being performed with great strength and vigour. It appears to be composed of two semilunar parts, which in the time of contraction approach each other laterally, and form between them a figure somewhat like a horse-shoe, whose upper side is flat, the under one convex. In the diastole, these two parts separate; the separation begins exactly in the middle of the lower part next the tail. In each of the semilunar parts there is a cavity, which closes when they come together, and opens when they separate.

The motion of the heart is communicated to all the other parts of the thorax, and indeed through the whole animal. It is necessary however to remark, that this motion is sometimes suspended, or at least quite imperceptible, for two or three minutes, after which it re-commences, and goes on with the same vigour and regularity as before. From the under part of the thorax a small transparent horn proceeds, which cannot be seen unless the insect turns on its back or side.

Below the thorax there is an annular circle that joins the thorax to the abdomen; this is considerably the largest part of the animal, and contains the stomach and viscera. When full of food, the intestines are opake, and of a crimson colour, extending from the thorax quite through the abdomen and a great part of the tail, exhibiting a fine view of the peristaltic motion, or those gradual contractions and dilatations of the intestines, which propel their contents downwards. Numerous ramifications of vessels, both longitudinal and transverse, surround the intestines. The abdomen is not only capable of contraction, but also admits of such a degree of extension, as to form a case for all the other parts of the body. The tail extends from a joint at the lower part of the belly to the posterior extremity; it is of a tapering form, and consists generally of three joints; when the animal is inclined to fix itself to any thing by the tail, it thrusts out four, sometimes six, little hooks from the extreme part; these are placed in pairs, one at the very extremity itself, the other two a a little way up the sides; the three pair are seldom seen at the same time. The wheels appear to be the organs used by the animal to assist it in swimming.

All the actions of this creature seem to imply sagacity and quickness of sensation; at the least touch or motion in the water, they instantly draw in their wheels. Baker conjectures that they have eyes lodged near the wheels, because while they are in the globular or maggot state, their motions are slow and stumbling;

but after the wheels are protruded, they are performed with great regularity, swiftness, and steadiness. Can we sufficiently admire the wonderful contrivance in the apparatus of this animal? a being so diminutive, as not to exceed in size a grain of sand!

Plate XXVI. Fig. 17, represents the wheel animal in what Baker calls the maggot state; while in this form small spiculæ are seen to dart out near the anterior part; the snout is sometimes more, at other times less acute than in this delineation. *a*, a small horn near the thorax.

Fig. 15 represents its manner of moving from place to place, while in the maggot state. *a*, the projecting horn.

Fig. 12 exhibits it with the two semicircular parts, *a a*, protruded, and in the posture in which it places itself, when preparing to swim about, or going to set its wheels in motion.

Fig. 1 shews the head at its full extent, and a couple of small bodies, *a a*, on the top of it, armed with small teeth, *b*, like those of the balance-wheel of a watch.

At Fig. 18 the interior parts are more particularly exhibited. *a*, the circle from which many vessels originate; *b*, the thorax or breast, joined to the head by the neck, *c*; the part which is supposed to be the heart is plainly seen at *d*; the abdomen, *f*, is separated from the breast by a ring, *e*; *g*, the tail.

Fig. 19 exhibits the animal not fully extended, though with its wheels in motion.

Fig. 20 shews it with its side towards the eye; in this position one of the wheels, *a*, appears to lie considerably below the other.

Fig. 6 and 16 represent two of these creatures in the postures in which they are frequently seen when the wheels are not protruded, but with the fibrillæ, *a b*, vibrating quickly.

Fig. 2 exhibits the animal with the body nearly drawn into the abdomen; at Fig. 21, the body still further drawn in; at Fig. 22, as it appears with the tail partly drawn in; at Fig. 23, in a globular form, but still adhering by the tail.

Sometimes, when in the maggot form, it rolls its head and tail together, without drawing them into the body; as represented at Fig. 14.

Baker has also described three other species, one of which, differing only from the preceding in having a very long tail, is represented at Fig. 7.

Fig. 11 is another kind, with crustaceous spiculæ, *b*, at the forepart; within this, at *c*, an opake oval body may be seen, which has been taken for an egg.

Fig. 3 is another kind; it has two projecting points, *a a*, from the tail, and the head furnished with a number of fibrillæ, *b b*.

Fig. 13 represents another species, described by Spallanzani.

Plate XXVII. Fig. 46, 47, 48, 49, represent the wheel animals seen and delineated by Müller. *a*, the head; *b*, the eyes; *c*, a small horn; *d*, the rotatory organ; *e*, the tail; *f*, the points of the tail.

324. VORTICELLA FURCATA. V. cylindrica, apertura integra, cauda longiuscula bifida. Cylindrical vorticella, the aperture undivided, the tail rather long, and divided into two parts.

A cylindric body with a rotatory organ, consisting of a row of hairs at the apex; the tail is divided into two parts turning a little inwards. When at rest, it joins the segments of the tail; but opens them when in motion. It is generally found in common water.

325. VORTICELLA CATULUS. V. cylindracea, apertura mutica, cauda perbrevi, reflexa, bicuspi. Plate XXVII. Fig. 50. Cylindrical vorticella, the aperture plain, the tail short, bent back, and divided into two points.

It is a little thick muscular animalculum, folding itself up; of an equal breadth throughout, the body disfigured by longitudinal folds winding in various directions; the anterior part or head is connected to the body by a little neck, and it occasionally exhibits a very minute rotatory organ. The tail, *e*, is short, terminating in two very small bristles, *d*, which are exposed or concealed at pleasure; the intestines ill-defined. Its motion is rotatory, but in different directions. It is commonly found in marshy waters.

326. VORTICELLA CANICULA. V. cylindracea, apertura mutica, cauda brevi, articulata, bicuspi. Cylindrical vorticella, the aperture plain, with a short articulated tail divided into two pointed parts.

327. VORTICELLA FELIS. V. caudata, cylindracea, mutica, cauda spinis duabus longis terminata. With a tail, cylindrical, beardless, the tail terminating in two long spines.

The body is large, the apex of an equal thickness, obtuse, with rotatory filaments; the tail acute, with two pellucid spines, in length about one-third part of the body, alternately separating from and approaching each other.

328. Vorticella Stentorea. V. caudata, elongata, tubæformis limbo ciliato. Long-tailed vorticella, trumpet-shaped, the arms furnished with rows of short hairs. See this fully described by the name of hydra stentorea, in page 392.

329. Vorticella Socialis. V. caudata, aggregata, clavata; disco obliquo. A description of this vorticella has also been given, as hydra socialis, in page 395.

330. Vorticella Flosculosa. V. caudata, aggregata, oblongo-ovata, disco dilatato pellucido. Plate XXVII. Fig. 51 and 52. With a tail aggregated, of an oblong oval shape, with a dilated pellucid disc.

To the naked eye it appears as a yellow globule, adhering to the ceratophyllum, or common horn-wort, Fig. 52, *a*, like a little flower; or a heap of yellow eggs, *b*. With the assistance of the microscope they are discovered to be a congeries of vorticellæ, constituting a sphere from a mouldy center. They contract or extend their bodies either when alone or associated, and excite a vortex in the water by means of the disc. When they quit the society, and act singly, their parts may be more readily distinguished, and will be found to consist of a head, abdomen, and tail. The head is often drawn back so far into the abdomen, that it cannot be seen, exhibiting only a projecting, broad kidney-shaped disc. The abdomen, Fig. 51, *d*, is oblong, oval, and pellucid, replete with obscure intestines, amongst which are one or two remarkable black oval spots, *e*; the tail, *f*, is sharp, twice as long as the abdomen, either rough and annulated, or altogether smooth.

331. Vorticella Citrina. V. simplex, multiformis, orificio contractili, pedunculo æquali. Plate XXVII. Fig. 53. Simple, many-shaped, with an orifice admitting of contraction, and equal-sized foot-stalk.

The head is full of molecules, round, everywhere of an equal size, and very pellucid; both sides of the orifice are ciliated, and each has a rotatory motion, appearing sometimes without the edge of the mouth, as at *a a*; at other times within it. No distinct intestines or internal motion are perceivable. Its motion is different from most of this genus, but not easily described; at *c c* are small feet. It is found in stagnant water.

332. Vorticella Piriformis. V. simplex, obovata, pedicello minimo retractili. Simple, somewhat oval, with a very small retractile foot, which it can draw within itself.

333. Vorticella Tuberosa. V. simplex, turbinata, apice bituberculata.

Simple vorticella, the upper part broad, the under part small, with two projections at the anterior end, furnished with a number of fibrillæ, which produce a current of water by their vibration, and thus collect food for the animal. Baker has delineated it in Plate XIII. No. 10, 11, 12, of his Employment for the Microscope.

334. Vorticella Ringens. V. simplex, obovata, pedunculo minimo, orificio contractili. Simple, somewhat of an oval

shape, with a small pedicle, and an orifice which it contracts or dilates.

The small head, or rather body of this little creature is pear-shaped, pellucid, the middle of the aperture convex, both sides ciliated, the pedicle four times shorter than the body; it can contract the orifice to an obtuse point.

335. VORTICELLA INCLINANS. V. simplex, deflexa, pedunculo brevi, capitulo retractili. Simple, bent, with a short pedicle, and small retractile head.

This has a pellucid pendulous little head; the anterior part truncated, occasionally contracting itself twice as short as the pedicle; its shape resembles that of a tobacco-pipe.

336. VORTICELLA VAGINATA. V. simplex, erecta, ovato-truncata, pedunculo vaginato. Simple vorticella, erect, of the shape of a truncated egg; the pedicle is contained in a sheath.

For the 337th, 338th, and 339th, the author refers to the Zool. Dan. he terms them, vorticella cyathina, vorticella putrina, vorticella patellina.

340. VORTICELLA GLOBULARIA. V. simplex, sphærica, pedunculo retortili. Simple, spherical, with a twisted pedicle.

This animalculum has a small spherical head, the aperture of the mouth ciliated; the pedicle four times longer than the body, which it contracts into a spiral form. It is frequent among the cyclopa quadricorni.

341. Vorticella Lunaris. V. simplex, hemisphærica, pedunculo retortili. Plate XXVII. Fig. 54. Simple, hemispherical, with a twisted pedicle.

The small head of this animalculum is goblet-shaped, the margin of the orifice protuberant, ciliated on both sides, with undulating hairs; the pedicle eight or ten times the length of the body. The pedicle extends itself as often as the mouth is opened, but is twisted up spirally when it is shut; and these motions are frequently repeated in a short space of time. *a a*, the head when expanded; *b*, when shut; *c*, the undulated edge; *d d*, the cilia erect; *e*, when horizontal; *f*, the pedicle when straight; *g*, when bent in a spiral form.

342. Vorticella Convallaria.. V. simplex, campanulata, pedunculo retortili. This animalculum, the bell-animal of Baker, has been fully described in page 407.

343. Vorticella Nutans. V. simplex, turbinata, pedunculo retortili. Simple, with a twisted turbinated pedicle.

The pedicle is simple, and twists itself spirally; is extremely slender, with a kind of cap on its head; the margin white and round, and appearing as if encompassed with a lucid ring; the head diminishes towards the base. It is transparent.

344. Vorticella Nebulifera. V. simplex, ovata, pedunculo reflexili. Plate XXII. Fig. 66. Simple, egg-shaped, the pedicle bent back.

The body is narrow at the base, open and truncated at the top; the margin apparently surrounded with a ring; but, when the aperture is shut, the animalculum is egg-shaped, with a simple setaceous pedicle, considerably longer than the body, and generally much bent back. *a a a*, the head open; *b*, partly closed; *c*, quite shut; *d*, the stalk when straight; and at *e*, when bent.

345. VORTICELLA ANNULARIS. V. simplex, truncata, pedunculo apice retortili. Simple, truncated, with a pedicle twisted at the end.

This is visible to the naked eye; when contracted, it appears to be annulated; the head is an inverted cone, convex when the mouth is shut, but truncated when it is open, and with a protuberant edge; the pedicle is simple, very long and thick, whiter at the top than any other part, and formed into a little head; the apex is twisted spirally.

346. VORTICELLA ACINOSA. An ample description of this animalculum, under the title of vorticella umbellaria, has been given in page 402.

347. VORTICELLA FASCICULATA. V. simplex, viridis, campanulata, margine reflexo, pedunculo retortili. Simple, green, bell-shaped, the margin or edge turned back, the pedicle twisted.

The head is bell-shaped, green, opake, narrow at bottom, pellucid. It has a rotatory organ, which may sometimes be seen projecting beyond the aperture; there is a little head at the apex, and the pedicle is twisted and very slender. A congealed green mass, which is often swimming about in ditches, is composed of myriads of these animalcula, which are invisible to the eye, but when magnified, appear like a bundle of green flowers.

348. VORTICELLA HIANS. V. simplex, citriformis, pedunculo retortili. This may be classed among the most minute. The

head resembles a citron, the apex is truncated, the base narrow; a gaping cleft is observable descending from the apex, to one-third of the body.

349. Vorticella Bellis. V. simplex, hemispherica, margine contractili. Simple, hemispherical, with a margin which it can contract at pleasure.

The body is of a yellow colour, much resembling the flower of a daisy; the head scarcely pellucid; the internal part quite filled; it is abundantly ciliated round the margin, moving in a rotatory manner.

The foot or pedicle is long, slender, and pellucid; it is divided into two parts, with small knobs on the top of each; the base adheres to a bulb, the under-part is covered with small scales.

350. Vorticella Gemella. V. simplex, sphærica, capitulo gemino. Simple, spherical, with a double head.

The pedicle is long, and constantly furnished with two small heads at its apex; these are bright and clear.

351. Vorticella Pyraria. The distinguishing characters of this animalculum will be found at page 400.

352. Vorticella Anastatica. A full description of this vorticella has also been given at page 397.

353. Vorticella Digitalis. At page 406 the reader will likewise meet with an account of the v. digitalis.

354. VORTICELLA POLYPINA. V. composita, ovato-truncata, pedunculo reflexili ramosissimo. Plate XXVII. Fig. 61. Compound vorticella, oval, truncated, with a bending branching stalk.

When viewed with a small magnifier, they appear like so many little trees; the upper part or heads are egg-shaped, the top truncated, the lower part filled with intestines; the branches are thick set with little knobs. *a*, the trunk; *b b b*, the branches; *c c*, the head when extended; *d*, the small knobs on the branches.

355. VORTICELLA RACEMOSA. V. composita, pedunculo rigido, pedicellis ramosissimis longis. Compound, rigid pedicle, with small branched long feet.

To the naked eye it appears like the vorticella socialis, described in page 395, but is distinguished from it by always adhering to the sides of the vessel in which it is placed. With the microscope, a long very slender pedicle is discovered sticking to the sides of the vessels, from which proceed an innumerable quantity of crystalline pellucid pearls, which, together with the stalk, are variously agitated in the water. They sometimes move separately, at other times together, are sometimes drawn down to the root, and in a moment expanded again.

XVII. BRACHIONUS.

Vermis contractilis, testa tectus, ciliis rotatoriis. A worm capable of contracting, covered with a shell, and furnished with rotatory cilia.

356. BRACHIONUS STRIATUS. B. univalvis, testa ovata striata, apice sexdentata, basi integra, cauda nulla. Plate XXVII. Fig. 64 and 65. Univalved brachionus, the shell oval and striated, six notches or teeth round the upper edge, the base whole or even, without a tail.

The shell is oblong, pellucid, and capable of altering its figure. The apex, *a*, is truncated, with six small teeth on the edge of it, twelve longitudinal streaks down the back, the base obtuse and smooth. The teeth are occasionally either protruded or retracted; on the other side of the shell, towards the tail, there are two little spines or horns, *c*.

The animalculum itself is muscular, pellucid, and crystalline, often of a yellow colour; from the apex it now and then puts forth three little bundles of playing hairs, the two lateral ones shorter than the middle one; a forked deglutatory muscle, *e*, is perceptible; and on the under side, when the apex is drawn in, two rigid points may be discovered. It is found in sea water.

357. BRACHIONUS SQUAMULA. B. univalvis, testa orbicularis, apice truncata quadridentata, basi integra, cauda nulla. Univalved brachionus, with an orbicular shell; the apex truncated, and having four teeth, the base smooth, no tail.

358. BRACHIONUS PALA. B. univalvis, testa oblonga excavata, apice quadridentata, basi integra, cauda nulla. Univalved brachionus, with an oblong excavated shell, four long teeth at the apex, the base smooth, no tail. It is of a yellow colour.

359. BRACHIONUS BIPALIUM. B. univalvis, testa oblonga inflexa, apice decemdentata, basi integra, cauda spuria. Univalved

brachionus, the shell oblong and inflected, ten teeth at the apex, the base smooth, and a spurious tail.

360. Brachionus Patina. B. univalvis, testa orbiculari integra, cauda mutica. Univalved brachionus, with an orbicular shell, the edges regular, and having a long beardless tail.

The patina is extremely bright and splendid; it has a large body, a crystalline and nearly circular shell, without either incision or teeth, though towards the apex it falls in so as to form a smooth notch; the body is affixed to the middle of the shell; a double glittering organ, with ciliated edges, is projected from the apex; both these organs are of a conical figure, appearing to stand on a pellucid substance, which is divided into two lobes; between these and the rotatory organ there is a silver-coloured crenulated membrane; two small claws may be discovered near the mouth. It is reckoned as one of the rarer species of vorticella, and is found in stagnant waters in the month of May.

361. Brachionus Clypeatus. B. univalvis, testa oblonga, apice emarginata, basi integra, cauda mutica. Univalved brachionus, the shell oblong, the apex notched, the base smooth, and the tail naked.

362. Brachionus Lamellaris. B. univalvis, testa producta, apice integra, basi tricorni, cauda bipili. Univalved brachionus, the shell extending considerably beyond the body; the base divided into three small horns, with two hairs at the end of the tail.

363. Brachionus Patella. B. univalvis, testa ovata, apice bidentata, basi emarginata, cauda biseta. Brachionus with a uni-

valve oval shell, two teeth at the apex, the base notched; two bristles at the tail.

The shell plain, oval, orbicular, crystalline, with the anterior part terminating in two acute points on both sides, though the intervening space is commonly filled up with the head of the animal. The head, the tail, and the trunk are very distinct; the bottom of the trunk is terminated in a semicircle, the fore-part marked with two transverse lines; it occupies the disc of the shell. The intestines are indistinct, and the tail affixed to the trunk; it is short, annulated, flexible, the middle projecting beyond the shell, the apex diverging into two very fine bristles; it fastens itself by these, and whirls about with the body erect; the rotatory cilia are not perceptible without great difficulty. It is found in marshy water all the winter.

364. Brachionus Bractea. B. univalvis, testa suborbiculari, apice lunata, basi integra, cauda spina duplici. Univalved brachionus, the shell rather orbicular, lunated apex, smooth base, and the tail furnished with two spines.

365. Brachionus Plicatilis. B. univalvis, testa oblonga, apice crenulata, basi emarginata. Univalved brachionus, with an oblong shell, the apex hairy, and the base notched.

366. Brachionus Ovalis. B. bivalvis, testa depressa, apice emarginata, basi incisa, cauda cirro duplici. Bivalved brachionus, with a flattened shell, the apex notched, a hollow part at the base, the tail formed of two tufts of hair.

367. Brachionus Tripos. B. bivalvis, testa apice mutica, basi tricorni, cauda duplici. Plate XXVII. Fig. 59. Bivalved, the

apex of the shell beardless, three horns at the base, and double tail.

The body is pellucid, nearly triangular, bivalved, and open on the back of the animalculum; from the orifice proceed two little laminæ larger than the rotatory cilia; at the bottom are three or four rigid points, *e f e*, and a moveable tail, *g*, between them, divided into two filaments, which the little creature opens and shuts at pleasure; by these it fixes itself to objects. *a a*, the lateral cilia; *b*, two small laminæ; *c*, a deglutatory muscle; *d*, an opake mass.

368. Brachionus Dentatus. B. bivalvis, testa arcuata, apice et basi utrinque dentata, cauda spina duplici. Bivalved brachionus, with an arched shell; the apex and the base are both toothed, and the tail formed of two spines.

369. Brachionus Mucronatus, B. bivalvis, subquadrata, apice et basi utrinque mucronata, cauda spina duplici. Bivalved, somewhat of a square form; the base and apex pointed; the tail consisting of two spines.

370. Brachionus Uncinatus. B. bivalvis, testa ovali, apice integra, basi mucronata, cauda rugosa biseta. Plate XXVII. Fig. 55. Bivalved brachionus, with an oval shell, the apex even, the base pointed, two thick bristles for the tail.

This is one of the smallest bivalved animalcula, muscular, the apex and anterior part round, the hinder part straight, terminating in a point, furnished with a hook on the fore-part, a small rotatory organ, a long tail composed of joints, and divided at the end into two bristles. It can open its shell both at the fore and hind-part.

a, the shell when close; *c*, the posterior point; *d*, the animalculum; *h*, the tail; *i*, the bristles.

371. BRACHIONUS CIRRATUS. B. capsularis, testa apice producta, basi curti bicorni, cauda biseta. Larger than the preceding, ventricose, somewhat pellucid, the head conical, with a bundle of hairs on both sides; it has likewise a rotatory organ.

372. BRACHIONUS PASSUS. B. capsularis, testa cylindracea, frontis cirris binis pendulis, setaque caudali unica. Capsular brachionus, in a cylindric shell, with two long pendulous locks of hair proceeding from the front; the tail consists of a single bristle.

373. BRACHIONUS QUADRATUS. B. capsularis, testa quadrangula, apice bidentata, basi bicorni, cauda nulla. Capsular brachionus, in a quadrangular shell, with two small teeth at the apex, two horns proceeding from the base, and no tail.

374. BRACHIONUS IMPRESSUS. B. capsularis, testa quadrangula, apice integra, basi obtusi emarginata, cauda flexuosa. Capsular brachionus, the shell quadrangular, a smooth undivided apex; obtuse base; notched margin, and a flexuous tail.

375. BRACHIONUS URCEOLARIS. For a full description of this animalculum, being the same as the vorticella urceolaris, the reader will please to refer to page 408. Views of the animal in its different positions will be found in Plate XXII. Fig. 36, 37, 38, and in Plate XXVII. Fig. 56 and 57. Fig. 56, *a a*, are the two fibrillæ; *b*, the head; *f*, the intestines; *i*, the aperture from which the tail is protruded; *i k*, the tail; at the end, *k*, is a cleft, enabling the animal to affix itself more firmly to any substance.

Fig. 57, at *a c a*, are seen the fibrillæ; *d* shews the moveable intestine, supposed to be the heart or lungs; *f*, the intestines; *h i k*, the tail.

376. BRACHIONUS BAKERI. B. capsularis, testa ventricosa, apice quadridentata, basi bicorni, cauda longa bicuspi. Plate XXVII. Fig. 58. Capsular brachionus, the shell ventricose, four teeth at the apex, two horns at the base, and a long tail terminating in two short points.

This differs considerably from the foregoing in the shape of the shell, from each side of which there is a curved projection, *f f*, inclining towards the tail, nearly of the same length with it, and terminating in a point, *h h*. The upper part also of the shell is of a different form, having in general four longer spiculæ, and two shorter ones. From the head two arms or branches, *e e*, are frequently extended; the circular end of each is furnished with a tuft of little hairs, which sometimes move in a vibratory manner, at other times have a rotatory motion. The eggs are either affixed to the tail, or the curved part of the shell; they have from one to five hanging from them. Müller has likewise discovered in this animalculum two small feelers, and a kind of tongue. *a a*, the rotatory organs; *b*, the tongue; *c c*, the feelers; *d d*, a ciliated part on the side of the shell; *g*, the heart or lungs; *m k*, the tail; at the extremity, *k*, two sharp points.

377. BRACHIONUS PATULUS. B. capsularis, testa ventrosa, apice octodentata, basi lunata quadricorni, cauda brevi bicuspi. Capsular brachionus, the shell ventricose, eight teeth at the apex, the base lunated or hollowed into the form of a crescent, and furnished with four horns; the tail short, with two small points at the end.

ADDITIONAL ANIMALCULA INFUSORIA, EXHIBITED IN PLATE XXVI.

378. Fig. *A A A.* An animalculum found in ditch water in the month of September, represented in three different forms which it assumed.

379. Fig. *B B B.* A species of testaceous wheel-animal; *a,* its appearance when protruded; *b,* when in the shell; *c,* another appearance of the same.

380. Fig. *C,* shews one of the same species; and

381. Fig. *D,* exhibits another of the same kind; they both appear as protruded from the shell. The above are all drawn as they were found adhering to a vegetable substance.

382. Fig. *E E E.* Several appearances of an animalculum found in stagnant water in September, about the one-hundredth part of an inch in length; it moved slowly, and there appeared a wheel-like motion in certain fibrillæ in the head. The double-forked part of the tail had a similar motion to the tail of the pulex aquaticus; the intestines appeared of different colours, as brown, yellow, and reddish, and had a quick irregular motion; the external parts were very transparent.

383. Fig. *F F F F.* Several animalcula in a drop of water from a leaden cistern; of different sizes, but apparently of the same species. They moved either end foremost, without any undulating motion, but very uniform and slow; each end appeared alike, and very transparent; the middle clear, brown, with a blackish

list nearly the whole length of the animal. The large one, *a*, lay sometime bent, as in the drawing, the others, both when in motion and at rest continuing quite straight. Some of the very small ones were transparent; others appeared as at *b* and *c*.*

Having in this and the preceding chapter described an extensive variety of those minute and wonderful productions of nature, the hydræ, vorticellæ, and animalcula infusoria, I shall take my leave of the subject with remarking, that though by the assistance of the microscope myriads of animated beings, roving in the smallest drop of water as if it were a sea, have been exhibited to the astonished eyes of attentive observers, it surely cannot be deemed an unreasonable supposition, that the ADORABLE CREATOR, who has filled the immensity of extent with suns and worlds, has also peopled every particle of fluid with beings far more minute than any apparatus of ours can perceive; and however insignificant many of the smaller parts of the creation may appear to the uninformed bulk of mankind, there cannot exist a doubt, but that they were all, collectively and individually, formed for the wisest purposes; and, though in many instances these designations are to us incomprehensible, let us not on that account rashly withhold our admiration. These sentiments are beautifully enforced in the following expressive lines of THOMSON:

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* In the former edition of this work, owing to an error in the numeration, it appeared that 379 of these animalcula were described, though in reality it contained only 377, or the number which has already been given.

Previous to the publication of Mr. Adams's edition, a friend communicated to him drawings and descriptions of several of these minute beings which had fallen under his observation; but they were received too late for insertion. Mr. A. having at that time favoured me with a copy of the drawings and manuscript, they are now added, with the hope that they will not prove unacceptable to the curious reader. EDIT.

Gradual from these what num'rous kinds descend,
Evading ev'n the microscopic eye!
Full nature swarms with life; one wond'rous mass
Of animals, or atoms organized,
Waiting the vital breath, when parent heaven
Shall bid his spirit blow. The hoary fen,
In putrid streams, emits the living cloud
Of pestilence. Thro' subterranean cells,
Where searching sun-beams scarce can find a way,
Earth animated heaves. The flowery leaf
Wants not its soft inhabitants. Secure,
Within its winding citadel, the stone
Holds multitudes. But chief the forest boughs,
That dance unnumber'd to the playful breeze,
The downy orchard, and the melting pulp
Of mellow fruit, the nameless nations feed
Of evanescent insects. Where the pool
Stands mantled o'er with green, invisible,
Amid the floating verdure, millions stray.
Each liquid too, whether it pierces, soothes,
Inflames, refreshes, or exalts the taste,
With various forms abounds. Nor is the stream
Of purest crystal, nor the lucid air,
Tho' one transparent vacancy it seems,
Void of their unseen people. These, conceal'd
By the kind art of forming heaven, escape
The grosser eye of man:---------
Let no presuming impious railer tax
Creative Wisdom, as if aught was form'd
In vain, or not for admirable ends.
Shall little haughty Ignorance pronounce
His works unwise, of which the smallest part
Exceeds the narrow vision of her mind?

As if upon a full-proportion'd dome,
On swelling columns heav'd, the pride of art!
A critic fly, whose feeble ray scarce spreads
An inch around, with blind presumption bold,
Should dare to tax the structure of the whole.
And lives the man, whose universal eye
Has swept at once th' unbounded scheme of things;
Mark'd their dependance so, and firm accord,
As with unfaultering accent to conclude
That this availeth nought? Has any seen
The mighty chain of beings lessening down
From infinite perfection to the brink
Of dreary nothing, desolate abyss!
From which astonish'd thought, recoiling, turns?
Till then alone let zealous praise ascend,
And hymns of holy wonder, to that Power,
Whose wisdom shines as lovely on our minds,
As on our smiling eyes his servant sun.

CHAP. IX.

ON THE ORGANIZATION OR CONSTRUCTION OF TIMBER, AS VIEWED BY THE MICROSCOPE.

THE subject of the following chapter opens an extensive field for observation to the naturalist, in which the labour of a life may be well employed: it is a branch where the observer will find the microscope of continual use, and without which he will scarce be able to form any just idea of the organization of trees and plants, or of the variations in the disposition, the number, nature, and offices of their several parts.

Vegetables are beautiful and perfect in their kind, wonderful in their growth, beneficial in their uses. "Herbs and flowers may be regarded by some persons as objects of inferior consideration in philosophy; but every thing must be great which has God for its author. To him all the parts of nature are equally related: the flowers of the earth can raise our thoughts up to the Creator of the world as effectually as the stars of heaven; and, till we make this use of both, we cannot be said to think properly of either. All trees and herbs in their place and seasons speak the same language from the climates of the north to the torrid regions of the south, and from the winter to the spring and the harvest, they join their voices in the universal chorus of all created beings, and to the ear of reason celebrate the wisdom of the Almighty Creator."

Malpighi, Grew, Duhamel, Hill, Bonnet, and De Saussure, are almost the only writers who have treated on the interior structure of vegetables; and, if we consider the imperfection of the instruments used by some of them in these anatomical researches, and the little attention paid by the rest to the advantages their favourite pursuits might have derived from the use of the microscope, as well as the dissecting knife, we find greater cause to wonder at what has been done, than at what remains to be performed. To the general inattention to the structure of plants, we may, amongst other causes, also ascribe the instability and fluctuation of the different theories on the principles of vegetation. We are, however, so little acquainted with the steps which Providence takes to lead intellectual, but free agents, to the knowledge of truth, and the various difficulties, errors, and prejudices, necessary to be removed, before it can shine in its native colours, that it is our duty to encourage every humble effort towards the advancement of science, that thus we may co-operate with our Creator and Redeemer in promoting that vast plan to which all things are now converging, the bringing all his creatures to a state of truth, goodness, and consequent happiness, an end worthy of the best and wisest of beings.*

As Dr. Hill is the first writer who has treated this part of natural history in an orderly and scientific manner, I shall use the names he has adopted for characterizing the different parts of trees, &c. which are, 1. the rind; 2. the bark; 3. the blea; 4. the wood; 5. the corona or circle of propagation; 6. the pith. These are placed immediately within or under one another; they are the essential parts upon which the strength of the tree depends: in,

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* See the Bishop of Exeter's Sermon before the Society for the Propagation of the Gospel.

among, and between these, the various vessels are placed, which nourish the whole, and maintain and carry on the vegetation of the tree, and from which it obtains its peculiar qualities and virtues. These vessels are of five kinds:

1. The Exterior }
2. The Interior } Juice Vessels.
3. The Intimate }
4. The Sap Vessels.
5. The Coronal.

Of these, the first are placed between the rind and bark; the second, in the substance of the bark; the third, in the substance of the blea; the fourth, in the substance of the wood; the fifth, in the corona.

More accurate instruments, or a more minute investigation of the parts, may probably discover new vessels in a system which appears to be entirely vascular, and brings us more thoroughly acquainted with the nature of vegetation.

OF THE RIND.

The exterior covering of all trees is a thin, dry, parched substance, which has been compared by many writers to the skin of animals, and called by names analogous thereto; thus it is called the epidermis by Duhamel, the skin by Grew, the rind by Hill.

When a tree is full of sap, this membrane may be easily detached from the part it covers; it may be separated from green branches which are not in sap, by boiling them in water; large pieces of it may also be obtained from rotten branches; the rind of the leaves of many trees is detached with singular dexterity from the other parts, by some of the mining caterpillars; artificial methods for effecting this purpose have been described in page 160 of this work. Though the rind may at first sight be thought to be of little use, it will be found to be a principal organ in the process of vegetation. The part which covers the root has the most important offices assigned to it.

Many are of opinion that the rind is formed of dried vesiculæ; and Malpighi says, that we may see in the vascular texture of the bark of the cherry and plumb-trees an arrangement of the parts proper to form the rind, and this arrangement is occasioned by the endeavour of the vascular part to extend itself to the circumference, and the resistance it meets with from the rind; and that hence the vessels are flattened, and assume a membranaceous form.

The rind is a general covering to the young trunks of trees, to the branches, the roots, the leaves, the fruit, the flowers, &c. Upon the trunks of large trees some pieces only of the rind are to be found, having probably been broken by the increased size of the tree. The rind of some species of trees will bear being stretched much further than those of others, and remain for a considerable time uniformly spread over the bark. Du Hamel asserts, that the rind of vigorous healthy trees remains longer whole than on those that are more languid, notwithstanding that the growth of the last is slower, and therefore makes less efforts against the rind. This circumstance is much in favour of the distinct organization of the rind, and against the opinion of those who only suppose it to consist of dried bladders.

Thin as the rind is, it is formed of many coats, adhering closely to each other, which in some species may be separated with ease, in others, with difficulty. Du Hamel says, that he has divided the rind of the birch into six distinct coats, and that he had no doubt but what the division might have been carried much further. Dr. Hill says, that unless some of these coats be obtained in a state of separation from the rest, the true construction of the rind cannot be discovered, for the connection and form of the parts are lost by the confusion in which they appear while they lie one upon another.

The following experiments may throw a little light upon this obscure subject.* All the rind was taken from the trunk of a cherry-tree, and the tree thus skinned exposed to the air; a part of the bark which was next to the rind dried up and exfoliated; the part next to this did the same; after two or three exfoliations, a farinaceous substance covered the superfice of the trunk, soon after which a new rind appeared. Some pieces of rind were taken from a few young branches, and the wounds were covered with a cloth that had been soaked in wax and turpentine; on these the rind appeared in a very little time, without any apparent exfoliation. From some other branches, not only the rind, but a part of the bark was also taken away, and the wounds covered as before; a slight exfoliation was observed here, which was soon followed with a new rind. The bark was taken entirely off from a vigorous cherry-tree, while it was in full sap, so that the wood appeared the whole extent of the trunk. This was protected from the rays of the sun, and from the air. A new bark and rind formed themselves upon the trunk, but they did not originate from the bark that was left on the branches and the root, but extended from different spots, which were first formed at considerable distances from each other. After a lapse of fifteen years, this new rind did not appear like the natural rind of the cherry-tree. From these experiments we learn, that the rind regenerates more readily in some cases than in others, and that it preserves

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* Du Hamel Physique des Arbres, tom. 1, p. 12.

and prevents in a degree the bark from becoming dry too soon, and in consequence thereof exfoliating.

Aided by the microscope, a number of luminous points may be discovered in the rind;* these are so many minute holes for other purposes of transpiration. In the cane these holes are visible to the naked eye. A few oval holes may also be perceived in it; these are, however, no more than a separation of the parts, occasioned by the extension of the vasa interiora.

Dr. Grew supposed the rind to be formed of small vesicles, or bladders, clustered together, and intermixed with ligneous fibres or vessels, which run through the length of the rind; these are conjoined by other transverse ones, but that as the rind dries, the bladders or blebs shrink up and disappear. This account does not differ much from that of Dr. Hill, who says, that the rind is formed of a series of longitudinal vessels, and a filmy substance between them, which, when viewed in a transverse section, form small circles, the sides of which are supported and made up of these longitudinal fibres; that the transverse vessels are only a deception, occasioned by the spaces between them and part of the film. The mode of obtaining an accurate view of the organization of this part, by conveying coloured liquors into the several vessels thereof, has been already described in page 160 of these Essays; by these means, together with the microscope, we find that the vessels are everywhere pierced with small dots or openings: of the use of these, the following conjectures have been formed.†

The root, which is equal in surface to a third part of the tree above ground, is covered with a pierced rind. The cold of

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* Du Hamel Physique des Arbres, tom. 1, p. 9.

† Hill's Construction of Timber, &c. p. 37.

winter contracts the whole of this, the parts are drawn closer together, and the mouths of these innumerable vessels are shut or nearly so, by this contraction; a very little of the half-congealed moisture of the ground gets into them, but this suffices for the service of the tree, when there is little heat to cause any perspiration, and at a time when in the deciduous trees, the very organs of the greatest perspiration, the leaves, do not exist.

The warmth of the spring arrives, the fluids of the earth grow thinner, every part of the root expands; this opens the mouths of the vessels, and the torrent of nutrition rushes in. By these means, every coat of the rind, and the interstitial spaces thereof, are rendered supple, and may be easily separated from the under coverings.

In roots, the colour of the rind varies very much, being white in some, brown in others, &c. Every root, according to Grew, after it has arrived at a certain age, has a double skin, the one coeval with the other parts, and exists in the seed; a ring is afterwards sent off from the bark, which forms the second skin; thus in the root of dandelion, towards the end of May, the original or outer skin appears shrivelled, and is easily separated from the new one, which is fresher, and adheres more firmly to the bark. Perennial plants are supplied in this manner with a new skin every year; the outer one always falls off in the autumn and winter, and a new one is formed from the bark in the succeeding spring.

OF THE VESSELS WHICH ARE CONTAINED BETWEEN THE RIND AND THE BARK.

These are called by Du Hamel the cellular coat, enveloppe cellulaire; by Hill, the exterior vessels, and the vasa propria exteriora.

It has been already observed, that in trees the juice vessels, or vasa propria, do not form those constituent parts of the wood of which the timber consists, but that it is from the nature of these recipient vessels that it derives its virtues, qualities, and specific properties.[*] A tree may grow, live, and give shade without them; but on those its peculiar character and decided virtues depend; these are greatest where the vasa propria are largest or most numerous; and where we do not find these, we scarce find any thing that will affect the taste or the smell. There are different ranges of these vessels between the several parts, each of which has its allotted place, its peculiar form, its different structure, and its separate use. Many trees have them in all their parts, others only in some of them, while others do not exhibit any.

On taking off the rind, we find a substance of a deep green colour, succulent and herbaceous, formed of a prodigious number of filaments interwoven together in various directions; it is more abundant in some trees than in others, particularly in the elder, and more succulent in summer than in winter; it is then also less adherent to the rind. Dr. Hill thinks the best time of separating the rind, in order to view this part, is in a living branch, at the time of its swelling for the spring, or for the midsummer shoot, but much easier by the means of maceration.[†]

When the rind is perfectly separated, it leaves the vasa propria of this class behind it; they scarce adhere to the inner bark, and but little to the rind; they are disposed in packets, and do not run straight down the branch, but interweaving with each other, form a kind of net. These packets may be separated easily from the bark; when a thin transverse section of one of them is exa-

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[*] Hill's Construction of Timber, p. 73. [†] Ibid. p. 75.

mined, it is found to be composed of twelve or fifteen distinct vessels with hard rinds. Dr. Hill says, that with a great deal of patience, a vast number of objects, and a good microscope, we may see by what means these vessels adhere to the bark; for we shall find upon the sides small oval depressions which fit thereto, and that are probably a kind of glands, that separate from the general store of sap, with which the bark is filled, the juices peculiar to these vessels.

OF THE BARK.

The bark lies next within the rind, and differs but little from it in construction, though it holds a more important office in the scale of vegetation, the growth and qualities of the tree being in a great measure connected with it. It is, therefore, found to differ considerably in substance, quantity, and quality, in various kinds.

It is originally the outer membrane, covering the lobes of the seed. Even there, as in the branch of a tree, it appears in the form of a kind of spunge, or like a crust of bread, composed of flatted bladders.

Its spunge-like nature may be further inferred from the contraction of its pores when dry, and the ease with which they dilate when in water. Grew has called it a most curious and exquisitely fine wrought spunge. In the course of its growth, the outer ranges of these bladders drying, it becomes what we call the rind; for the rind was once bark, and has only suffered a slight change in separating from it.

By the bark the tree is fed with a continual supply of moisture, protected from external injuries, and defended from the excesses of heat and cold; for these purposes it is variously disposed in different trees. In the hardy and slow growing, as the oak and chesnut, it is thin; in the quick growing, as willow, poplar, and the like, it is thick. And what is more particularly to be attended to is, that in some its inner verge is radiated. There are some trees, and a great many herbaceous plants, in which this part is continued inward, in form of rays, through the blea into the wood, and seems to form so many green wedges, that split as it were the substance of both those parts;* a circumstance which accounts for the vegetation of some particular trees, which are known to live when deprived of the bark; because they have rays of the same substance within which answer the purpose, and this in a degree answering to the nature of their life.

The bark appears to be formed, first, of longitudinal fibres, which Du Hamel considers as so many lymphatic vessels; secondly, by a sort of a filmy cellular tissue, which has been considered as a kind of bladders by some, or as parenchymatous by others; thirdly, of the vasa propria interiora, or interior juice vessels.

The longitudinal fibres are disposed in strata, which lie one over the other. In that stratum which is next the rind, or rather the cellular coat, we perceive a net of longitudinal fibres, the meshes of which are large and easily distinguished, particularly when the cellular tissue that fills up the interstices is removed. To do this, the branches should be macerated for a considerable time; some require to be kept in this state for years. It will then be easy to separate first the rind, then the cellular coating, and afterwards this pulpy matter. It may sometimes be easily removed after the branches have been boiled.

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* Hill's Construction of Timber, p. 118. Ibid. p. 120.

The most exterior stratum, when examined by the naked eye, seems to be formed of simple fibres, which graft, solder, or inosculate one with the other; but when examined by a microscope, each of these fibres will be found to be a bundle of filaments, which may be easily separated from each other.

Grew says, that each filament, like the nerves in animals, consists of twenty or thirty small contiguous tubes, which run uniformly from the extrémity of the root, without sending off any branches, or suffering any change in their size and shape. Hence the bark may be torn or divided lengthwise, with greater ease than in an horizontal direction; when macerated, they are capable of a very great degree of subdivision.

The filaments of a cortical vessel are to be looked on, agreeable to what we have already observed, as so many little bundles placed near together, and at first growing parallel to each other; but soon quitting this direction, the filaments of one fascicle parting from that to which they originally belonged, and inclining more or less obliquely towards another, sometimes uniting with it, at others, bending backwards, and uniting again with that from which it proceeded, or with some one that it meets with. In this manner new fascicles are often formed, while other parcels are increased or diminished by the additions of new filaments; by these means, a kind of irregular net is formed, and the fibres proceed in a serpentine line from the top to the bottom of the tree.

The thickness of the bark is entirely formed of strata of these longitudinal fibres, which lie one over the other; each of these strata is similar to the exterior one, only the meshes are smaller, and the fibres finer, in proportion as they are more interior, insomuch that at last the meshes are almost annihilated, and the fibres seem to lie quite parallel to each other.

There are some trees, however, where the meshes are not visible, and in which the fibres lie quite in a straight direction. There are many other circumstances in which they vary in different trees; in some the meshes of each stratum correspond with each other, diminishing gradually in size as they are more interior, and forming as it were so many conical cells.

We may, I think, conclude from what has been said, that the bark is composed of several thin membranes, which extend over the whole exterior surface of the tree. The most exterior membrane is the rind; under this is what Du Hamel calls the cellular coat; next to this the cortical stratum or true bark of the tree, which is formed of lymphatic vessels ranged more or less in a reticular form, and of the vasa propria interiora. The meshes are so constituted as to form large cavities next the rind, and small ones near the wood. These cavities are filled with a parenchymatous substance or the cellular tissue, which being continued from the wood to the rind, joins and unites the cortical stratum, and afterwards spreading on the outside thereof, forms what has been termed the cellular coat.

OF THE CELLULAR TISSUE.

We now proceed to give some account of the substance which fills up the vacant spaces that are left between the longitudinal fibres. It is called by Grew the parenchyma or pulp, by Malpighi, the vesicular tissue or web; both of them consider it as formed of small bladders or reticles, that are in contact with each other, lying in an horizontal position, or at right angles to the longitudinal fibres: they do not suppose them to be all of the same size, or even of the same figure: Grew compares it to the froth of beer or eggs. The flesh of fruits consists for the most part of this substance, very much filled with juice, though with considerable difference in its organization. Be this as it may, the nature of this substance, its form and structure, are at present but very little known. It is floccose, and varies in colour in different species.

OF THE VASA PROPRIA INTERIORA.

Besides the lymphatic vessels and the cellular substance, we find the juice vessels, or vasa propria, in the bark. In those trees which are famous for medicinal virtues, they are usually very large; they carry the milky juices of the sumach, and in them is lodged the finest and highest-flavoured turpentine in all the kinds of pine. Dr. Hill thinks that a tree of that genus exhibits them best, and the more, as the turpentine which fills them may be perfectly dissolved in spirit of wine. The pinus orientalis is the species in which these vessels are most distinctly seen.

OF THE BLEA.

This is that part of the tree which is formed into wood, and therefore lies between it and the bark, and may be separated from them by maceration.

A longitudinal piece of the blea, when examined by the microscope, exhibits a number of vessels running parallel to each other, the interstitial spaces being filled with a floccose, white, formless substance, of which Dr. Hill suspects even the vessels themselves to be formed. Innumerable small openings or mouths may be discovered in these vessels, suited to imbibe the moisture which is so essential to the life and health of plants. These mouths cannot be well discerned, except when they are opened by the season of the year, either before the first leaves of spring, or in the midsummer shooting time; though a small quantity of moisture will keep them open at that time, yet no quantity would be sufficient at an improper season.*

The blea is a zone more or less perfect, which lies under the bark, and covers or surrounds the wood, and is principally distinguished from it by being less dense. In some species the difference between the blea and the wood is very remarkable, in others it is less so.

The ancient botanists, struck with the difference they observed between the wood and the blea, compared this substance to the fat in animals. Malpighi, Grew, and Du Hamel considered it as the wood not yet arrived to a state of perfection. It is organized in a manner similar to the wood, and possessing the same vessels disposed nearly in the same manner. The juice vessels of this part may be separated from it by maceration; Dr. Hill says, that in this state they appear perfect cylinders, with thick white coats, the surface perfectly uniform.

OF THE WOOD.

When the bark and the blea are taken away, we come to the wood, which is a solid substance, on which the strength of the tree depends, and which has been considered by naturalists as being to the tree what bones are to the animal. The wood, in a general view may be considered as formed of strata, which are inclosed one within the other; these strata consist of ligneous fibres or lymphatic vessels, the cellular web or tissue, vasa pro-

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* Hill's Construction of Timber, p. 47.

pria, and what have been called the air vessels. It is more difficult to investigate the construction of the wood than that of the other parts, because the texture is in general much harder, and therefore not so easily separated, requiring very long macerations, and many subjects, before one may be found fit for examination.

If a transverse section of almost any kind of wood be examined, we shall perceive these strata very clearly and sensibly distinguished from one another. It has been generally supposed that each of these is the product of one year's growth; though, if we cut the same wood obliquely, it will be found that each of these strata is compounded of smaller ones, which are therefore not so easy to discover as the larger. By macerating rotten pieces of trees, the wood may be divided into an immense number of leaves or strata, thinner than the finest paper.

If the foregoing strata be examined in their detached state by the microscope, we shall find them to be composed of longitudinal fibres; some pieces of rotten wood, after maceration, will divide of themselves into very fine longitudinal fibres; the existence of these is further proved by the facility with which wood may be split in the direction of these fibres. From hence we may collect, that the ligneous strata are formed of small fibres or vessels, collected together in fascicles, like the bark: in some trees they are parallel to each other, in others they are disposed more obliquely, crossing and forming an irregular kind of network. There is great probability that this reticular disposition exists in all trees, though it may be difficult to discover it in many on account of the fineness of the meshes, the hardness of the wood, and the sameness of colour in the constituent fibres.

We are here only speaking of the lymphatic vessels or ligneous fibres of the wood, which exist in it as well as in the bark, though in different states; for the ligneous fibres are always harder and less flexible than the cortical ones. Malpighi thinks they differ in another particular, namely, that a juice or fluid issues from the cortical fibres, while none is found in those of the wood. In this it would appear from the observations of Du Hamel, that he was mistaken.

A transverse section of wood generally appears formed of a number of rays proceeding from the corona to the bark, which are intersected at different distances by concentric circles, interspersed with vessels of varying magnitude: the variations in this structure afford much pleasure to the curious observer, and throw considerable light upon the nature and properties of timber; for it is by means of a variety of strainers that different juices are prepared from the same mass. Matter, considered as matter, has no share in the qualities of bodies. It is from the arrangement of it, or the recipient forms given to it, that we have so many different substances. According to the modifications that these receive, we shall find the same light, air, water, and earth, manifesting themselves in one by a deadly poison, and in another by the most salubrious food. A lemon ingrafted upon an orange stock, is capable of changing the sap of the orange into its own nature, by a different arrangement of the nutritive juices. One mass of earth will give life and vigour to the bitter aloe, to the sweet cane, the cool house-leek, and the fiery mustard, the nourishing grain, and the deadly night-shade.

The wood may be considered as composed of two parts, ligneous and parenchymatous. The former has already been treated of; the latter is that which is disposed into rays, running as it were between the ligneous fibres, and interweaving with them; it originates either with the pith or corona. There is a very great diversity in these radial insertions; in some trees there are very few, while they abound in others; in some they are very fine, in others very thick. In texture, they seem similar to the blebs of the bark, only that here they are so crowded and stretched out as to appear like parallel threads, somewhat similar to a net when drawn tight.

OF THE CORONA.

Dr. Hill gives this name to that circle which surrounds the pith, and separates it from the wood; although in his opinion it differs greatly from both, and in its composition has no resemblance to either. It is, according to him, the most important part in the whole vegetable fabric, by which the propagation and increase of the branches, buds, and shoots, are carried on.*

It has been usual to suppose the pith of vegetables to be the part in which these wonderful sources of increase reside, but this is not the case; and he asserts, that so far from being prior to the other parts, it is in reality posterior to some of them in the time of its formation.

The corona is not so uniform as the other parts, nor is it constituted exactly similar in all trees. It is placed between the pith and wood in all vegetables, forming a ring, whose outline is more or less regulated. The general circle is cellular, composed of blebs and vessels, like the bark and the rind, and is perfectly similar to them, only that at different distances oblong clusters of different vessels are placed amongst it. These clusters are usually eight or ten in number, and give origin to the angles of the corona. They are not uniform, or of one kind of vessels, as in the bark, but each has two distinct sorts, the exterior one an-

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* Hill on the Construction of Timber, p. 55.

swering to the blea, and the interior, to the wood of trees; and within each of these are disposed vessels not unlike those in the blea and wood, though often larger than they are found in those parts.

Thus each cluster is composed of all the essential parts of the succeeding branch, and the intermediate parts of the circle are absolutely bark and rind; they are ready to follow and clothe the cluster when it goes off in the form of a shoot, because it will then need their covering and defence, though in its present inclosed state it does not. It is from this construction, that a tree is ready at all times and in all parts to shoot out branches, and every branch in the same manner to send out others; for the whole trunk, and the branch in all its length, have this course of eight or ten clusters of essential vessels ready to be protruded out, and the proper and natural integuments as ready to cover them. In some trees, these parts are more evident, in others more obscurely arranged. Dr. Hill says, the bocconia, or parrot-wood of the West-Indies, and the greater celandine, are proper subjects for opening this great mystery of nature. On the corona and its clusters depend that property of vegetables, that they can be produced entire from every piece. These clusters follow the course of the other portions of the tree; they are therefore everywhere; they are always capable of growing, and their growth, even in a cutting of the smallest twig, cannot produce a leaf, or any other part of a vegetable alone, but must afford the whole; for they are complete bodies, and the whole is there waiting only for the opportunity of extension, by obtaining sufficient nourishment. For the knowledge we have of this part we are altogether indebted to Dr. Hill. It remains for future observers to confirm or disprove his observations.

OF THE PITH.

The pith is found in the center of every young shoot of a tree; it is large in some, less in others, but present in all. It is placed close within the corona.

It seems to be nothing more than a congeries of the cellular tissue; it is generally found near the center of the tree, inclosed as it were within a tube; in general, the cells of the pith are larger than those of the cellular tissue, with which, according to Du Hamel, it communicates. For the rays which extend from the pith to the bark are, in his opinion, produced from it. Thus, though it may differ in name from the parenchymatous parts of the bark, and the radial insertions in the wood, yet it is of the same nature and texture, and is continuous with them; so that, according to this idea, the skin, the parenchyma, the insertions, and the pith, are all one piece of work, filled up in divers manners with the vessels.

The bark and the wood grow thicker every year, while the pith, on the contrary, grows more slender, so that in a branch of one year it is of a larger size than it is in the same branch when two years old, and so on. In very young branches, while in an herbaceous state, the pith forms the greatest part of its substance; but when the fibres are stronger, the pith becomes less succulent, and surrounded with a tube of wood; when the branch has arrived to a certain age, it is so compressed as to be almost annihilated. In examining different branches that proceed from others in their first state, a small communication between the pith of the one and the other will be found; but this communication is generally entirely closed up in the second or third year.* The

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* Du Hamel Physique des Arbres, tom. 1, p. 38.

cells of which the pith is formed are at first entirely one connected body; but as the plant grows up, it is often so broken and ruptured, as to remain no longer a continuous substance.

This, as well as many other particulars in the history of the pith, corroborates the opinion of Dr. Hill,* who thinks it is formed for the purpose of moistening the clusters of the corona, and regulating its extension; it has been supposed coeval with, or primordial to all the other parts, but he thinks it is postnate, and comes after them in the order of time, as well as in its uses; that exhaled air gives origin to its blebs, and the thickness of the juices cloathing the bubble, gives it form and substance. The first season is the time of its greatest use, and it immediately after begins to decay.

The pith has in general been represented as much more complex than it really is. It consists of a range of bladders lying one over the other. The membrane is simple, the outline single; but as it is very difficult to procure it in this simple state, it is often seen and represented under a variety of irregular, though pleasing forms, which are occasioned by the intersections of the outlines of the blebs, as seen one over another.

A cluster in any part of the corona, protruding itself onward and outward in the growing season,† carries a part of the circle out with it. The cluster itself is a perfect piece of the wood and blea, and the bark which follows it out in its progress perfectly clothes it; thus is the first protrusion of ths shoot made, but all this while there is no pith. The continuation of growth is made by the extension of all the parts obliquely upwards; in the course

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* Hill's Construction of Timber, p. 66. † Ibid. p. 99.

of this extension they hollow themselves into a kind of cylinder, of the form of the future branch, and by this disposition a small vacancy is made in their center. This enlarges as they increase, and as it enlarges it becomes filled with the exudation of those little bladders which remain and constitute the pith, fed from the inner coat of the pith, which already begins to form itself into a new corona. Grew seemed to think, that in some instances the pith was of posterior growth to the other parts, and derived its origin from the bark; and that the insertions of the bark running in between the rays of the wood meet in the center, and constitute the pith.

OF THE SAP VESSELS.

The most numerous and the largest apertures are generally to be found in the wood, which are perceived very distinctly in a transverse section, in which the ends of the vessels are seen as cut through by the knife. The scarlet oak of America is recommended as a proper object for exhibiting them. If a short cylinder of a three years branch of this oak, a little macerated, be hollowed away with a chissel, we shall see what a large portion of the wood is occupied by these vessels; they are thick and strong, and it is easy, with some care and attention, to loosen several of them.

If a number of these thus separated be put into a vial of rain water, and frequently shook for several days, some will at length be found perfectly clean; these are then to be put into spirit of wine, and when that has been two or three times changed, they will be in a condition to be viewed for understanding their structure; another method of preparation has already been shewn in page 162.

These are the vessels which have been called by some writers air, by others, tracheal vessels. It is, however, to be remarked, that most of those who have considered them as air vessels, refer us to the tree while in a more herbaceous state; in this case they say, that we shall find these parts filled with a fine spiral filament. As these vessels are often to be found empty, they have been supposed to answer the purposes of lungs to the plant. Malpighi asserts, that if they be examined in winter, they often exhibit a vermicular motion, which astonishes the spectator.

Those who suppose the corona to contain the whole structure of the tree in miniature, and that it is the embryo of future shoots, suppose it to contain the vessels proper for each part, a subject that must be left to the decision of future observers.

OF THE VASA PROPRIA INTIMA.

These are the only vessels which remain to be spoken of. They are large, conspicuous, and important; their natural place is in the blea, though they are sometimes repeated in the wood and the corona. Their coats are thicker than those of any other vessels.* It is not difficult, after a successful maceration, to separate some of these vessels from the blea; in this state they appear perfect cylinders, with thick white coats, of a firm, solid, and uniform texture.

It has generally been supposed, that each of those concentric circles, which are to be observed in the transverse section of almost every tree, was the product of one year, or the quantity of wood added to the tree in that space; here, however, Dr. Hill differs again from the general opinion.

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* Hill's Construction of Timber, p. 83 and 85

From what has been said, we may deduce the following general ideas relative to the organization of trees. The most obvious and remarkable parts of a plant, or tree, are the root, the stem, the branches, the leaves, the flower, and the fruit. The component parts of these divisions are not complicated; they are simple when compared with those of an animal, and this because the offices of the vegetable are fewer than those of the animal.

The interior part may be considered as consisting of ligneous fibres, interspersed with a vast number of bladders, which are here named the cellular tissue, the vasa propria, and the sap vessels; though these are considered by some writers as mere air vessels.

The ligneous fibres are very fine tubes, proceeding nearly in a vertical direction from the top to the bottom of the tree; they are sometimes parallel to each other, sometimes they divaricate, and often leave oblong intervals or spaces. There is great reason for supposing them to be a species of lymphatic vessels. The vacant spaces between these fibres are filled up by a vesicular membrane, lying in an horizontal direction, and which is called in this chapter the cellular tissue.

The vasa propria are formed of ligneous fibres, but differ from the foregoing in their size, and in the juices which they contain. In the part properly called the wood, we meet with the sap vessels; but as in some states they seem as if they were formed of a silver-coloured spiral membrane, and are found without any juices, they have been supposed to be air vessels, and called the trachea, making up an arterial system, and supplying the place of the heart in animals.

The interior part of the tree may be further considered as divided into four principal concentric strata, the bark, the blea, the wood, and the pith; to these Dr. Hill has added the corona. Whatever part of a plant is examined, we find these and no more. The root, its ascending stalk, and descending fibre, are formed of one, and not three different substances. Thus the whole vegetable is reduced to one entire body. And what appears in the flower to be formed of altogether distinct parts, will be found to originate in these.

The bark, which is the exterior covering of the tree, is divided into two parts, a thin outer rind, and a much thicker inner one. The exterior one seems to be little more than a fine film of irregular meshes, the inner one composed of large blebs, leaving in some subjects large vacant spaces, which form its vasa propria. It is made up of several strata lying one over the other.

Next to this is the blea, which is of an uniform structure. It is an imperfect wood, waiting only for the hand of time to be brought to perfection. The duration of the blea in this middle state depends on the internal powers and strength of the tree, being so much shorter as this is more vigorous.

The wood, including the corona, comes next; it differs in density and duration both from the blea, the bark, and the wood. It is made up of strong fibres. The life of the vegetable seems to reside in it; from it all the other parts are produced. It shoots a pith inwards, and a blea and a bark outwards.

Every tree may be considered as consisting of numerous concentric strata or flakes, forming so many cones, inscribed one within the other, and whose number is almost indefinite. The most exterior contain the rudiments of the bark; the more interior, those of the wood. In the germ they are gelatinous, by degrees they become herbaceous, and in process of time assume the consistence of wood. Thus the stem, the root and the branch, may be considered as formed of a prodigious number of concentric vertical strata, each composed of different fascicles of fibres; which fibres are again formed of smaller ones. The spaces between these, and among the fibres, are filled up, interwoven with, and connected by the cellular tissue, of which the radial insertions are formed.

The strata harden successively one after the other; the most interior stratum is that which hardens first; this is then covered by another which is more ductile and herbaceous, and so on; so that the bulk of the tree is increased every year by the accession of an hollow cylinder of wood derived from the internal bark. From the extension in breadth, the tree acquires bulk; from that in length it gains its height. The strata gradually diminish in size as they gain in length; from hence the conical figure of the root, stem, and branch. All the parts of the plant are the same, differing in nothing more than in shape and size. The roots are sharp and pointed, that they may make their way more readily through the earth. The leaves are broad, that they may more effectually catch the moisture from the atmosphere, &c. When the root of a tree is elevated above, instead of being retained under the earth, it assumes the appearance of a perfect plant, with leaves and branches. Experiment shews that a young tree may have its branches placed in the earth, and its roots elevated in the air, and in that inverted state it will continue to live and grow. The principal source of the phænomena of vegetation is the simplicity and uniformity of their organization.

The figures in Plates XXVIII. XXIX. and XXX. are portions of transverse sections of trees and herbs. The sections were cut by Mr. Custance,* who first brought this art to perfection, and remains hitherto unrivalled in these performances.

Plate XXVIII. Fig. 1, exhibits a piece of an herb growing on rubbish, and known by the name of fat-hen:† Fig. 2, a microscopic view of the same. Fig. 3, a magnified representation of a section of a reed that comes from Portugal: Fig. 4, the real size of the section.

Plate XXIX. Fig. 1, is a magnified view of a section of the althea frutex: Fig. 2, the natural size of the section. Fig. 3, a magnified view of a section of the hazel: Fig. 4, its natural size. Fig. 5, a microscopic view of a section of a branch of the lime-tree: Fig. 6 represents its natural size.

Plate XXX. Fig. 1, a magnified view of a section of the sugar cane: Fig. 2, its natural size. Fig. 3, a magnified view of a section of the bamboo cane: Fig. 4, the natural size. Fig. 5, a magnified view of a section of the common cane: Fig. 6, the real size.

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* For a collection of Mr. Custance's vegetable cuttings, and which, in sets, usually accompany the best sort of microscopes, made by Messrs. Jones, see the list of microscopical objects now annexed to this work by the editor.

† Chenopedium bonus Henricus.

CHAP. X.

OF THE CRYSTALLIZATION OF SALTS, AS SEEN BY THE MICROSCOPE; TOGETHER WITH A CONCISE LIST OF OBJECTS.

CRYSTALLIZATION, in general, signifies the natural formation of any substance into a regular figure, resembling that of a natural crystal. Hence the phrases of the crystallized ores, crystallized salts, &c. and even the basaltic rocks are now generally reckoned to be effects of this operation; the term, however, is most commonly applied to bodies of the saline kind; and their separation in regular figures from the water, or other fluid in which they were dissolved, is called their crystallization. If the word crystallization were to be confined to its most proper sense, as it seems to have been formerly, it could only be applied to operations by which certain substances are disposed to pass from a fluid to a solid state, by the union of their parts, which so arrange themselves, that they form transparent and regularly-figured masses, like native crystal; from which resemblance the word crystallization has evidently been taken.*

But modern chemists and naturalists have much extended this expression, and it now signifies a regular arrangement of the parts

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* Macquer's Dictionary of Chemistry, Art. Crystallization.

of any body which is capable of it, whether the masses so arranged be transparent or not. Thus opake stones, pyrites, and minerals when regularly formed, are said to be crystallized, as well as transparent stones and salts.

The opacity and transparency of substances are justly disregarded, in considering whether they be crystallized or not; for these qualities are perfectly indifferent to the regular arrangement of the integrant parts of substances, which is the essential object of crystallization.

This being established, crystallization may be defined, an operation by which the integrant parts of a body, separated from each other by the interposition of a fluid, are disposed to unite again, and to form solid, regular, and uniform masses.

To understand as much as we can of the mechanism of crystallization, we must remark,

1. That the integrant parts of all bodies have a tendency to each other, by which they approach, unite, and adhere together, when not prevented by an obstacle.

2. That in bodies simple or little-compounded, this tendency of integrant parts is more obvious and sensible than in others more compounded; hence the former are much more disposed to crystallize.

3. That although we do not know the figure of the primitive integrant molecules of any body, we cannot doubt but that those of every different body have a constantly uniform and peculiar figure.

4. That these integrant parts cannot have an equal tendency to unite indiscriminately by any of their sides, but by some preferably to others, excepting all the sides of an integrant part of a body be equal and similar; and probably the sides, by which they tend to unite, are those by which they can touch most extensively and immediately.

The most general phænomena of crystallization may be conceived in the following manner:

Let a body be supposed to have its integrant parts separated from each other by some fluid; if a part of this fluid be taken away, these integrant parts will approach together: and, as the quantity of intervening fluid diminishes, they will at last touch and unite. They may also unite when they come so near to each other, that their mutual tendency shall be capable of overcoming the distance betwixt them. If, besides, they have time and liberty to unite with each other by the sides most disposed to this union, they will form masses of a figure constantly uniform and similar. For the same reason, when the interposed fluid is hastily taken away, so that the integrant parts shall be approximated, and be brought into contact before they have taken the position of their natural tendency, then they will join confusedly by such sides as chance presents to them; they will, in such circumstances, form solid masses, whose figures will not be determinate, but irregular and various.

Different salts assume different figures in crystallization, and are, by these means, easily distinguished from one another. But besides the large crystals produced in this way, each salt is capable of producing a very different appearance of the crystalline kind, when only a drop of the saline solution is made use of, and the crystallization viewed through a microscope. For our knowledge of this species of crystallization, we are indebted to Mr. Henry Baker, who was presented by the Royal Society with a gold medal for the discovery, in the year 1744. These microscopical crystals he distinguishes from the larger ones by the name of configurations; but this term seems inaccurate, and the distinction may be properly preserved by calling the large ones the COMMON, and the small ones the MICROSCOPICAL, crystals of the salt.

It has not yet been shewn by any writer on the subject, why salts should assume any regular figure, much less why every one should have a form peculiar to itself. Sir Isaac Newton endeavoured to account for this, by supposing the particles of salt to be diffused through the solvent fluid, at equal distances from each other; and that then the power of the attraction between the saline particles could not fail to bring them together in regular figures, as soon as the diminution of heat suffered them to act on each other. But it is certain some other agent must be concerned in this operation, besides mere attraction, otherwise all salts would crystallize in the same manner. Others have, therefore, had recourse to some kind of polarity in the particles of each salt, which determined them to arrange themselves in such a certain form; but unless we give a reason for this polarity, we only explain crystallization by itself. One thing seems to have been overlooked by those who have endeavoured to investigate this subject, namely, that the saline particles do not only attract one another, but they also attract some part of the water which dissolves them.

Did they only attract each other, the salt, instead of crystallizing, would fall to the bottom as a powder; whereas, a saline crystal is composed of salt and water, as certainly as the body of an animal is composed of flesh and blood, or a vegetable of solid matter and sap; if a saline crystal be deprived of its aqueous part, it will as certainly lose its crystalline form, as if it were deprived of the saline part. It is, therefore, not improbable, that crystallization is a species of vegetation, and is accomplished by the same powers to which the growth of plants and animals is to be ascribed. Some kinds of crystallization resemble vegetation so much, that we can scarce avoid attributing them to the same cause.

It has been imagined, that all the great operations in nature may be reduced to two principles, those of crystallization and organization; but that often they are so concealed, as to be invisible. Hence crystallized substances have been frequently mistaken for organized ones, and vice versa. They differ, however, essentially in their growth and origin. Organized beings spring from a germ, in which all the essential parts are concentrated, and they grow by intusception; whereas crystallized substances increase by the successive apposition of certain molecules of a determined figure, which unite in one common mass. Thus crystallized beings do not grow, properly speaking, though their substance is augmented, they are not preformed, but formed daily.

The phænomena of crystallization have much engaged the attention of modern chemists, and a vast number of experiments has been made with a view to determine exactly the different figures assumed by salts in passing from a fluid to a solid form. It does not, however, appear, from all that has yet been done, that any certain rule can be laid down in these cases, as the figure of saline crystals may be varied by the slightest circumstances. Thus, sal ammoniac, when prepared by a mixture of pure volatile alkali with spirit of salt, shoots into crystals resembling feathers;

but if, instead of a pure alkali, we make use of one just distilled from bones, and containing a great quantity of animal oil, we shall, after some crystallizations of the feathery kind, obtain the very same salt in the form of cubes.

Such salts as are sublimeable crystallize not only in the aqueous way by solution and evaporation, but also by sublimation; and the difference betwixt the figures of these crystals is often very remarkable. Thus, sal ammoniac, by sublimation never exhibits any appearance of feathery crystals, but always forms cubes or parallelopipeds. This method of crystallizing salts by sublimation has not as yet been investigated by chemists; nor indeed does the subject seem capable of investigation without much trouble, as the least augmentation of the heat beyond the proper degree would make the crystals run into a solid cake, while a diminution of it would cause them to fall into powder. In aqueous solutions, too, the circumstances which determine the shapes of the crystals are innumerable; and the degree of heat, the quantity of salt contained in the liquor, nay, the quantity of the liquor itself, and the various constitutions of the atmosphere at the time of crystallization, often occasion such differences as seem quite unaccountable and surprizing.

Mr. Bergman has given a dissertation on the various forms of crystals; which, he observes, always resemble geometrical figures more or less regular. Their variety at first appears infinite; but by a careful examination it will be found, that a great number of crystals, seemingly very different from each other, may be produced by the combination of a small number of original figures, which therefore he thinks may be called primitive. On this principle he explains the formation of the crystalline gems, as well as salts.*

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* Encycl. Britan. Vol. V. p. 583.

It has been already shewn, page 163, how to prepare the various salts for microscopical observations. The beautiful crystallizations represented in Plates XXXI. and XXXII. were produced in the manner there described.

Plate XXXI. Fig. 2, exhibits a view of the microscopical crystals of nitre. These shoot from the edges with very little heat, in flattish figures, of various lengths, and exceedingly transparent, the sides nearly parallel, though rather jagged, and tapering to a point; after a number of these are formed, they often dissolve under the eye, and disappear entirely; but in a little time new shoots will push out, and the process go on afresh. Beautiful ramifications are formed round the edge, and many regular figures are to be observed in different parts of the drop. Fig. 1 is the real size of the drop.

Fig. 4 is a drop of distilled verdigrise, as it appeared when viewed by the microscope. There is a difference in the appearance from this substance, according as the time of the application is nearer to, or more distant from that in which the solution was made. Fig. 3, the size of the drop.

If a drop of distilled verdigrise upon glass be viewed through the microscope, after the crystallization is completed and the water evaporated, there remains a substance round the crystallization, which preserves the original size and shape of the drop when a liquid; betwixt this verge of the drop and the crystals fine lines are discernible running from the crystals to the circumference of the drop, at various angles with the crystals; whatever direction they take, they are always perfectly straight, and of an equal thickness throughout. When the drop is viewed through a light ground, these lines appear dark; but when viewed through a dark ground, they then shine and appear of the beautiful green colour natural to the crystals of verdigrise.

Plate XXXII. Fig. 1, represents the microscopical appearance of the crystals of salt of wormwood. The shootings from the edges of this solution are often very thick in proportion to their length, their sides full of notches, the ends generally acute; many spear-like forms are also to be observed, as well as little crystals of a variety of figures.

Fig. 2. Salt of amber. The shootings of this salt are highly entertaining, though the process is very slow; many spiculæ shoot from the edge towards the middle of the solution, and from the pointed ends of the spiculæ a great variety of diversified branches may be observed, variously divided and subdivided, and forming at last, says Baker, a winter scene of trees without leaves.

Fig. 3. Salt of hartshorn. This salt shoots out from the edge of the drop into solid, thick, and rather opake figures; from these it often shoots into branches of a rugged appearance, similar to those of some species of coral.

Fig. 4 represents the microscopical crystals of sal ammoniac. These form a most beautiful object in the microscope; a general idea may be more easily acquired by attentively viewing the figure here exhibited, than by any verbal description.*

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* A collection of salts, as recommended by Mr. Baker, properly prepared and packed in portable boxes by Messrs. Jones, the reader will see in the extensive list of microscopic objects now annexed to this work by the editor.

A
CONCISE LIST OF OBJECTS
FOR
THE MICROSCOPE.

The short list here presented to the reader must, from the nature of the subject, be very imperfect; for the whole of the animal, vegetable, and mineral kingdoms, with all their numerous subdivisions, furnish objects for the microscope; and there is not one of them, that, when properly examined, will not afford instruction and entertainment to the rational investigator of the works of creation. The Systema Naturæ of Linnæus may therefore be regarded as a catalogue of universals for microscopic observation, each of which comprehends a variety of particulars. The list here given can be considered as little more than a directory, to point out to those who have only begun to study this part of natural history a few of those objects which merit their attention, and which, from their beauties, may incite them to pursue the study with greater ardor.

OF OPAKE OBJECTS.

Ores and minerals afford an immense variety of very beautiful and splendid objects. From amongst these the observer may select the peacock or coloured copper ore, green crystallized ditto, lead ore, crystallized ditto, crystals of lead, small grained marcasites, coloured mundic, cinnabar, native sulphur, needle and other antimony, moss copper, &c. A mixture of small pieces of ores, &c. of different kinds, produces a pleasing effect. Sands in general exhibit something not discoverable with the naked eye. Sand from the sea-shore is often intermixed with minute shells, particularly that from Rimini, in Italy. Mr. Walker has published a specimen of the small microscopic shells which are found on our own coast. From this work we learn, that there are shell-fish as small as the minutest insects, and possessed of beauties of which we can form no conception till we have seen them. Mr. Walker's work is entitled, " A Collection of the minute and rare Shells lately discovered in the Sand on the Sea-shore near Sandwich."* There is a sand from Africa full of small garnets. The ketton, or kettering stone, is a pleasing object; when examined by the microscope, we find the grain of it very different from that of other stones, being composed of innumerable minute balls, which barely touch each other, and yet form a substance much harder than free-stone; the grains are, in general, so firmly united together at the points of contact, that it is hardly possible to separate them without breaking one or both of the grains. See Hooke's Micrographia.

Insects of all kinds, both foreign and domestic, are pleasing objects; but as the foreign ones are not so easily met with, I shall mention but a few of them, confining myself principally to those of this country. Among the exotic insects, none appear more beautiful in the microscope than the curculio imperialis, Brazil or diamond beetle; the buprestis ignita, or large beetle from China; the meloe vesicatorius, Linn. the cantharis or Spanish fly of the shops; several species of locusts, grasshoppers, &c.

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* This publication will be more particularly noticed in the ensuing chapter. EDIT.

Among the English beetles, we may reckon the scarabæus auratus or rose chaffer, scarabæus nobilis, scarabæus horticola, silpha aquatica, cassida nobilis and nebulosa. Coccinella or lady-cow; of these there are great varieties both in size and colour, some red and black, others black and red, and some yellow and black. Chrysomela graminis, chrysomela fastuosa, chrysomela nitidula, chrysomela sericea, chrysomela melanopa, chrysomela asparagi, see Plate XX. Fig. 2. Curculio frumentarius, lapathi, betula, nucum, scrophularia, argenteus, a beautiful little insect resembling the diamond beetle, but in miniature; curculio albinus, very beautiful, but scarce in this country. Leptura aquatica, these are of various colours, as blue, purple, bronze, and crimson. Arcuata arietis, very common, and is often called the wasp beetle. Cicindela campestris, on dry banks. Carabus nitens, found in Yorkshire, a beautiful insect; many small carabi. Gryllus, gryllo-talpa or mole cricket, this insect, and the grasshoppers, are many of them too large to be observed at one view, but the head, fore and hind feet, elytra, &c. viewed separately, are fine objects. Cicada sanguinolenta, nervosa, interrupta, notonecta striata, minutissima, head and claws of the nepa cinerea or water-scorpion, and the whole variety of cimices or field bugs. The wings of butterflies and moths; the chrysalis of the common white butterfly is extremely fine.

I wish it were in my power to invite the reader to consider the pupa state of these insects, as he would find them interesting in various points of view. Perhaps the following passage from an ingenious writer may have this effect.

" Some of these creatures crawl for a time as helpless worms upon the earth, like ourselves; they then retire into a covering, which answers the end of a coffin or a sepulchre, wherein they are invisibly transformed, and come forth in glorious array, with wings and painted plumes, more like the inhabitants of the heavens than such worms as they were in their former state. This transformation is so striking and pleasant an emblem of the present, the intermediate, and glorified state of man, that people of the most remote antiquity, when they buried their dead, embalmed and inclosed them in an artificial covering, so figured and painted, as to resemble the caterpillar in the intermediate state; and as Joseph was the first we read of that was embalmed in Egypt, where this custom prevailed, it was probably of Hebrew original."

The eggs of moths and butterflies, particularly the phalæna neustria, see Plate X. Fig. 1 to 6. The bodies and heads of many libellulæ.

Many of the ichneumon flies, spheges, and wasps, head of the hornet, sting of ditto, collectors of the bee, many sorts of muscæ, or flies with two wings, especially those whose bodies are highly coloured; acari or ticks; phalangium cancroides, see Plate XVIII. Fig. 1 and 6. Some spiders, but the eyes of all; the oniscus or wood-louse, julus, and scolopendra.

The feathers of peacocks, and many other birds, have a grand effect when viewed in the opake microscope, as have also some species of ferns, mosses, and wood cut transversely. Madrepores, millepores, sponges, corallines, &c. exhibit wonderful appearances not discernible to the naked eye. Parts of echini or sea eggs, spines of ditto; these may also be cut transversely to shew their construction. Minute shells dissected, skin of many species of fish, particularly the lump-sucker, see Plate XVIII. Fig. 2. Sole fish, Plate XIX. Fig. 5. and the rasp fish from Otaheite; also the skins of snakes, lizards, guanas, &c. &c.

The exterior form, and even the interior structure of the generality of vegetable seeds, have been supposed by some so much alike in the several kinds, and of so little curiosity and beauty in the whole, that they have scarcely been regarded by the curious; but when nearly examined with the help of microscopes, they are found to be worthy of a greater attention; those which appear most like to one another when viewed by the naked eye, often proving as different, when thus examined, in their several forms and characters, as the different genera of any other bodies in the creation. If their external forms carry all this variety and beauty about them, their internal structure, when laid open by different sections, appears yet more admirable.

The seed of the greater maple, which we commonly, but improperly call the sycamore tree,* consists of a pod and its wing; two of these grow upon a pedicle, with the pods together, which makes them resemble the body of an insect with its expanded wings: the wings are finely vasculated, aud the pods are winged with a fine white down resembling silk; this contains a round compact pellet, covered with a brown membrane that sticks very closely to it. When this is pulled off, instead of discerning a kernel, as in other seeds, there appears an entire green plant folded up in a most surprizing manner. The pedicle of this is about two-eighths of an inch long, and its seminal leaves of about six-eighths each; between these the germina of the next pair of leaves are plainly visible to the naked eye, but with a microscope they are seen with the greatest beauty and perfection.

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* The Acer pseudo-platanus, Hudsoni Fl. Angl. p. 445. Parkinson calls it acer majus, adding, sycomorus falso dictum. Hudson, however, agrees with Hunter in his edition of Evelyn's Sylva, in affixing to it the English term greater maple or sycamore. Edit.

The seed of the musk scabious is beautiful in its shape and structure. The calix or cup which contains the seed is of an octogonal form, and makes an appearance like a fine vase, having scallopped edges, and toward the inner part of the edge a white ruffled membrane. The ribs run down from its mouth, which is bell-fashioned, and becoming narrower downward, form obtuse angles by continuing from the bend to form the bottom of the vase. Between these ribs, down to the beginning of the narrow part, it is clear, though not wholly transparent, and from thence to the bottom the ribs are hairy. This vase contains the seed, wherein appears first its thick body, which runs up with a narrow neck, till it divides into five spiculated fibres, whose spiculæ are determined upwards, and are thereby prepared to cause the seed to recede from any thing that might injure it on being touched. The bodies of the vases, when first ripe, are of a fine lemon yellow, but grow by long keeping darker; and the bason formed by the roots of the minute fibres is of a fine green, but the fibres themselves of a shining brown, like brown sugar-candy, as their spines are also.

These, and a number of similar beauties in this part of the creation, are described at large by Dr. Parsons, in his work entitled, " The Microscopic Theatre of Seeds."* Most kinds of seeds should be prepared for a microscopical examination by steeping them in warm water till their coats are separated, and their seminal leaves may then be opened without laceration. But

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* This curious work was published in the year 1745. It was the author's intention to have comprised the whole design in four volumes quarto, but the first volume only appeared. It contains the etymology, synonyma, and description of the several plants and their flowers, with an account of their medical virtues, and an explanation of botanical terms. As the work is in but few hands, and a copy not easy to be procured, I flatter myself that extracts from those parts containing the microscopical descriptions will form an agreeable addition to these Essays; which the reader will accordingly meet with in the following chapter. EDIT.

seeds, while dry, and without any preparation, are of an almost infinite variety of shapes, and afford a number of pleasing objects for the microscope.

One of the most interesting scenes in microscopical botany is exhibited in mouldiness. Those miniature plants seem to bear the same relation to the vegetable kingdom that the animalcula infusoria do to the animal; they were formerly considered as shapeless and unformed masses, but we now view them with surprize and pleasure taking their place in the great scale of organized beings, and presenting us with some of the most striking characteristics of vegetables.

OF TRANSPARENT OBJECTS.

We may select from the elytra, or upper wings of beetles, many beautiful objects, the construction of these will be found to differ very much; the membranaceous wings, as in the scarabæus solstitialis or small cock-chaffer; blatta Americana or cockroach; all the grylli, as locusts, grasshoppers, &c. Among the cicadas, the elytra of the nervosa are the most elegant, the nerves are elevated, and curiously spotted with brown. The elytra of the cimices or field bugs, which are a very numerous tribe, afford a great variety of objects; we may select from these as the most beautiful the elytra of the cimex baccarum and the cimex striatus, Plate XX. Fig. 1. The elytra of the fulgora candelaria, from China, differ essentially from all others.

The under or more transparent wings of beetles excite our attention even more than the upper or crustaceous ones; for whether we consider the delicacy of their texture, the great weight that many of them are calculated to sustain in the air, or the very curious manner in which they fold them up under the upper case, their mechanism must astonish and delight us; no two genera will be found alike, though every individual of the same genus will be exact. The wing of the forticula auricularia or earwig, Plate XIV. is an elegant specimen of the manner of their folding; this wing folds under a case not one-eighth of its size.

The under wing of the blatta orientalis, or beetle common in most kitchens, appears to unite the elytra and transparent wings, partaking in some degree of both.

Among the membranaceous or more transparent winged insects, the variety is endless, each genus differing essentially from the other; some appearing full of membranes or nerves, curiously disposed; others, again, with scarce any, like a clear piece of talc or isinglass; some exhibit a curious ground-work of points, which on close examination prove short hairs, while the nerves of others are furnished with little scales or feathers, as in some species of the gnat. The wings of many muscæ are coloured with black, brown, and white, in clouds, spots, stripes, &c. &c.

The libellulæ or dragon-flies alone afford a great variety, not only in form but colour; these are all furnished with numerous and very strong nerves, adapted to the velocity of their flight. The wings of the ephemera or may-flies, are much more delicate, these flies rest with their wings erect. The phryganeæ differ very much from the foregoing, and also from one another; their under wings fold, and their upper ones are of a stronger texture, many of them so much resembling small moths as not easily to be distinguished from them: these are all found in the vicinity of ponds and marshy places. In the hemerobii a wonderful degree of elegance is exhibited in the disposition of the nerves which compose their wings, each nerve being adorned with hair in a beautiful manner; there are many species of these flies equally beautiful, a specimen is given in Plate XV. The ichneumon fly has four transparent wings, the inferior ones smaller, and more delicate than the superior; the tube through which the female deposits its eggs is an additional object well worth attention. The wings of wasps are folded longitudinally; the wings of the large bee are very curious. Gnats in general, and the various species of tipulæ, together with the clouded and variegated wings of the muscæ, tabani, &c. increase the catalogue beyond the power of enumeration; in short, there is not a wing but has its particular beauties, and will amply repay the attentive observer. The currant sphinx moth connects the transparent and farinaceous wings, partaking of both; the white plumed, and many-plumed moths, exhibit wings totally different from all the rest; many other small moths furnish wings sufficiently transparent for observation, the fringe or edges being remarkably beautiful.

OF THE PULEX IRRITANS, OR COMMON FLEA.

Many small insects that are not too opake, may be viewed and examined as transparent objects; some of these having been particularly noticed by the early microscopic writers, it will be necessary to enumerate a few of them, as without it the work might be deemed incomplete. Every one is acquainted with the agility and blood-thirsty disposition of the flea, of the caution with which it comes to the attack, and the readiness with which it avoids pursuit. It belongs to the class aptera, has two eyes, six feet particularly constructed for leaping, the antennæ or feelers are filiform, or rather moniliform; the rostrum is inflected, setaceous, and armed with a sting; the belly is compressed. This creature is produced from eggs, which it deposits on the animals that afford it food, or affixes them to the wool of blankets, rugs, &c. These eggs in about a week are hatched into small larvæ or worms, which are of a whitish colour, with a slight tinge of reddish, and adhere closely to the body of the animal, or other substance on which they are produced; in a fortnight they come to a tolerable size, and are very lively and active; but if they be touched, they roll themselves up in a ball. At this period they prepare themselves for their pupa or chrysalis state, by inclosing themselves in a loosely-spun web, or diffused envelopement of a very soft, silky, or rather cotton-like appearance, and of a white colour. In this the larva changes into a chrysalis, out of which in about twelve days emerges the animal in its perfect state, armed with powers to disturb the peace of an emperor, and occasion uneasy sensations in the fairest bosom.*

It is difficult to obtain such a view of the flea, as will display the mechanism and apparatus belonging to the head; these parts are but imperfectly represented in the celebrated drawing of Dr. Hooke in his Micrographia. The neck is long, finely arched, and much resembles the tail of a lobster; the body is covered all over with a polished suit of sable armour, formed of a hard shelly substance, curiously jointed and folded over one another, and yet yielding to all the nimble motions of the little animal; the edges of the scales are curiously set with short spikes or hairs: it has two sharp eyes to look before it leaps, for which purpose its legs are excellently adapted, having three large joints in each, besides several smaller ones. These joints are so contrived, that it can

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* Notwithstanding the inconveniences attending this little insect, and the general disapprobation which its frequent intrusion occasions, there is something pleasing in the appearance of the flea; all its motions are elegant, and all its postures indicate agility. The shelly armour in which it is enveloped, is in a state of perpetual cleanliness; while the muscular power which it is capable of exerting is so extraordinary, as justly to excite our wonder at so much strength confined, and concentrated as it were, in so small a space.

The flea, like many other insects, is eminent for its powers of revivescence, and will frequently recover after being placed in situations very unfavourable to animal life. Some of the coleopterous insects are, however, capable of exhibiting far more striking examples of suspended animation. Nat. Misc. vol. v. EDIT.

as it were fold them up one within another; in leaping, they all spring at once, and the whole strength of the insect is exerted. The flexure of the fore legs is forward, that of the hind legs backward. They are all very hairy, and terminated by two long hooked sharp claws; the two fore legs are placed very near the neck, and often conceal the proboscis from our view, the other four join all at the breast: the proboscis or sucker with which it penetrates the skin, is placed at the end of the snout, and is not easily seen except the two fore legs are first removed; in it are included a couple of darts or lancets, which, after the proboscis has made an entrance, are thrust farther into the flesh, and make the blood flow from the adjacent parts, occasioning that round red spot, with a hole in the center of it, called a flea-bite.

OF THE CIMEX LECTULARIUS, OR BED BUG.

Various are the antipathies of mankind, but all appear to unite in their dislike to this animal and the louse, and to detest them as their natural and nauseous enemies. The bug " intrudes upon the peace of mankind, and often banishes that sleep which even anxiety and sorrow permitted to approach: the night is the season when the bed bug issues from its retreat to make its depredations; by day it lurks in the most secret parts of the bed, takes the advantage of every chink and cranny to make a secure lodgement, and contrives its habitation with so much art, that scarce any industry can discover its retreat; but when darkness promises security, it then issues from every corner of the bed, drops from the tester, and crawls from behind the arras, and travels to the unhappy patient, who vainly wishes for rest and refreshment."

Linnæus is of opinion that this insect is not originally of European growth, but was imported from some other country. It is not only disagreeable on account of the extremely offensive smell proceeding from it, but also because of the rapidity with which it increases, and the voraciousness of its appetite. It has two brown small prominent eyes, two antennæ, and a crooked proboscis, which lies close under the breast. Instead of wings, we find on the first ring of the belly two flat pieces which entirely cover it, and extend towards the sides. These plates, the trunk, and the head, are amply set with hairs. The proboscis is divided transversely into four parts, which are probably so many articulations; this piece is best seen on the under side of the bug, being bent flat on the belly, and reaching half way down the body; but the mechanism of this, as well as other parts of these minute insects, cannot be perfectly understood, but by an accurate examination with the microscope. It has six legs, each of which has three joints; these legs, like those of the fly, are formed for running, not leaping; the skin is shagreened, and the separation of the rings usually marked by a smooth shining band. On the belly, at a small distance from the edge, a set of circular spots may be perceived, two on each ring, except the last; these are the spiracula. Examined internally, we find one large artery, a stomach, and intestines. The instant it perceives the light, it endeavours to gain its obscure habitation, and seldom fails in making good its retreat.

OF THE PEDICULUS HUMANUS, OR LOUSE.

"Whenever wretchedness, disease, and hunger seize upon man, the louse seldom fails to add itself to the tribe, and to increase in proportion to the number of his calamities."

When the human louse is examined with the microscope, its deformity fills us with disgust. In the head we may distinguish two fine black eyes, looking backward and fenced with hair; near these are the two antennæ, each of which has five joints set with short bristles; the fore-part of the head is rather long, the hinder more round or obtuse; there is a small part that projects from the nose or snout, this serves as a sheath or case to the proboscis or piercer, which the creature thrusts into the skin to draw out the blood and humours which are its destined food, for it has no mouth which opens in the common way.

This proboscis has been estimated to be seven-hundred times smaller than a hair; it is contained in another case within the first, and can be drawn in or thrust out at pleasure; the skin is hard and transparent. From the under side proceed six legs, each of which has five joints, and terminates in two unequal hooked claws, these it uses as we would a thumb and finger; there are hairs between the claws, as well as all over the legs; the body finishes in a cloven tail, which is generally covered, and partly concealed by hairs.

From the extreme transparency of its skin, the internal parts may be seen to greater advantage than in any other insect; as, the various ramifications of the veins and arteries, in which a kind of regular pulsation may be observed, as well as the peristaltic motion of the intestines, which is continued from the stomach to the tail. When the louse feeds, the blood rushes like a torrent into the stomach, moving with so strong a propulsion and contraction, as appears very curious. The digestive powers are so great, that the colour of the blood changes in its passage from thick and black at its first entrance, to a fine ruby colour in the intestines, and nearly white in the veins. Its greediness is so great, that the excrement contained in the intestines is ejected at the same time, to make room for this new supply. There is scarce any animal that multiplies so fast as this unwelcome intruder; the moment it is excluded from the egg it begins to breed.

It would be endless to describe the various creatures which go under the name of lice, and swarm upon every part of nature. The reader, desirous of a more particular account of those which infest various animals, will obtain full satisfaction, by consulting Rhedi's Treatise de Generatione Insectorum.

OF THE ARANEA, OR SPIDER.

The spider is another insect which is often examined with the microscope, and certainly affords much matter for observation. "Formed for a life of rapacity, and incapable of living but by blood, all its habits are calculated to deceive and surprize; it spreads toils to entangle its prey; it is endued with patience to expect its coming, and is possessed of arms and strength to destroy it when fallen into the snare."

" --------- To heedless flies the window proves
A constant death; where, gloomily retired,
The villain spider lives, cunning and fierce,
Mixture abhorr'd; amid a mangled heap
Of carcases, in eager watch he sits,
O'erlooking all his waving snares around.
Near the dire cell the dreadless wanderer oft
Passes, as oft the ruffian shews his front;
The prey at last ensnar'd, he dreadful darts
With rapid glide along the leaning line;
And fixing in the wretch his cruel fangs,
Strikes backward grimly pleas'd: the flutt'ring wing
And shriller sound declare extreme distress,
And ask the helping hospitable hand." THOMSON.

The eyes of the spider have been described in page 199, they are a very beautiful microscopic object, viewed either as transparent or opake. Ths spider has eight legs with three joints, thickly beset with hairs, and terminating in three crooked moveable claws, which have little teeth like a saw; at a small distance from these claws, but placed higher up, is another something like a cock's spur, by the assistance of which it adheres to its webs; but the weapon wherewith it seizes and kills its prey is a pair of sharp crooked claws or forceps placed in the fore-part of the head. The insect can open or extend these pincers as occasion may require; when undisturbed, it suffers them to lie one upon another, concealed in two cases constructed for their reception. Leeuwenhoeck says, that each of these claws has a small aperture or slit, through which he supposes a poisonous juice is injected into the wound it makes.

The exuvia, or cast-off skin of the spider, which may be found in cobwebs, being transparent, is an excellent object; and the fangs or forceps may be more easily separated from it, and examined with greater exactness than in a living subject. The contexture of the spider's web, and the manner of weaving it, have been discovered by the microscope. The spider is supplied with a large quantity of glutinous matter within its body, and five tubercles or nipples for spinning it into thread, of what size it pleases, either by opening or contracting the sphincter muscles. This substance, when examined accurately, will be found twisted into many coils, of an agate colour, and which from its tenacity may be easily drawn out into threads. The five nipples are placed near the extremity of the tail; from these the aforesaid substance proceeds; it adheres to any thing against which it is pressed, and being drawn out hardens in the air. The threads unite at a small distance from the body, so that those which appear to us so fine and single, are, notwithstanding, composed of five joined together, and these are many times doubled when the web is in formation. The web serves him for the double purpose of an habitation and of a machine for catching his food; for in the center of this web it dwells in dismal solitude, like a dragon in his lonely den, an image of the evil one, wasting all things round about it, and eager to destroy every appearance of life. When first hatched, even these loathsome insects seem endued with a principle of association, spinning a web in common; but this connection is of short duration, and soon terminates by their destroying one another. If, like the silk-worm, they were disposed to live together peaceably, it is possible that their labours might be productive of advantages nearly similar to that valuable insect; for which purpose repeated attempts have been made, though they proved ineffectual.

OF THE CULEX, OR GNAT.

The gnat is a beautiful object for the microscope. The curious manner in which it disposes its eggs upon the surface of the water has been noticed in page 288. From the egg proceeds the larva, in which state it is most happily suited to shew the several operations of life; for a moderate magnifying power will discover what passes within its transparent body. It has a large scaly head, with two large antennæ, besides several hairy parts, and articulated bristles near the mouth, which are in continual motion. If the worm be dissected, the feet of the gnat may be found folded up in the divisions of the thorax; the abdomen is divided into eight rings, from the edges of each of which three or four bristles proceed. The tail is divided into two parts of very different forms; by one of these it can steer itself in any direction; in the other, two pulmonary tubes may be discovered, through which the insect breathes. The larva has a power of moistening the tail with an oleaginous liquor, by which means it can suspend itself on the surface of the water. On agitating the water, the worms descend with precipitation to the bottom; but they soon return to the surface, to breathe the air through the tube that is annexed to their tail. From this state, they pass into that of the pupa, which is the gnat enclosed in a third skin, under which it is formed and strengthened; the organs of respiration are changed, breathing at this period through a couple of horns, which are placed near the head, keeping itself rolled upon the surface of the water, though on the least motion it unrolls itself and descends, aided by the oars near the tail.

From the spoils of the pupa, a little winged insect proceeds, whose every part is active to the highest degree, and whose entire structure is the just object of our admiration. Its head, adorned with feathers, is a fine microscopic object; but the proboscis may be deemed one of the most curious instruments in the insect creation. This formidable apparatus has been particularly described in page 187.

The exuviæ or cast-off skins of insects, being exceedingly transparent, are well adapted for observation, as they exhibit the external appearance of the little animal; among these, may be reckoned those of spiders and cimices, but particularly the forficula auricularia or earwig, which is an elegant exuvia; a magnified view of the beautiful wing of this insect is exhibited in Plate XIV. and described in page 205. The stings of insects vary not only in their form, but also in their apparatus; most of them require dissection; as the stings, for they have generally two, are inclosed in a hard sheath or case, to which is added a pair of feelers. The stings of bees, wasps, &c. are barbed, while those of the chrysis are serrated, or notched like a saw. The head of insects is furnished with an instrument or proboscis various as the insects themselves, but all meriting attention, as being admirably adapted to their different uses and purposes. Among the most remarkable are those of the bed bug, flea, gnat, empis, conops, &c. to which may be added the singular one of the tabanus, described in page 188, and figured in Plate XVI. A description of the apparatus of the bee has also been given in page 181, and of that of the butterfly in page 186.

The antennæ of moths, butterflies, and most other insects, display as great beauty in their formation as they are endless in their variety; the distinguishing characters of many of them have been described in pages 190---193, and that of the lepas anatifera in particular in page 345, and exhibited in Plate XIII.

The eyes of insects are singularly constructed, but this structure is not discoverable without the assistance of the microscope; the eyes of the libellula are hexagonal, see Plate XVI. Fig. 3, and their description in page 195; those of the lobster are square, as exhibited in Fig. 5 of the same plate, and described in page 197.

The hair of animals, as the mouse, goat, large bee, and many species of caterpillars, particularly the tufts on the head and tail of the larva of the phalæna antiqua, offer many beauties to the curious observer. The bristles of a hog, cut transversely, appear tubular, and the root of hair is evidently bulbous.

The muscular fibres, and every anatomical preparation that can be brought under the microscope, are pleasing objects; the reader will meet with many curious and interesting observations on the hairs, the muscles, nerves, and other parts of the human body, in Fontana's Treatise on the Venom of Vipers.

The legs of all insects appear very much diversified, and their mechanism truly astonishing, according with their different occupations, as particularized in pages 210---212.

Scales of fish, as soles, roach, dace, salmon, eels, &c. as also the scales of snakes, lizards, &c. &c. Specimens of scales are given in Plates X. and XIX. The scales form a light, but at the same time a solid and smooth covering to the fish; they hinder the fluid from penetrating the body, for which purpose they are laid in a kind of natural oil; they serve also as a protection, and break the force of any accidental blow, which may be the reason why river-fish have larger and stronger scales than sea-fish, being more liable to accidents.

The purple tide of life, nay the very globules of the blood, may be seen distinctly rolling through veins and arteries smaller than the finest hair.*

Feathers, and parts of feathers of birds, are not to be passed by or unnoticed; but it is impossible to point out any of these in preference to others, as each has its peculiar beauties; the plumulæ of these have generally in the microscope the appearance of large feathers; the pith contained in the quill, if cut transversely and examined, exhibits an admirable reticular texture. Many

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* The manner of viewing the particles of the blood has been described in p. 149, together with some remarks on their form, by our author. It was not my intention to have renewed the subject; but a chirurgical treatise having been lately published by Everard Home, Esq. F. R. S. in which it appears that he has paid particular attention towards investigating these minute particles, and ascertaining their true form, I shall here subjoin an abstract.

" As the result of microscopical experiments has been found exceedingly fallacious, a prejudice has very naturally arisen against all experiments of this kind upon the secretions of the human body, from a supposition that they are not to be depended upon. But it is right that we should discriminate, and not condemn the use of the microscope altogether, because from ignorance of its principles it has been misapplied; since these very deceptions have been the means of our acquiring a more accurate knowledge of the use and application of that instrument.

" The errors in the use of the microscope have arisen from increasing the magnifying powers of the glasses too much, and not taking in all the circumstances relating to the refraction of the other parts of birds will afford a great variety of curious objects, particularly the egg: Mr. Martin says, that the internal spongy substance of bones may be better observed in those of birds, than of any other animal; even the feathers or scales of a moth's wing amply repay the observer; these also vary in their texture and figure; but the largest and most commonly applied, are from the body of the sphinx stellatarum, or humming-bird moth; a specimen is given in Plate XVI. Fig. E F H I.

Transverse sections of all kinds of wood, especially those of a pithy or soft nature, form some of the most delightful objects for the microscope; among these, the section of fern root will be found strikingly curious, from the singular disposition of the air and sap vessels; their beauty will be seen by the figures in Plates XXVIII. XXIX. and XXX.

Flowers, whose brilliancy and variety constitute one of the principal beauties of nature, each being distinguished from the rest by some peculiar beauty or shining character.

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rays of light, making no allowance for the aberration. An attention to the aberration alone will explain the different appearances under which the red globules of the blood have been represented. Some have found them perfect spheres, which will always be the case when the glasses are perfectly adjusted, and the object placed at the true focal distance. Others have found them annular, from the object being at the focal distance of the rays transmitted near the circumference of the magnifying glass, which are refracted in a greater degree, and consequently shorter than the central rays. Others, again, have viewed them as flattened bodies of a circular figure, bright in the center, and becoming darker towards the edges; which appearance arises from the object being at the focal distance of the central rays of the magnifying glass, which will be less refracted than those near the circumference. Although such are the errors which arise, when microscopical researches are pushed beyond certain bounds; yet, that the red part of the blood is made up of globules, is a discovery for which we are indebted to the microscope, and which seems to be as well ascertained as any discovery in anatomy or physiology. The appearances of pus are equally distinct, when examined on the field of a microscope, as the globules of the blood; they are visible with a small degree of magnifying power, and are the same to the eyes of different persons." Edit.

The flowers of most grasses, with all the varieties of mosses; the farina of flowers; mouldiness, which evidently appears to vegetate; all the kinds of sponge; sea-weeds; particularly the confervæ, which are jointed like a cane. The extensive family of corallines present an elegant appearance; the most beautiful are the sea hair, sea fir, sickle, fox tail, &c. described by Ellis.

Dissected leaves, which shew the fibres and nerves; the human intestine injected with wax is a fine object; as are many other anatomical preparations. The seed of the silver-rind birch appears like an insect; seed of the quaking grass is also much admired, as is the leaf which covers the seed of sorrel. Among artificial productions, the edge of a razor, and point of a fine needle, as also fine cambrick, evidently discover the inferiority of the workman; particles from the collision of flint and steel; wire melted by the electric explosion, and other articles innumerable.

Besides these, there is an immense variety of objects which can only be satisfactorily examined alive, such as polypes, minute aquatic insects; animalcula of various infusions, as eels in paste, vinegar, &c. The eyes and teeth of snails; the circulation of the blood in the tails of fishes, &c.*

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* Those who possess leisure, particularly such who reside in the country, may easily procure the major part of the preceding objects, and also add an extensive variety to them; but those who have not the opportunity of collecting for themselves, may be supplied with objects in considerable variety by application to Messrs. Jones. EDIT.

CHAP. XI.

AN ARRANGEMENT AND DESCRIPTION OF MINUTE AND RARE SHELLS.---A DESCRIPTIVE LIST OF A VARIETY OF VEGETABLE SEEDS, AS THEY APPEAR WHEN VIEWED BY THE MICROSCOPE. BY THE EDITOR.

NOTWITHSTANDING the abundance of objects which have from time to time afforded delight to the attentive and diligent microscopic observer, little doubt can be entertained but that amidst the immense variety of minute shells, as well as the seeds of vegetables, numbers remain unexplored, though highly meriting notice.

With the hope of exciting the attention of the curious toward these subjects, and affording hints to those who may happily possess inclination, together with leisure and opportunity to pursue the inquiry, I shall enumerate to the reader a few specimens of each of these admirable productions of nature; towards the elucidating of which, very little, comparatively, has as yet been done.

As far as my knowledge extends, the first author who has treated on the subject of minute and rare shells, is Planeus, who published a treatise in quarto, at Venice, in the year 1739, with the title "De Conchis Ariminensibus minus notis;" a third and improved edition of which appeared in 1760. It is a very curious and learned work, containing a natural history of testaceous animals of Rimini, an Italian town situated on the Adriatic shore; and more particularly of minute nautili.

In the year 1784, Mr. Walker of Faversham published in quarto a collection of minute shells, which was the joint production of himself and William Boys, Esq. F. S. A. of Sandwich, in Kent, assisted by the late Edward Jacob, Esq. F. S. A. It contains an arrangement and concise description of ninety shells, accompanied with neatly engraved figures of the whole series; the greater part of them as well in their magnified state, as that in which they appear to the naked eye. Specimens of those which are esteemed most curious and rare, I have selected from this work: a reference to the original will afford the reader more complete satisfaction, and possibly animate him to further pursuits.

This publication appeared in so favourable a light to that eminent patron of science, Sir Joseph Banks, that I should accuse myself of unjustifiable remissness, were I to neglect this opportunity of introducing an extract from the copy of a letter addressed by him to the late Mr. Jacob, which is now in my possession.

"We" (the Royal Society) "are all much obliged to you for the pains you have taken in bringing this work to light. Natural history is, I am convinced, more benefited by a thin volume of real new facts, which is the case in yours, than by a folio of comments generally written by those who mean to receive praise, more founded on the elegance with which they express the ideas they conceive, than on any prospect of utility to be derived from the ideas themselves. From such naturalists, De Buffon, &c. good Lord deliver our honest science"

That truly amiable, and no less intelligent lady, the late Duchess Dowager of Portland, likewise expressed her approbation of the work in a letter to Mr. Boys.

By this publication, a number of shells, heretofore unknown, are added to the British conchology, sufficient to shew that the path is now laid open and made easy of access to inquisitive naturalists in different parts of the kingdom for still greater discoveries. Indeed, it is rather extraordinary, that the authors of this country, who have so advantageously applied the microscope to a variety of objects in the animal kingdom, should have neglected to examine the shores of our own seas, crowded as they are with objects equally worthy of their investigation. Baker's observation in his "Employment for the Microscope," p. 244, is entitled to more attention than has been paid to it. "Shell-fish," says he, "are objects that have as yet been very slightly examined by the microscope, and therefore the serious inquirer into nature's secret operations may here be certain of discovering beauties, which at present he can have no conception of." But thus it is, nature opens her rich and inexhaustible treasures by slow degrees to the inquisitive mind of man. In fact, different observers have generally different pursuits, otherwise these objects would scarcely have escaped the attention of many ingenious naturalists, particularly the quick-sighted Mr. Ellis, who has so clearly investigated and described the corals and corallines of the adjacent coasts.

To those who have perused the treatise of Plancus, already mentioned, it is necessary to observe, that though the sand on our coasts contain a vast variety of specimens, yet it by no means appears so productive as the sand of Rimini; lest, despairing of success in their first researches, they may be induced to desist from further examination. Every parcel will, however, be found to contain some of the more common shells.

It may not be improper here to point out to future inquirers the mode of facilitating the discovery of these minute objects. The sand being perfectly dried, put a handful on an open sheet of paper, and by gently shaking it from side to side, the minute shells, being specifically lighter than the sand, will be separated from, and lie on its surface, and will thus be more expeditiously procured than by any other method. It is also adviseable to place the objects intended for inspection in a situation secured from any sudden blast of air, otherwise, owing to their levity, they may be unexpectedly blown away, and a loss sustained of some of the rarer specimens; even incautiously breathing on them, or coughing, may be productive of similar disagreeable effects.

The following observations by an ingenious critic* are so apposite, and so perfectly coincident with my own sentiments on the subject, that I cannot resist the impulse I feel to enable the reader to partake of the pleasure which I have experienced in their perusal.

"Let not the minuteness of the objects here delineated call up the surly inquiries of those, who have not been accustomed to live with their eyes open to the works of nature: they are not fit judges in these matters. If they will persist in asking, Of what use is all this labour? What good can accrue to mankind from this knowledge, in point of food, or other use? We know of none at all, either present or likely to happen, as to the body, for use

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* Monthly Review, Vol. LXXI. p. 190.

or ornament, or to the satisfying any appetite: nevertheless, a much nobler idea will take its rise in our opinion; one which, by displaying so momentously the power of the omniscient Creator, will thwart the infidel in his favourite ideas of escaping the eyes of the Almighty, and force him, as he descends the scale from the more immense objects to these minutissima, to confess, that the being which has formed these, can fully equal all that the tongue of man has yet declared of the possibility of his power. For, what a train of wonders have we here to pursue? What must be the œconomy of animals so very diminutive, so weak, so exposed from their situation to the force of every rude wave, and who, notwithstanding, so often escape unhurt? How do they rear their young? From whence collect their prey?"

A DESCRIPTION AND ARRANGEMENT OF MINUTE AND RARE SHELLS.*

SERPULA.

THE WORM-SHELL.

Serpula Bicornis. Plate XIV. Fig. 2. S. bicornis ventricosa. The bellied semilunar worm-shell.

The colour white, opake, and glossy. From Sandwich and Reculver, though not common.

Serpula Perforata. Fig. 3. S. bicornis umbilico perforato. The semilunar perforated worm-shell.

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* Being possessed of Mr. Jacob's own corrected copy of the work, to which he has annexed the trivial names, I am thereby enabled to affix them to the several shells here enumerated.

The colour white, opake, and glossy. From Sandwich: very rare.

SERPULA LACTEA. Fig. 4. S. tenuis ovalis lævis. The thin, smooth, egg-shaped worm-shell.

The colour pellucid, with milky veins. From Sandwich: not common.

SERPULA LAGENA SULCATA. Fig. 5. S. (lagena) striata sulcata rotunda. The round striated and furrowed flask worm-shell.

The colour whitish, transparent, and glossy. From Sandwich, Reculver, and Shepey: very rare.

SERPULA RETORTA. Fig. 6. S. (retorta) rotunda marginata cervice curvatim exerto. The marginated retort worm-shell.

The colour white and opake. From Sandwich: not common.

SERPULA INCURVATA. Fig. 7. S. recta anfractibus tribus contiguis regulariter involutis. The straight horn worm-shell, with three close intorted spires at the tip.

The colour white, semitransparent. From Sandwich: rare.

This shell, though resembling the semilituus of Linnæus, p. 1163, No. 280, is not of the genus of Nautiſus, having neither syphon in the aperture, nor the internal concamerated structure.

DENTALE.

THE TOOTH-SHELL.

Dentalium Imperforatum. Fig. 8. D. apice imperforata transverse striatum. The imperforated transversely striated tooth-shell.

The colour white and opake. From Sandwich: not very common.

PATELLA.

THE LIMPET.

Patella Rota. Fig. 9. P. plana orbiculata margine regulariter dentato. The toothed-wheel limpet.

The colour white and opake. From Sandwich: extremely rare.

HELIX.

THE DEPRESSED SNAIL.

Helix Carinata. Fig. 10. H. striata apertura compressa tribus anfractibus carinata. The striated suboval-mouthed snail, of three spires and a sharp edge.

The colour light brown pellucid. In a fresh water stream, near Faversham.

HELIX SPINOSA. Fig. 11. H. subglobosa umbilicata ore subrotundo margine spinoso. The roundish mouth deeply umbelicated snail with a thorny margin.

The colour brown pellucid. From Bysing Wood, near Faversham: exceeding rare.

HELIX RETICULATA. Fig. 12. H. unici anfractus subumbilicata apertura rotunda marginata eleganter reticulata. The round mouthed reticulated single spired slightly subumbilicated snail.

The colour white and pellucid. From Reculver: extremely rare.

HELIX STRIATA. Fig. 13. H. striata apertura subovali anfractibus supradorsalibus. The oval mouthed striated snail with the spires reflected on the back.

The colour greenish, white pellucid. From Sandwich: very rare.

TURBO.

THE PRODUCED SNAIL.

TURBO RETICULATUS. Fig. 14. T. subumbilicatus quatuor anfractibus reticulatis apertura subrotunda. The slightly umbilicated turbo with four reticulated spires, and a roundish aperture.

The colour white and pellucid. From Seasalter: very rare.

Turbo Eburneus. Fig. 15. T. quinque anfractibus ventricosis apertura subrotunda. The five spired ventricose turbo with a roundish mouth.

The colour white and opake. From Reculver: very rare.

Turbo Strigatus. Fig. 16. T. tribus anfractibus primo strigis tribus transversis apertura subovata. The three spired turbo, the first spire with three transverse ridges and a suboval aperture.

The colour opake white. From Seasalter: very rare.

Turbo Albidus. Fig. 17. T. turritus septem anfractibus strigatis apertura ovali. The taper turbo with seven ridged spires and an oval aperture.

The colour opake white. From Sandwich: rare.

Turbo Carinatulus. Fig. 18. T. turritus carinatus septem anfractibus apertura coarctata marginata. The taper carinated turbo with seven spires and a contracted marginated aperture.

The colour opake white. From Sandwich: very rare.

Turbo Clathratulus. Fig. 19. T. clathratus sex anfractibus apertura ovali marginata. The barred six spired turbo with an oval marginated aperture.

The colour opake white. From Sandwich: exceeding rare.

Turbo Crassus. Fig. 20. T. crassus clathratus quinque anfractibus apertura rotunda marginata. The thick barred turbo of five spires and a round marginated aperture.

The colour opake white. From Sandwich: very rare.

Turbo Punctatus. Fig. 21. T. turritus perversus novem anfractibus punctatis apertura coarctata. The reversed taper turbo of nine dotted spires and straitened aperture.

The colour light-brown opake. From Sandwich: not common.

Turbo Shepeianus. Fig. 22. T. sex anfractibus reticulatis apertura ovali submarginata. The six spired reticulated turbo with an oval submarginated aperture.

The colour semipellucid white. From Shepey island: very rare.

Turbo Sandvicensis. Fig. 23. T. tribus anfractibus reticulatis apertura unidentata. The three spired elegantly reticulated turbo with a one toothed oval aperture.

The colour pellucid white. From Sandwich: exceeding rare.

TROCHUS.

THE TOP-SHELL.

Trochus Fuscus. Fig. 24. T. umbilicatus quinque anfractibus marginatus apertura subrotunda. The five spired umbilicated marginated top-shell with a roundish aperture.

The colour opake brown. From Sandwich: common.

BUCCINUM.

THE WHILK.

Buccinum Obtusulum. Fig. 25. B. ampullaceum tribus anfractibus apertura ovali. The bellied whilk of three spires with an oval aperture.

The colour opake white. From Faversham Creek: very rare.

Buccinum Longiusculum. Fig. 26. B. turritum quinque anfractibus apertura ovali. The taper whilk of five spires with an oval aperture.

The colour white semipellucid and glossy. In Faversham Creek only; but not uncommon there.

VOLUTA.

THE VOLUTE.

Voluta Alba. Fig. 27. V. alba opaca longitudinaliter striata. The white opake volute. From Sandwich and Shepey island: not uncommon.

This shell resembles Mr. Pennant's voluta Jonensis, but differs in the form of the aperture, as well as in the size.

BULLA.

THE DIPPER.

BULLA REGULBIENSIS. Fig. 28. B. crassa apertura medio coarctata. The thick dipper, with a compressed aperture.

The colour white and opake. From Reculver: very rare.

NAUTILUS.

THE CHAMBERED NAUTILUS.

NAUTILUS BECCARII. Fig. 29. N. spiralis umbilicatus geniculis insculptis. The spiral umbilicated nautilus with deep joints.

The colour, while the fish is alive, is a fine pellucid crimson; when dead, is white. It is found alive on the fucus vesiculosus, and is a very common shell on all the coast, and seems to be an universal litoral one, by the numbers found at Rimini, and in the sand of the South Seas.

Lin. S. N. p. 1162, No. 276. Nautilus Beccarii. Planch. Tab. 1. Fig. 1. Gualtier, Tab. 19. Fig. H, H, I.

NAUTILUS CRISPUS. Fig. 30. N. spiralis geniculis crenatis. The spiral nautilus with crenated joints.

The colour opake white. The finest specimens are from Shepey: not uncommon.

Lin. S. N. p. 1162, No. 275. crispus. Planch. T. 1. f. 2. Gualt. T. 19. f. A. D.

Nautilus Calcar. Fig. 31. N. spiralis apertura lineari geniculis elevatis. The spiral nautilus, with a narrow aperture and raised joints.

The colour opake white. From Shepey island: not common.

Lin. S. N. 1162, No. 274, calcar. Pl. T. 1. f. 3, 4. Gualt. T. 19. f. C. B.

Nautilus Lævigatulus. Fig. 32. N. spiralis geniculis lævibus. The spiral nautilus with smooth joints.

The colour semipellucid, white and glossy. From Sandwich and Seasalter: not common.

Nautilus Depressulus. Fig. 33. N. spiralis utrinque subumbilicatus geniculis depressis plurimis. The spiral subumbilicated nautilus, with many depressed joints.

The colour opake white. From Reculver: very rare.

Nautilus Umbilicatulus. Fig. 34. N. spiralis umbilicatus geniculis sulcatis. The umbilicated spiral nautilus, with furrowed joints.

The colour opake white. From Sandwich: not common.

Nautilus Crassulus. Fig. 35. N. spiralis crassus utrinque umbilicatus geniculis lineatis. The thick spiral doubly umbilicated nautilus, with fine joints.

The colour opake white. From Reculver: exceeding rare.

Nautilus Lobatulus. Fig. 36. N. spiralis lobatus anfractibus supra rotundatis subtus depressioribus. The spiral lobated nautilus, with the spires rounded on the upper side, and depressed on the under.

The colour opake white. From Whitstable: not common.

Nautilus Carinatulus. Fig. 37. N. oblongus carinatus apertura lineari ovali. The oblong carinated nautilus, with a narrow oval aperture.

The colour whitish, transparent like glass. From Seasalter and Sandwich: very rare.

Nautilus Subarcuatulus. Fig. 38. N. subarcuatus geniculis exertis. The bending nautilus with raised joints.

The colour opake brown. From Shepey island: very rare.

MYTILUS.

THE MUSCLE.

Mytilus Phaseolus. Fig. 39. M. lævis valvulis antice inflexis. The smooth muscle, with the valves inflected in front.

The colour brown and glossy. From a fresh water stream near Faversham: common.

Mytilus Punctatulus. Fig. 40. M. subrhombiformis punctatus. The subrombic dotted muscle.

The colour pellucid white. From Sandwich: common.

Mytilus Discors. Fig. 41. M. discors areis tribus distinctis. The divided muscle.

The colour opake brown. From Sandwich: not common.

Lin. S. N. 1159, No. 261. Da Costa Br. Conch. p. 221. Tab. 17. f. 1. where it is exactly described, and as badly engraved.

ANOMIA.

THE SCALE.

Anomia Squamula. Fig. 42. A. squamula. The scale anomia.

The colour opake white and glossy. From Sandwich: not uncommon.

Lin. S. N. 1151, No. 221. This shell is well described by Da Costa; but neither he, or Mr. Pennant, have caused it to be engraved.

ARCA.

THE ARC.

Arca Modiolus. Fig. 43. A. oblonga striata antice angulata. The oblong striated arc, with the foreside angulated.

The colour opake white. From Sandwich: not uncommon.

Lin. S. N. p. 1141, No. 171. Arca Modiolus.

CARDIUM.

THE COCKLE.

Cardium Muricatulum. Fig. 44. C. subcordatum antice muricatum. The heart cockle, with the front muricated.

The colour opake white. From Shepey island: not uncommon.

LEPAS.

THE ACORN-SHELL.

Lepas Strigatulus. Fig. 45. L. balanus striatus apertura obliqua. The striated acorn-shell, with an oblique aperture.

The colour light brown. From Sandwich, on the roots of sea-weeds, the finest specimens on lobsters: not uncommon.

ECHINUS.

THE SEA-URCHIN.

Echinus Lobatulus. Fig. 46. E. subrotundus planus lobatus. The flat roundish lobated echinus.

The colour opake white. From Reculver: rare.

ASTERIAS.

THE STAR-FISH.

Asterias Triradiata. Fig. 47. A. triradiata lævis. The smooth three-rayed star-fish.

The colour white, transparent as glass. On all the different shores that have been examined.

Having thus described a few specimens of those pleasing microscopical objects, minute shells, I shall agreeably to the intimation given in the note to page 613, proceed to

A DESCRIPTIVE LIST OF A VARIETY OF VEGETABLE SEEDS.*

Lithospermum Officinale. Plate XV. Fig. 1. Ibid. Linn. Gromwell. This seed is in figure exactly like a human heart without the auricles, but has no flat or depressed part on its sides; it is pretty circular round its thickest part, and terminates in a blunt cone. At the thickest extremity there is a circular roughness, which is the umbilicus, and from thence to the cone on the shortest side it is bisulcated longitudinally; so that the space between the sulci is a kind of ridge, nor do either sulci or ridge extend to either extremity of the seed; the rest of the surface is smooth and polished, the ground a light ash-colour, with a shade or cloud of yellow or brown.

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* To the names as given by Dr. Parsons, those adopted by Linnæus are here added.

These seeds are very hard, and the ash-coloured shell is brittle like that of a hen's egg; which being broken, appears to be lined with a light olive-coloured uniform membrane, which encloses a nucleus of a Spanish snuff-colour, pretty smooth, and of the same form with its shell, being in close contact with it all round.

The natural size of a middling grain of this seed is about the eighth part of an inch long, and the ninth of an inch in diameter at the roundest part.

Cyminum. Fig. 2. Cuminum C. Linn. Cummin. This seed is double, though fixed side by side to one little stem; both which while together seem like one, and are ribbed in an uneven manner longitudinally, having great numbers of little threads or fibres sticking out all over them, which makes them look hoary. They are thick in the middle and run to a cone at each end. At the upper extremity there is an appearance like a bifurcation in the stilus, each of them belonging to its particular seed; this appears when the seeds are separated.

These seeds are of a darkish straw-colour, the little threads or fibres being much lighter than the body of the seed. Each of these seeds contains in it a kernel of an olive-colour, and exactly in shape like a waterman's boat, and of the same proportion, having a concave and convex side; the latter has a blunt ridge like the keel of a boat, and the former has a white line from one end to the other, which proves to be a ridge, to which the stilus that rises from the little stem of the seed, adheres to support it.

When the seeds are together upon the stem their length is about the fifth part of an inch, and about an eighth part of an inch in the broadest part.

Papaver Album. Fig. 3. P. somniferum. Linn. Poppy. This is a little yellowish white seed exactly resembling in shape a sheep's kidney, having a yellow place about the hollow part, which is its umbilicus, analogous to the hollow part of the kidney into which the blood-vessels (emulgents) enter.

If it be viewed on the back or convex part, concealing the hollow, it is exactly shaped like an egg, having one end somewhat rounder than the other.

All over its surface it has superficial cells, formed by ridges that rise from the surface, which are some heptagons, some pentagons, but for the most part hexagons, though not precisely of equal sides; and the bottoms of these cells seem to be very porous.

The seeds seem very light and springy, as a gentle blast of ones breath is capable of blowing them away, or a touch of any thing of making them roll a considerable way. As to their size, they are not above a twenty-fourth part of an inch long, and about a thirtieth part broad or thick.

Carduus Benedictus. Fig. 4. Centaurea Benedicta. Linn. Blessed Thistle. The body of this seed is about twice as long as it is thick, is round and shaped much like a nine-pin, only instead of being small at the upper end, it has a stricture, from whence arises a beautiful crown of ten angles or points, out of which come also ten aristæ or spiculæ like ivory, about the length of the body of the seed, running taper upward, and set round in an uniform manner. Within the circle of these long spikes there are ten more, which are but very short, and of the same colour and consistence with the others. when these are all plucked off, the vestiges of the circles they form appear in the upper surface of the crown; in the middle of which a little process arises, but very superficially. That part which appears circular is white, and the rest of this surface, of the corona, of the same colour with the rest of the body of the seed, which is a sort of an olive-colour.

The body of the seed is of the sulcated kind, and looks exactly like a fluted pillar, and the surface shines as if varnished with some gummy substance.

At the lower or small end of this seed, there is an opening reaching up above a third of the length of the body of the seed, which discovers a white root, shaped like a cone at the bottom, and rising thicker by degrees till it divides into three limbs; these run taper upwards, till they are lost in the parenchyma of the seed, which at the place of their entrance appears somewhat fungous, but is more compact and clammy through its substance.

The length of the body is more than two eighths of an inch, and the aristæ exactly the same length. The corona is its umbilicus.

Plantago. Fig. 5. P. Major. Linn. Plantain. By the imperfect idea we have of this seed from its minuteness, it may seem like a flea, as any small speck would, if a little oblong; yet its form is not constant, that is, there are scarce two of them precisely alike, some being perfectly elliptical, some with blunt angles, and some approaching a spheroid. They have a whitish mark on one side, which is the umbilicus of the seed, from whence the first rudiments of the plant spring, and the surface is entirely granulated over, and has a general appearance like some kinds of plumb-stones; the surface also shines a little, as if oiled or moist, and their colour is brown. One of the seeds cut transversely appears to have the shell or covering pretty strong in proportion to its size, which contains a parenchyma that is very porous and succulent. It is about a sixteenth part of an inch long, and a twenty-second broad.

Staphis Agria. Fig. 6 and 7. Delphinum S. A. Linn. Stavesacre. The seeds of this plant are rough and angular, inclining to a triangle, although imperfectly so. They may be considered as having a basis or apex; the basis is thick and clumsy, and the apex runs to an angular point, which point is the umbilicus of the seed, out of which its first rudiments arise; it also has a convex and a plane or concave side; the former, Fig. 7, is rough, by reason of its being covered all over with porous cells, the ridges of which are also depressed or indented with rough pores, and granulated as if stuck full of sand. The concave surface, Fig. 6, is also rough, but not in the same manner, and so are the sides, which have a little flatness; these also are porous and sandy, and before the microscope, shine, and are coloured like dirty brown sugar-candy. The concave surface, notwithstanding the roughness, has one longitudinal ridge, and sometimes more, running from the basis to the apex, which has the same granulated surface with the rest. It contains a parenchyma, which is of a yellowish grey colour, and is moist and succulent.

This seed is in its natural size about two eighths of an inch long from its basis to the apex, and near as broad; however, some are broader in proportion to their length than others, and they are one eighth of an inch thick.

Anisum. Fig. 8 and 9. Pimpinella A. Linn. Anise. Two of these seeds grow together upon one little stalk; when they are pulled asunder, they appear to have a flat and a convex surface. On the convex surface, Fig. 8, each seed has three ribs placed at equal distances from one another, which are porous and a little rough, being of a straw-colour; and the spaces between them are also rough and porous, but of an olive-colour. The flat surface, Fig. 9, has a white ridge running longitudinally from its basis to the apex in the middle; this white ridge or line serves to cling to the stilus, upon which it sticks. The stilus is also white, and has the same contexture with the ridge, and is bifid, in order to support two seeds with their flat sides together, which keeps them the more compact and less liable to injuries than if a single seed stuck on. It is certain, a single stilus would do as well to support two seeds as the bifid one, for even the two stick together as if single, if there was not a necessity for a double stilus, for a very important reason; which is, that when the seeds are ripe, they would stick on a single one, till the time of their being scattered about would pass, which would be a detriment to their propagation; but the stilus being double, and of a springy nature, the two parts are glued together, as long as moisture remains about the seeds capable of keeping them together; but when the seeds are grown ripe and dry, then this moisture is exhaled, and the stilus, as well as the flat surfaces of the seeds, begin to contract from their former plumpness; the stilus first begins to split asunder, and thereby separates the two surfaces of the seeds, each of which sticks loosely to its particular limb of the stilus; till at length the remaining moisture exhaling more and more, it grows rigid, and cracks with a blast of wind, and so the seed is scattered or sown in the ground in its due time. This is a most excellent provision of nature, and highly worth regard.

When the two seeds are sticking together, they have a round end which is the basis, and grow smaller by degrees upward, till they become an apex, having upon each seed a kind of fungous or bulbous corona, which is the umbilicus of the seed; and the shape of the two together may be compared to that of a green fig reversed. The parenchyma of these seeds is that of a pale greenish olive-colour. They are more exactly of a size than most other seeds, and are each one-eighth part of an inch long, and more than half that breadth.

FŒNICULUM DULCE. Fig. 10 and 11. Anethum F. Linn. Sweet Fennel. In viewing these seeds, they do not look much unlike one species of the cucumber in general, some of them being thicker and longer than others, and some straighter; but upon applying the microscope, the ridges appear high, and form deep furrows.

Two of these seeds grow together upon the same little stalk, which is divided, like that of the anise seed, into a double or bifid stilus, in the same manner, and for the same reasons; when the two are pulled asunder, they appear to have a flat surface, Fig. 10, and a round and ridged one, Fig. 11. On the former, these characters are conspicuous: viz. 1. The whitish cortex or covering of the seed shews its edge distinctly. 2. Withinside this edge a white fungous substance appears running parallel to, and in close contact with it, on each side from end to end, being both together about one-third of the breadth of the seed; and between these, in the center, there appears a dark brown elliptical substance, which, upon separating the cortical and fungous coverings, appears to be a nucleus, whose internal substance is of an olive colour and something succulent. On the external surface there appears three high ridges, and when the flat faces of the seeds are close together upon the stilus, so as to seem but one, these three ridges on each seed and the two edges of each meeting firmly together, form eight regular ridges equally divided upon that round body that we have before said to resemble a cucumber. The extremity which is fixed to the stem is smaller than the other; the latter has a fungous kind of process arising from the body of the seed, which is the umbilicus of the seed. The ridges are of a light straw-colour, and the bottoms of the sulci they form are darkish. A middling seed is somewhat more than two-eighths of an inch long, and above half that breadth.

GRANA PARADISI. Fig. 12 and 13. Amomum G. P. Linn. Grains of Paradise. These seeds are of an irregular form, but may be said to have a basis and apex; the basis is generally so flat as to render it capable of standing well upon it; the sides consist of several flats and angles, and the apex looks very much like the mouth of a purse drawn or gathered up close together.

The body of the seed is of a reddish brown colour, the surface much granulated and rough; and the apex, which is its umbilicus, degenerates from this reddish brown colour into a yellow, appearing in little oblong ridges or plates..

Upon making a transverse section of this seed, a most beautiful appearance presents itself; the external cortex is very thin, and retains the same colour through its substance with the outer surface; this incloses a black, porous, pitchy substance, which is much thicker than the cortex, in close contact with it, and at the angles of the seed is pretty considerable. Next to this the parenchyma appears, as white as the finest white salt, and radiated from the center outward; and in this transverse section seems to have a round hole in the center of one of the divided parts, and a processs answerable to it in the other. If a longitudinal incision be made through the middle, the appearance will be as in Fig. 13, when the center of the white parenchyma appears exactly like a modern vinegar glass, commonly called a cruet, the bottom of which tends obliquely towards the basis, and the top towards the apex of the seed. The surface of this part looks polished, and the colour is a yellowish olive; nor does it look unlike a gummy or resinous body; however, we cannot be certain what its substance is, notwithstanding its great resemblance to that kind of matter. The white parenchyma is very singular, being almost divided into two lobes by this little cruet, whose top runs up into or is lost in a remarkable circular part, which has a rising towards the umbilicus of the seed in form of an acorn, and this rising stands in the open place, into which the pursy umbilicus leads. As to its natural dimensions, an ordinary seed is somewhat more than the eighth of an inch long, and about an eighth thick.

PETROSELINUM. Fig. 14. Apium P. Linn. Common Parsley. The seeds of this garden parsley, being of the umbellated kind, grow two upon a little stem, whose bifid stilus supports them like the ammi or smallage; they are striated or ribbed like those, having three of such ribs on the convex part, spread further asunder, and being much more conspicuous than those of either of the seeds just mentioned. There is another rib which runs on each side of the seed, which is its lateral rib, and that which runs round the edge of the flat surface makes it resemble the edge or gunnel of a barge or lighter, to which each of these bears some resemblance. This seed is considerably larger than either, and much longer in proportion to their size; the colour of the interstices between the ribs is a dusky olive, and the ribs of an oaker yellow. They are pretty round where they rest on the stem, and run up elliptically to an apex, where there is a fungous corona, which is the umbilicus. In making a transverse section through the middle of one of them, the parenchyma appears of the same form with the cortex, having this remarkable property, that between the ridges or ribs are canals, formed of the cortex and the surface of the parenchyma, containing a brown balsamic fluid, with which they are filled from one end to the other of the seed; and in some seeds this balsam appears all round between the parenchyma and the cortex. This will be further explained when we come to speak of the seseli, in which this is so apparent, that a transverse view of that seed will serve for both. The parenchyma is somewhat succulent, and of a greyish olive colour. An ordinary seed is one-eighth of an inch long, and about a sixteenth thick.

PETROSELINUM MACEDONICUM. Fig. 15 and 16. Bubon Macedonicum. Linn. Macedonian Parsley. These are long slender elliptical seeds, growing like the seeds of other umbelliferous plants, two together on the stem and bifid stilus; when they are pulled asunder they appear each to have a convex or back side, and a flat part or belly. The convex side, Fig. 15, may be said, from its roundness at one end, and smallness at the other, to have a basis and apex; the former is round, and after swelling a little towards the middle, runs taper upwards, till within one-fifth of its length there arise two rough hairy processes, one on each side, like ears, and the rest runs to a point; so that the entire back surface is a near representation of a mouse lying flat. The colour of the body of this seed is a kind of olive, but the hoary fibres all over are of an ash-colour, and the striæ or ridges much the same.

The flat surface, Fig. 16, is of a brown colour and porous, having none of these fibres upon it; and is surrounded by an edge or ridge, like those on the back of the seed, which are also hoary. Upon this surface the bifid stilus is apparent, one extremity of which terminates at a hollow part, that may be likened to the under jaw of the mouse, between the roots of the ears; and the other stands loose, to which the fellow-seed was also attached.

The ridges are also hollow, like those of the garden parsley, and contain such a balsamic fluid as that; but this being so exceedingly slender, requires the greatest magnifier of the microscope for opake objects to discern it. This seed is about an eighth of an inch long, and about a twentieth broad.

CORIANDRUM. Fig. 17, 18, and 19. C. sativum. Linn. Coriander. The seed of common coriander is spherical when entire, and may be said to have two poles; the lower, or that into which the stem is fixed, which forms a fungous hole, and the upper or little apex, as at Fig. 17, this is the umbilicus of the seed. From one of these poles to the other several ridges or striæ run like the lines of longitude upon the globe, between which there are several roughnesses; they are of a yellowish oaker colour, and about the sixth of an inch in diameter, or something less.

Each of these seeds, upon being bruised, divides into two hemispheres, Fig. 18, which discovers the edges of the rigid cortex. on the concave side there is a rising, and within it a lens, concave on one side and convex on the other, Fig. 19, as it is turned out of the cortex. On the concave side is a rising in the middle extending from one pole to the other, and on each side just below the apex, there is a white roundish fungous spot rising from the surface, from each of which runs downward a little curved a ridge, which appears to be resinous; and the surface is rough, and has a great many particles of resin also.

SESELI. Fig. 20 to 24. S. Montanum. Linn. Long-leaved Meadow-saxifrage. This seed stripped of its foliaceous wings may be compared to a sort of canoo which is too narrow in proportion to its great length, has a hollow and a convex side, like that kind of boat, and is ridged longitudinally on its convex side, Fig. 20, from end to end, with four principal ridges; and between these, with others less considerable. There are, however, some of these seeds wider than others in proportion, but the majority are too long for their breadth, as I have said before.

These principal ridges are the support of the wings, and may be called their basis, for they rise broad from the body of the seed, and run out to a thin edge, which being continued constitute this leafy border. These are yellowish, and the spaces between them and the other less considerable ridges inclining to a brown.

On the concave side, Fig. 21, there is an edge or gunnel like that of a boat, and a considerable cavity from the edge; in the center of which the vestige of the stilus, Fig. 22, which is also bifid here, appears from one end to the other. The edge and this vestige are also of a yellowish colour, but the rest of the surface brown and porous, and the whole body of the seed and ridges shine, as if varnished over with some oily substance.

Fig. 23 is a view of the convex side of a seed divested of its wings, which is one of the most proportioned seeds I could pick out; at the upper extremity of which a little process may be perceived to turn or crook back upon the body; the same may also be discerned on that of Fig. 20. At the root of this process the opening or umbilicus of the seed lies.

Among the many beauties with which this seed abounds, there is one that is most agreeably surprising, which (says our author) I discovered by making a transverse section of one of them, in order to see what its internal substance consisted of. I no sooner applied the cut surface, Fig. 24, to my microscope, than each of the principal ridges, which I said above is the basis of the leafy wing, appeared to be a triangular tube, containing a fine brown liquid balsam of the colour of brown basilicon. This was a high entertainment, as every other curious discovery that arises by the diligent inspection of the seed is, and prompted my examining others in the same manner; and I found such a balsam as this common to the several kinds of parsley seeds also, as well as to that of the bishop's weed and smallage; although these are so minute, that I could not be sensible of it but with difficulty, and with one of my greatest magnifiers. There is also something analogous to this in the sweet fennel and finoki, not in tubes of the husks or cortex, but rather in spungy channels that sink into the surface of the parenchyma, between the ridges of these last. The length of an ordinary seed is one-third of an inch, the thickness about an eighth, and the breadth of each wing nearly equal to the thickness of the body.

HYOSCYAMUS. Fig. 25. H. Niger. Linn. Common Henbane. After the calyx has split and cracked by drying, the seed-pot comes to be exposed to the heat of the sun, which also grows dry, by which the lid or cover becomes loose, having no other visible attachment to keep it on the edge of the pot but its moisture, which in some measure helps to keep it there by agglutination, as well as by the squeezing or pressure of the segments of the calyx. But, this moisture exhaling, and the calyx splitting off, the lid, being now dry, blows off with the first blast of wind, and scatters the seeds, which by this time are hard and ripe.

When the seeds are ripe they are of a light colour, like white-brown paper, and incline to a triangular figure, whose angles are rounded off. They are depressed on both sides, so as to become pretty flat, and their whole surface is cellular; the cells have no particular form, but are somewhat irregular, and the ridges that form them are pretty eminent. As the drawing appears, the seeds may be said to have a basis and an apex; the former has no other particular mark than the cells, but the latter has a kind of notch indented downward from the top, which is the umbilicus of the seed. The parenchyma appears of a greyish colour. A middling grain is about a sixteenth of an inch long, and not quite so broad in the broadest part.

CICER RUBRUM. Fig. 26 to 29. C. Arietinum. Linn. Chick-pea. There is a good deal of reason for comparing the chiche grain to the head of a ram; for each of them, Fig. 26, consists of a round or back part, and an apex or snout. There are, besides this shape, which indeed favours the simile, several depressions upon the grain which add still to the likeness of that head; and these we shall consider in particular. On the upper or convex side there is, in most of them, a longitudinal little ridge, and a depression on each side, which resembles the rising in the frontal bone of a sheep; and, a little further forward, two risings, one on each side, which look like the superciliary eminences of the eyes. Each side of the round or occipital part has a depression that also adds to the same image; but what is yet a greater argument for it, is, that the under part, Fig. 27, is flattish, having an edge on each side, which may be compared to the edges of the under jaw. In the center of this flat part there is a little mamillary rising very remarkable, and just under the apex or snout an oval hole, whitish at the bottom, which is the umbilicus of the seed; besides which, there is an apparent sulcus on each side the apex, running a little way back, and is a close resemblance to the rictus oris. The husk is thin and fragile, and when taken off, looks like thin tortoise-shell; and the nucleus or parenchyma is of a yellowish white, exactly like the substance of a split-pea, without the covering. The entire nucleus has the same depressions which appear on its husk or cortex; and a fore view of it,

Fig. 28, shews the naked apex, with the hole underneath, which is but superficial; and the seam which distinguishes the tip of the apex, I take to be the rudiment of the plant, for it is easily separated in that seam. The natural size of this seed appears, Fig. 29, being almost three-eighths of an inch from the apex to the outer edge of the basis, and something narrower.

LAURUS. Fig. 30, 31, 32. L. nobilis. Linn. Bay-berries. The bay-berries, Fig. 30, are a fruit of an oval shape, sticking to a short stem not above a quarter of an inch long; the surface is generally black, but some of them, whether through age I cannot say, are crusted over with a dull ash-coloured scurfy matter, and sometimes with fine ragged membranes. When the husk is opened, it appears of a fine dark-brown colour on the inner surface, being a smooth thin membrane that lines the husk, and at the smaller end it suddenly grows yellowish, and looks like a brown cup with a yellow bottom.

The nucleus easily comes out when the husk is opened, and as easily separates into two parts or lobes longitudinally; each of which is represented, Fig. 31. They lie in the husk with the flat surfaces together, each of which has a sinus at the smaller end shaped like the sole of one's shoe; one of these contains the little piece which has the rudiments of the tree, adhering closely to its sinus; the other is empty, and serves only to give room to these rudiments when the flat surfaces of both lobes are together: Fig. 32 represents that little piece taken out and viewed by a larger magnifier, and appears to be convex on the visible side; having in its outline much the same form with the cell or sinus which contained it. It has a ridge in a longitudinal direction, is smaller at one end than the other, has risings on the sides, and is a most entertaining object.

FICOIDES AFRA. Fig. 33, 34. Mesembryanthemum Crystallinum. Linn. Diamond Fig-marygold, or Ice-plant.* The whole stalks, leaves, and calix are covered with little glassy globules, which are called diamond or silver drops, and which are rather like ice than either. They are transparent, in as much as opposite windows of houses appear through them, and the green stalk makes those between it and the microscope look green. Those upon the stalks are spheroids, but those on the leaves and calix are globular. They seem like so many transparent stones set into a case, like those of a ring; others are more prominent. Upon breaking them, they appear to be little membranous bladders, very clear, and filled with an aqueous liquor. When they begin to wither and the juice to exhale, these membranes appear flaccid and collapsed.

Fig. 33 shews a flower of its natural size, with a bit of its stalk and a leaf; the leaf has its apex bent towards one side, is fat or thick, and has in its sinus the bud of another. The seed-vessel is also fleshy, and the calix has but three leaves, which is an exception to the general rule mentioned above, each of which has its apex in the center, or nearly so, differing from those of the stalk. The flower is indeed polypetalous, having an infinite number of narrow little leaves crowded together, of a whitish faint purple, in some parts nearly white, but very inconsiderable.

Fig. 34 is the seed, which is enlarged microscopically, having a streaky surface, and being of a triangular form. At one angle there is a dent or rictus, the end of which is the umbilicus of the

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* Dr. Parsons having given the microscopical description of the flower as well as the seed of this plant, and each of them forming a very agreeable object, the figure and description of the flower is here introduced.

seed. It is of a yellowish brown colour, and is very minute in its natural size, which is seen in those little specks near it.

Palma Arecifera. Fig. 35, 36, 37. Areca Catechu. Linn. Syst. Vegetab. Areca Nut. The areca nut grows in a husk like the walnut or nutmeg. Fig. 35 is that hard nut which we are now to describe. Its surface is a dark brown, striated promiscuously with a yellowish brown colour; its figure a cone, and is capable of standing firmly upon its basis. In the center of the basis there is the hole or vestige of its pedicle, or whatever other thing stuck to it whilst inveloped in its husk, round which the bottom is whitish. Fig. 36 is another species of the areca nut, at least in shape, being somewhat less, more squat, and having no cone. I cannot say, whether these different shaped cones might not be a variation of the fruit of the same tree, as apples or any other fruits often are; but the surfaces are not precisely alike in one respect only, their colour being the same, that is, the yellowish brown lines upon the surface of the latter are thicker together, and sink deeper into the cortex between the dark brown parts, which are consequently made more imminent thereby than those of the conical one.

Upon cutting one of these into two parts, the surface appears at Fig. 37. On the outer part all round the internal substance appears radiated outward, being of a dark red and brown colour, and in its center inclosing a white substance, which in many places shoots itself out into the brown substance in little radii towards the cortex.

Juniperus. Fig. 38, 39. J. Communis. Linn. Juniper Berry. Fig. 38, *a*, is a juniper berry magnified to shew its marks the more plainly. This fruit is quite round, of a black colour, which, although it appears smooth, yet the covering appears porous, and resembles the surface of shagreen in some measure. At the top it has a triangular sulcus, which is not very deep, and in some it is superficial. At the other extremity the stem appears, which is rough near the place of its insertion, with a scaly covering for a little space. *b*, is a transverse section of a juniper berry, which shews the thickness of the pulpy substance of the fruit, which appears every where interspersed and mixed with a great quantity of fine yellow gum, that in many places is in lumps, especially about the ossicula or stones of the fruit. This parenchyma incloses three of these ossicula, lying in close contact together by their flatter sides, and with their apices meeting at the top. *c*, is the fruit of its natural size, some grains may be a little bigger, some a little less.

Fig 39 is the convex side of one of the stones, having from the apex three or four ridges, which render it triangular at the top, and are lost towards the basis, of an irregular form, long, narrow, and shining, after being cleansed of the pulp that covers them with the gummy matter just mentioned; but when dry, has an appearance like that of the stones of other fruit. Fig. 40 shews a longitudinal section of one of them, which brings to view a nucleus in all respects like that of a plumb-stone, being cloathed with a membrane, and having a succulent parenchyma. *a*, is the stone in its natural size.

Santonicum. Fig. 41, 42. Artemisia S. Linn. Worm-seed. Fig. 41 shews the form of a middling seed enlarged by the microscope, for they are of different sizes among one another. This is one of the most singular in its structure, having scarce any thing substantial in it. The four little figures near it are those of a natural size, which are very small, and therefore renders the examination of them the more difficult. The seed has a small end or handle, being the place to which the stem which supports it was fixed, and the other end is bulky and round, having from the hoary handles several bulges all round, which are soft, and so very tender, that the rubbing of the seeds together reduces the surfaces to powder, whereby a large seed may be reduced to a very small one. The seed seems to be entirely composed of thin brittle membranes of an extreme delicate contexture, as at Fig. 42, having a dark center, from which it is transparent outward to the edge all round, and radiated upwards by infinitely fine radii, which do not render it in the least opake. Thus from the very outer surface the seed is composed of these sort of membranes, one after another, till nothing remains behind. Their colour before the naked eye is of a yellowish cast, but before the microscope for opake objects shines in many places like gold.

SCABIOSA MAJOR VULGARIS. Fig. 43 to 46. S. Arvensis. Linn. Scabious. There is no seed perhaps which has more beauties than this of the scabious. Fig. 43 is a view of what botanists call one one of the florets, which is a calix to the seed, whose fibres appear to extend themselves over its edges. This cup is of an octagonal form, and makes an appearance like a fine vase, having scallopped edges, and towards the inner part of the edge a whitish ruffled membrane. The ribs run down from its mouth, which is bell-fashioned, and becoming narrower downward, form obtuse angles, by continuing from the bend to form the bottom of the vase. Between these ribs down the bend the vase is clear, though not quite transparent, and from thence to the bottom the ribs are hairy, and make an agreeable figure.

Fig. 44 is the seed taken out of the vase, and drawn in another proportion, wherein appears first its thick body, which is somewhat hoary by the microscope, and runs up with a narrow neck, till it divides into five spiculated fibres, called by Gerard purple thrumbs, whose spiculæ or spines are determined upwards, and are thereby ready to cause the seed to recede from any thing that might injure it upon being touched. The bodies of the vases when first ripe are of a fine lemon yellow, but grow by long keeping darker; and the bason formed by the roots of the fine fibres is of a fine green, but the fibres themselves of a shining brown, like brown sugar-candy, as their spines are also.

Fig. 45 represents the stalk to which the vases stick by their bottoms, all which, when together, form the head mentioned by botanists to be the characters of some species of the scabious. In this figure the body of the stalk appears all stuck full of narrow whitish leaves, and the round spots between their roots are the vestiges of the bottoms of the vases; so that the leaves and vases are mixed together all over the stalk.

Fig. 46 shews a vase with a piece of its side cut out from the edge to the bottom. The bulbous part of the seed is contained in a delicate white membranous case, arising from the inner membrane of the bottom of the vase, and running up about half way the neck of the seed, embracing it pretty close, with a mouth consisting of six or eight sides as beautifully formed as that of any fine cut-glass decanter. The seed is loose in this theca, so that it may be turned round within it, but cannot be pulled out without tearing this beautiful theca, upon account of its narrow neck.

CHAP. XII.

INSTRUCTIONS FOR COLLECTING AND PRESERVING INSECTS--- A COPIOUS LIST OF MICROSCOPIC OBJECTS. BY THE EDITOR.

THOSE who have been long accustomed to microscopical investigations will readily admit, that the numerous class of insects, and their several parts, afford some of the most diversified, as well as the most admirable objects for the microscope. To readers of this description, who should be considered as adepts, the following instructions may possibly afford little that is novel, as by constant habit they must be thoroughly conversant in the best manner of procuring and preserving the various objects; it may be, however, reasonably presumed, that there are many persons who have not hitherto devoted their attention to this subject, as well as numbers who, deterred by the imaginary difficulties attending it, have either totally relinquished the pursuit, or made but small progress therein; to such, the directions here given it is hoped will prove an acquisition.

Confident as I am of the delights which this employment affords to the intelligent and industrious admirer of the works of nature, it is to be deplored that so many persons, who possess every requisite for these enjoyments, should remain totally insensible to their attractions; how much might be atchieved, could such be prevailed upon to devote their hours of leisure to so rational a purpose? especially if it be considered how easily these pleasures are to be attained, as well as the tranquillity with which they may be enjoyed.

Investigations of this kind particularly recommend themselves to the attention of the ladies, as being congenial with that refinement of taste and sentiment, and that pure and placid consistency of conduct which so eminently distinguish and adorn those of this happy isle. To the honour of several ladies of eminence be it recorded, that they are proficients in the study of the various branches of natural history, and many others are making considerable progress in this pleasing science; than which, none can possess a greater tendency to sweeten the hours of solitude and anxiety. How infinitely superior to a rational mind is the gratification arising from such pursuits, to those, to which numbers unhappily sacrifice their health and beauty, and frequently the peace of mind of themselves and relatives, by a baneful attachment to the gaming table; and that not owing to intellectual incapacity, but merely from not possessing fortitude sufficient to prefer the improvement of their minds to amusements, for which no better plea can possibly be urged, than that of their being sanctioned by the idol, Fashion.

Actuated by no other motives, than the sincerest respect I entertain for my fair countrywomen, and anxiety for their real welfare, I have presumed thus freely to deliver my sentiments; with greater confidence in the merits of the cause I plead, and reliance on their prudent discrimination, than on the persuasive eloquence of the advocate, I am willing to flatter myself that these remarks may not be entirely ineffectual; at least in warning those who have happily as yet escaped so dangerous a gulf.

Again, how many of my own sex, divested of a taste for rational enjoyments, groan under the oppressive load of listlesness and dissatisfaction; for, independent of the more serious and requisite duties of our respective callings, we require amusements to refresh us in our vacant moments, which if not devoted to some laudable pursuit, will necessarily, like those of too many of our young men of fortune, be sauntered away, or consumed in senseless and illicit delights, eventually productive of infallible ruin to both body and mind; viewed in this light, it may indeed be said, that the situation of men of opulence is of all stations the least to be envied. I cannot, therefore, but earnestly recommend to those entrusted with that important charge, the education of youth, to enforce both by precept and example, their employment of that time which is not engaged in necessary avocations, to some purpose, that, whilst it amuses, may likewise instruct and improve their understandings. These measures are more peculiarly important in times like the present, when idleness, dissipation, and infidelity are with gigantic strides endeavouring to encompass mankind with chains of slavery of all others the most dreadful and pernicious.

I shall close these observations in the elegant language of an admired writer.

" A man that has formed a habit of turning every new object to his entertainment, finds in the productions of nature an inexhaustible stock of materials upon which he can employ himself, without any temptations to envy or malevolence; faults, perhaps, seldom totally avoided by those whose judgment is much exercised upon the works of art. He has always a certain prospect of discovering new reasons for adoring the sovereign Author of the universe, and probable hopes of making some discovery of benefit to others, or profit to himself. There is no doubt but many vegetables and animals have qualities that might be of great use, to the knowledge of which there is not required much force of penetration or fatigue of study, but only frequent experiments and close attention. What is said by the chemists of their darling mercury, is, perhaps, true of every body through the whole creation, that, if a thousand lives should be spent upon it, all its properties would not be found out.

Mankind must necessarily be diversified by various tastes, since life affords and requires such multitudes of employments, and a nation of naturalists is neither to be hoped or desired; but it is surely not improper to point out a fresh amusement to those who languish in health, and repine in plenty, for want of some source of diversion that may be less easily exhausted, and to inform the multitudes of both sexes, who are burthened with every new day, that there are many shews which they have not seen. He that enlarges his curiosity after the works of nature, demonstrably multiplies the inlets to happiness."*

The characters by which the several classes of insects are distinguished, have been already explained in pages 218 and 219; their transformations have likewise been fully described; I shall now proceed to enumerate the best methods of obtaining them in their different states. Justice to the merits of two eminent naturalists † obliges me to mention, that to them I am indebted for a considerable part of these instructions.

Of all the different classes or orders of insects, that called LEPIDOPTERA is not only one of the most numerous, but the most beautiful, with respect to the variety as well as richness of

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* Johnson. † Lettsom's Naturalist's Companion; Curtis's Instructions for Collecting and Preserving Insects. Both these tracts are now become very scarce.

their colours; and, as from the peculiar delicacy of their structure, they require greater care to be used in catching, as well as in preserving them, it will be proper first to speak of, and be more particular in the directions concerning them.

THE METHOD OF PROCURING MOTHS AND BUTTERFLIES.

There are two methods of collecting insects of this kind; first, by breeding; secondly, by catching them in their fly state: of these, the former is by much the preferable mode; as, besides the pleasure which arises from observing the gradual progress of the insects from their egg or caterpillar to their perfect or fly state, they may be killed before they have sustained the smallest injury in the farina or meal of their wings by flying.

The difficulty likewise in procuring the most beautiful and valuable insects of this class in their fly state, renders this method by far the most eligible. Most of the sphinges of Linnæus, or, as they are usually called, hawk-moths, are but seldom met with in their fly state, and when seen on the wing, generally elude the swiftest pursuit; but in their caterpillar state they are frequently found, and easily taken. Thus the caterpillar of the sphinx atropos or jasmine hawk-moth, the largest and most beautiful species of moth this country produces,* is often found feeding on the jasmine and potatoe, and sometimes on green elder; the

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* Desirous as every collector must be of obtaining these moths, it is certain there are many persons still existing, who would consider it as a great calamity were one of them to fly into, or even approach their habitation; and so far from affording the pretty fugitive an asylum, would experience the highest satisfaction at his speedy departure. The reason, if it be not a prostitution of the term, is, that as the plumage on the back of this moth exhibits somewhat of the resemblance of a death's head, these intelligent prognosticators (naturalists they cannot be called) are fully convinced that this harmless insect must be the harbinger of mortality, and

sphinx elpenor or elephant hawk-moth, on the Galium palustre or white ladies-bed-straw; the sphinx ocellata or eyed hawk-moth, on the willow and apple-trees; sphinx tiliæ or lime hawk-moth, on the lime-tree; sphinx lagustri or privet hawk-moth, on the privet; phalæna pavonia or emperor-moth, on the briar, black-thorn, willow, &c. and so of a great number of others.

THE METHOD OF COLLECTING MOTHS, &C. IN THEIR CATERPILLAR STATE.

Independent of the method of collecting caterpillars by an attentive examination of the leaves, and other parts of plants, at those times of the year when they are in full verdure, there is another, viz. by beating the boughs of trees, particularly the taller ones, with long poles, having previously spread a large sheet underneath to receive them as they drop from the trees. By these means many very valuable caterpillars are frequently obtained, which could not otherwise be procured without considerable difficulty. Caterpillars should be handled as little as possible, particularly those with smooth skins; the more hairy ones in general sustain less injury by it. To convey them home with safety, the collector should be provided with a chip box in his pocket; and it would be proper to have it partly filled with fresh leaves.

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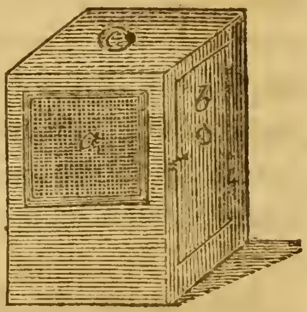
that its appearance infallibly portends speedy death to some one of the family! Indeed, to weak minds, especially if previously debilitated by sickness, such an idea, if permitted to prey upon their spirits, may be productive of fatal consequences, and thus stamp a credit on the prophetic abilities of those sagacious observers of the mysteries of nature. To medical men, who are daily witnesses of the wonderful influence which the mind possesses over the body in a diseased state, such events do not appear at all surprizing.

THE METHOD OF REARING OR BREEDING THEM.

Having procured the caterpillars, our next endeavour must be to rear them. For this purpose, it will be indispensably necessary to afford them an ample supply of the plant on which they are found feeding, and to renew their food as often as the decay of that first procured for them may render it expedient. Insects in this state usually feed voraciously; the caterpillar of the papilio brassica has been known to consume in one day twice its own weight of food. Although many of them live on a variety of food, the greatest part are attached to some particular kind; deprived of which, some species would form objects less beautiful when arrived at their perfect state, and others infallibly perish.

As to many it may prove very inconvenient to supply the caterpillars with fresh food daily, to avoid this trouble, several sprigs of the tree or plant may be put into a wide-mouthed glass filled with water, and the caterpillars placed on them. Most plants may in this manner be preserved fresh for three or four days. The glass, together with the caterpillars and their food, is to be placed in the breeding box represented in the figure annexed. *a*, shews an opening in the front covered with gauze; *b*, the door on the side; *c*, a ring for conveniency of carriage; and a constant supply of fresh food is to be given them, as soon as the former appears in the least withered. The breeding boxes should never be exposed to the scorching rays of the sun, but placed in a cool and shady situation; nor should they contain more than one kind of caterpillar, as some species devour others.



When arrived at their full growth, the caterpillars leave off eating, and soon after, change into the chrysalis or pupa form; previous to which, butterflies spin a little web, just sufficient to suspend themselves by: many of the moths, like the silk-worm, spin a large web, in which they inwrap themselves; and a great number penetrate into the earth, where they spin themselves cases, or change without any spinning, as do most of the sphinges or hawk-moths. It will therefore be necessary to cover the bottom of the box with fine mould to the depth of four or five inches, and keep it constantly moist.

It frequently happens that caterpillars are what the aurelians call stung, that is, have the eggs of the ichneumon-fly deposited in them, of which operation a full account has been given in pages 295---298. Caterpillars, previous to their going into the chrysalis state, generally lose the brilliancy of their colours, and many of them rove about for some time.

After remaining in their chrysalis state till near the time of their coming forth, such as are inclosed in a hard case or spinning, as the phalæna vinula, puss moth; phalæna quercus, great egger moth, &c. are to be carefully freed from it; as the aperture which the insect naturally makes is often too narrow for it to pass through without sustaining considerable injury in its plumage. The opening will be best made, by cutting off the larger extremity of the case, taking especial care not to wound the inclosed pupa or chrysalis.

The learned Dr. Bellardi, Foreign Member of the Linnean Society, &c. a few years since discovered a new method of feeding silk-worms, when they are hatched before the mulberry-trees have produced leaves, or when the tender branches are destroyed by frost: how far this practice may be successfully applied in other instances, seems as yet undetermined; though from some recent experiments, it appears possible that caterpillars may be thus fed in backward seasons. This method consists in giving the caterpillar the dried leaves of their accustomed food reduced to powder, and gently moistened with water; a thin coating of which must be placed round the young worms, who will immediately begin to feed upon it. The Doctor informs us that the caterpillars of the silk-worm prefer it to any other food, and devour it with the utmost avidity. The leaves should be gathered towards the close of the autumn, before the frost commences, in dry weather, and when the heat is greatest; they must be dried in the sun by spreading them upon large cloths, and after being reduced into powder, laid up in a dry place. Donovan says,* that the experiment has been tried with several caterpillars which were nearly full fed on the leaves of thorns and oaks thus prepared, and that they were observed to eat it when no other food was given, but he cannot determine how far they may thrive if fed on that aliment only.

THE METHOD OF COLLECTING THEM IN THEIR CHRYSALIS STATE.

Butterflies and moths may often be found in chrysalis under the projection of garden walls, pales, out-houses, in summer-houses, &c: and frequently affixed to the food on which the caterpillar fed. A great variety of moths in the pupa state may with more certainty be found, during the winter months, by digging under the trees on which they feed, particularly under the oak, willow, lime, and elm trees. When they are procured in this manner, they should be placed as soon as convenient in

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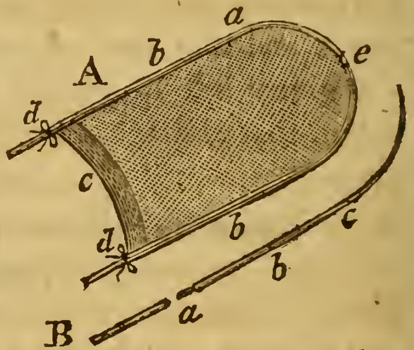
* Treatise on the Management of Insects.

the breeding box before described, and kept covered with moist earth till the ensuing spring; when, as soon as the weather is mild, they may be dug up and placed somewhat nearer the surface of the mould, and in that manner left to come out of themselves. Should the collector not succeed in procuring chrysalides by this method, it will frequently happen that his labour will be amply recompensed by obtaining a variety of beetles.

THE METHOD OF COLLECTING THEM IN THEIR FLY OR PERFECT STATE.

The extreme delicacy of the wings of moths and butterflies will not admit of their being caught without injury, but in nets made of the finest materials. It will be necessary, therefore, that the collector should provide himself with a net properly adapted to this purpose: the one here represented has, after long experience, been found to answer extremely well. Fig. A shews the net expanded ready for use; *a* exhibits the part made of fine Scotch gauze, which should be previously dyed green; *bb*, the sticks; these should be of some light wood. To render them compact and convenient for carriage, they are made to take to pieces somewhat in the manner of fishing-rods, and connected by means of screws or hollow brass ferrils fixed to the end of each: there are three of them for each side of the net. Fig. B shews one of the sticks; *a*, the brass ferril; *b*, the end of the next stick, which fixes tight into it; to the upper end of the sticks, at *c*, is joined in like manner a piece of cane bent to a proper shape. Instead of three pieces of wood, as here described, the other stick may consist of one entire piece, and be used as a walking-stick. The gauze must be edged with two



pieces of binding sewed together, to receive the sticks when joined; and, as the sticks are taper, so must be the cavity to receive them. At the lower part the gauze is to be turned up about six inches, so as to form a bag, Fig. A, *c*. At the extremity of the gauze, next the handles, two pieces of tape must be fixed on each side, *d d*, of sufficient length to pass through a hole bored in the stick, and then be tied in a loop, so as to prevent the gauze from sliding on the sticks. At the upper part of the net where the canes meet, *e*, the cavity should be closed by a few stitches, that the sticks may shut even together. The net may be about a yard in width when expanded, and the length of it a yard and an half: the size, however, may be varied at pleasure. The gauze should be deprived of its glazing by being soaked for a short time in warm water; but, if dyed green, which is usually the case, this will be unnecessary. The handles are to be held one in each hand, when the net is used.*

Besides the gauze net for catching butterflies, &c, the collector should be provided with a pair of forceps, made of steel, about nine or ten inches in length, and of the shape represented in the figure;† the fans are to be covered with fine green gauze. This instrument will in many instances be found exceedingly commodious, as being of more general use; it is very portable,

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* Though this net be principally intended for catching moths and butterflies on the wing, it may be usefully applied to another purpose: if one person expand the net under a bush or branch intended for examination, and another shake the bush, or beat it well with a stick, numbers of caterpillars, as well as some of the minuter kinds of coleopterous, and other insects, will fall into the net. By these means moths are likewise often taken, as they remain in a torpid state during the day, sheltered in the bushes.

† This figure shews the forceps in the proportions in which they have been generally made; I would, however, recommend the fans to be considerably larger, and the handles shorter. The form of the fans has commonly been either hexagonal, or, the worst of all, triangular; experience has taught me that the shape as here given is to be preferred, as being less liable to miss

and possesses this advantage over the net, that the insect caught in it will be more confined, and consequently not so liable to injure its down. If the insect be met with on the trunk of a tree, paling, or any flat surface, it may be readily caught; if on a leaf, both may be enclosed in the forceps. Whilst in the forceps, it should be pressed with the thumb, or, if the creature be small, with the thumb-nail, sufficient to stupify, but not crush it.

The next articles necessary to be provided, will be two or three oval chip boxes, cut sufficiently flat for the pocket, and lined at top and bottom with thin cork; and a cushion well stored with pins of various sizes.

The collector being now furnished with the necessary instruments, it will be proper to give him such instructions as may enable him to use them. With regard to the manner of using the net with expertness and success, this knowledge will be much better acquired by practice than by the most ample description. Harris, in his elegant work, The Aurelian, has been rather diffusive than clear on this subject. Having caught the butterfly or moth in the net, it will be necessary to proceed with caution, as on killing it properly its beauty in a great measure depends. It should not be laid hold of indiscriminately in any part; but by managing skilfully the net, its wings must, if possible, be brought into an erect position or close together; then press the under part of the thorax or breast between the thumb and the fore-finger sufficiently hard to kill the insect. By carefully attending to these directions, the wings will not be distorted or the plumage injured.

the insects, who are usually upon their guard, and frequently elude the vigilance of their pursuers. A front view of the fans is given, the better to shew their form; but it is obvious that they must be placed in a contrary direction, so as to flap on, not slide over, each other.

The net being now opened, the insect is to be laid hold of by one of its antennæ or horns, and again placed between the thumb and fore-finger; in which situation it is to be held, while a pin proportioned to its size is stuck through the upper part of the thorax or back; it may then be affixed to the pocket-box by sticking the point of the pin into the cork lining. The larger kinds of these insects, especially moths and hawk-moths, which are far more tenacious of life than butterflies, will not expire so readily by this method, as by fixing them upon the bottom of a cork exactly fitted to the mouth of a bottle into which a little sulphur has been put; by gradually heating the bottle till an exhalation of the sulphur takes place, the insect usually dies without injuring its colour or plumage.

THE METHOD OF MANAGING THEM IN THEIR FLY STATE.

Though by the means just described these insects may be caught uninjured, some farther care is requisite in order to make them appear to advantage; this is called setting them, and is performed in the following manner. The insect being stuck through with a pin of a proper size, is to be placed before its wings are become stiff, on a piece of cork, having a smooth surface and covered with white paper. The body of the fly should not be made to touch the cork when the insect is affixed to it, but to stand up some little distance from it, as only the edges of both wings are intended to touch, not the wings to lie flat on the cork. The wings are then to be expanded, as in the figure, with a fine needle, or some sharp-pointed instrument. The instruments used in the operation for the eye called couching, being fixed to taper handles, are peculiarly commodious for this purpose.

The upper edges of the superior wings are to be placed in a line with the head of the insect, and they are to be kept in this situation by means of little braces, formed of card-paper and cut in the shape represented in the figure; a number of which should always be kept in readiness in a small box. These must be proportioned to the size of the wings, and fitted to their shape, by being more or less bent; by a proper attention to which, the spots, &c. on both wings are rendered conspicuous, and the beauties of the insect exhibited in full perfection. To acquire the method, however, of setting them well, requires considerable practice and some ingenuity. After remaining in this position four or five days, or till the insect is become thoroughly stiff, the braces may be taken off, and the insect removed into the store box. The shape of the store box is immaterial; it should, however, be flat, and may be made either of wood, or, which is preferable, of tin. The inside should be lined with thin cork and covered with paper, and some slips of cloth glued to its edges to make it shut closer, and thus exclude as much as possible insects and animalcula; a little camphor tied in a bit of rag, and pinned to a corner of the box, will be found very useful to prevent their depredations.

It is particularly to be observed, that there is a continual succession of insects as well as of plants; some appear with the early primrose, others accompany the late-flowering ivy: so that in this respect, the aurelian and entomologist may regulate their excursions by those of the botanist; the latter would in vain search for the ranunculus ficaria or pile-wort, in the month of July, and the former be equally disappointed in seeking for the papilio cardamines, orange-tip, in the month of August.

Some of these insects continue longer in their fly state, and their plumage is less injured by flying, than others; some continue for a few days only; others, several weeks. In general, moths and butterflies, unless they are caught the first day of their coming out of chrysalis, are of small value; hence arises the necessity of carefully watching those particulars, and of making frequent excursions in order to obtain them in the greatest perfection.

Butterflies are to be caught on the wing only when the sun shines warm. They inhabit a variety of places; the greatest number of them frequent woods, and may be taken in or near them, as the papilio iris, purple emperor; papilio hyperantus, ringlet; and most, if not all the fritillaries. Some delight in meadows, as the papilio jurtina, meadow brown; galathea, marbled white; C. album, comma; rhamni, brimstone: and others frequent gardens, as the brassicæ and rapæ, large and small garden white; others, again, clover fields, corn fields, heaths, lanes, &c. Many of those which frequent woods are taken with much greater facility in the morning, a few hours after sun-rise; at which time they are found feeding on the flowers that grow by the sides of the woods; afterwards, when the sun shines with greater strength, they fly high, and with such rapidity, as not to be taken but with the utmost difficulty.

Moths fly chiefly in the evening, a little after sun-set. Like butterflies, they inhabit a variety of places, and are to be met with in the greatest plenty near woods; they may also be taken in great numbers in the day-time by beating the hedges, &c. more particularly in the afternoon, as the least motion will then put them on the wing. They are likewise frequently met with in the day-time sticking to the bark of trees, on walls, and pales that surround gardens, &c. and may be thus caught in great perfection. Some few, like the butterflies, fly in the middle of the day, when the sun shines warm, over the flowers of honeysuckles, and other plants with tubular flowers. Insects of this species seldom sit to feed, but continue vibrating on the wing while they thrust their tongue or proboscis into the flower.

Geoffroy says that moths may be taken in great plenty by means of a candle or lanthorn carried into or near some wood, towards dark. Independent of the recommendation of authority so respectable, the well-known propensity that moths have to fly towards, and even into candles, has induced some collectors to adopt this method with success; many of the most valuable caterpillars have also been thus obtained.

THE METHODS OF COLLECTING INSECTS OF THE BEETLE KIND.

By these are meant all such as are included in Linnæus's first order of insects, under the term COLEOPTERA; these have generally been called scarabæi or beetles: some few of them have obtained distinct English names, as the chaffer, lady-bird, earwig, &c. and all have been divided by Linnæus into genera and species.

The insects of this, as well as the preceding and following order, may be found in their caterpillar or grub state, in which they often prove extremely destructive to the roots of plants; and may in like manner be brought to their perfect or fly state, regard being had to their different manner of feeding. The time and care, however, required for this purpose, is probably more than can be spared by the generality of collectors; the curious entomologist, possessed of both leisure and abilities to engage in the pursuit, will be enabled to establish with certainty the different genera of insects.

These insects are generally collected in their fly state: some creep and fly in the day-time when the sun shines warm; others, like the moth, fly in the evening and the night only.

Their habitations are exceedingly diversified: some are found in rotten and half decayed wood, and under the decayed bark of trees, as the lucanus cervus, flying stag, scarabæus cylindricus, and many of the cerambyces; others, among the dung of various animals, particularly of horses, cows, and sheep, as the dermestes, leather-eater; hister, mimic beetle; scarabæus fimetarius, &c. Many of them make holes under the dung three or four inches deep, it will therefore be necessary to have an iron spade to dig them out, when in search of this kind of insects; some reside in the bodies of animals that are become putrid, as the silpha vespillo, carrion beetle, hister, &c. also in moist bones that have been gnawed by dogs, or other animals, on flowers having a fetid smell, and on several kinds of fungous substances; others may be found in the morning about the bottoms of perpendicular rocks and sand-banks, as the curculio, weevil; and brachus, sand-beetle. Great numbers are found on the leaves and stalks of plants, as the scarabæus melolantha, chaffer; coccinella, lady-bird; chrysomela, curculiones, &c. others delight more particularly in the flowers of plants, as the scarabæus auratus: some reside altogether in woods, as many of the cerambyces; some are found swimming on the surface of standing waters, as the gyrinus natator; others in ditches, ponds, &c. as the dytisci; many may be caught in rivers, lakes, and standing pools, by means of a thread net with small meshes, in a round wire hoop fixed to the end of a long pole; some are discovered by the light which they emit, as the lampyris noctiluca, glow-worm; and vast quantities are found on dry banks, sand-banks, sand-pits, &c. particularly when the sun shines warm; numbers may be found in houses, dark cellars, damp pits, caves, and subterraneous passages, as the tenebrio, stinking beetle; or on umbelliferous flowers and in timber-yards. Multitudes live under stones, moss, rubbish, and creeks near the shores of lakes and rivers; these are found also in bogs, marshes, moist places, pits, and holes of the earth, on stems of trees, and in the evening they crawl plentifully along pathways after a shower of rain. Some may be discovered in the hollow stems of umbelliferous plants, as the forficula, earwig.

These insects, as soon as caught, may with a pin of a proper size be stuck through the body, close to the suture that runs down the middle of the back; and then placed in the pocket box, taking care that they do not injure one another from being placed too close together. Or, if the collector be disposed to procure this class of insects, he will find it very convenient, and certainly much less cruel, to carry a number of small pill-boxes in his pocket, in which the insects may be readily secured and kept till he return home, without their suffering any pain; they are then to be immersed in boiling water, that being a most expeditious mode of killing them, and far preferable to their immersion in spirits, in which many of them will live a considerable time;* they may afterwards be stuck through in the manner abovementioned, being careful to make the pin pass a sufficient length through the body of the insect, and then placed on a piece of smooth cork. When they have remained in this situation two, three, or four days, or longer, according to their size, the legs, antennæ, &c. are to be extended with a pair of fine nippers or tweezers, and placed in a natural position; in which they will, if proper care be taken of them, always remain: particular caution

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* "The best method is to inclose them in a chip box, and kill them by exposing the box to the heat of a fire; this treatment will rather absorb than add to the superfluous juices of the insect, and greatly contribute to its preservation." Donovan.

should, however, be used not to place them in the store box or cabinet till perfectly dry, as otherwise they will be liable to be infested with animalcula, by which they will soon be destroyed.

THE METHOD OF COLLECTING INSECTS CALLED HEMIPTERA.

The genera contained in this order of insects are principally these: viz. blatta, the cockroach; mantis, camel cricket; gryllus, locust, grasshopper, cricket; cicada, flea locust; cimex or bug.

The first of these, the cockroach, has been imported from warmer climates, where these insects are extremely numerous, and far more troublesome.* They are found in the greatest plenty here in bakehouses, particularly in the night, their usual time of feeding; they likewise abound in corn-mills, in ships, and in all places where meal is deposited.

All those of the next genus, mantis, are foreign; some of them are extremely remarkable and curious, and from their particular shape, as well as their colour, have been called walking leaves; they are found in meadows, on grass, and on the leaves of plants and trees. The grylli mostly reside in meadows and fields among the herbage; however formidable the mischief occasioned by the blattæ may appear, it is trivial when compared with the ravages of the gryllus migratorius or locust.† One species of this

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* In the island of Senegal they do incredible mischief; they gnaw linen, sheets, wood, paper, books, and, in short, whatever comes in their way; they attack even the aloes, the bitterness of which keeps off all other insects. Adanson's Voyage, p. 296.

† Adanson relates, that soon after his arrival in Senegal, he was a witness to the mischief done by locusts, that scourge so dreadful to hot climates! Towards eight o'clock in the morning there suddenly arose a thick cloud that darkened the air, and obstructed the rays of the sun;

genus, the gryllus domesticus, resides in houses, particularly where there are ovens, and entertains the inhabitants with the chirping sound it emits. Most of the fulgoræ or lanthorn-flies are discoverable by the light which proceeds from them; these, like the mantæ, are foreign, and many of them equally curious. The cicadæ are found on trees and plants; the notonectæ and nepæ frequent rivers, lakes, and standing waters. There is scarce a person who has resided any time in a very populous place, but knows where to find one species of the next genus or cimex, viz. that distinguished by the name of cimex lectularius or bed bug.*

These insects may be killed either with boiling water or a few drops of the etherial oil or spirit of turpentine. They are all of them to be stuck through the thorax or back, betwixt the shoul-

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the cause of which was soon found to be myriads of locusts, raised about twenty or thirty fathoms from the ground, and covering an extent of several leagues, upon which a shower of these insects fell, devouring while they rested themselves, and then resuming their flight. This cloud was brought by a very strong easterly wind; it was all the morning passing over the adjacent country, and it was supposed the same wind drove the locusts into the sea. They spread desolation wherever they came; after devouring the herbage, with the fruits and leaves of trees, they attacked even the buds and the very bark; they did not so much as spare the dry reeds with which the huts were thatched. Hasselquist in his Voyage to the Levant, says that "the inhabitants of Asia sometimes take the field against locusts with all the apparatus of war. The bashaw of Tripoli in Syria some years ago raised 4000 soldiers against these insects, and ordered those to be hanged who refused to go." Amidst the numerous blessings our own favoured isle enjoys, what a happiness it is to be exempted from the ravages of these pernicious insects, as well as from the government of bashaws! In the year 1748 great numbers of the grylli migratorii were seen in London and its vicinity, but they were not productive of any mischief, and soon perished.

* These unpleasant domestics were scarcely observed in England previous to the fire of London in the year 1666. It is conjectured that they were afterwards introduced with the timber imported for re-building the houses: allowing this to be the fact, posterity may console themselves with the inconveniences they sustain from this evil, by reflecting how much benefit they have derived in other respects from the unhappy catastrophe which produced it.

ders; the wings of the grylli and some of the others are to be expanded, and kept so by the little braces, and their legs, antennæ, &c. placed in a natural situation.

THE METHOD OF COLLECTING INSECTS CALLED NEUROPTERA.

Those of this class, the fourth order of Linnæus, are chiefly aquatic, residing in the waters as caterpillars, and flying about them in their perfect state. The principal genera are, the libellula, dragon-fly; ephemera, may-fly; phryganea, spring-fly; hemerobius, and panorpa. The libellulæ are considered by the generality of people as containing in them something venomous; and from hence, in addition to the epithet, alone sufficiently tremendous, of dragon-fly, have obtained the several names of adder-spear, adder-bolt, horse-stinger, &c. It must be confessed, that their shape, manner of flight, &c. are such as might readily raise such an idea in the minds of the multitude, who but too often form their decisions from appearances only; but naturalists are unaccustomed to such hasty determinations, and they can safely advise the collector not to be misled by terrific words, nor intimidated from catching them, they being perfectly harmless, indeed more so than the gnats which constitute a part of their food. The butterfly net already described will be very convenient for catching insects of this order, particularly the libellulæ.

They are all of them easily killed, either by pressure of the thorax, or with spirit of turpentine, spirit of wine, or the fumes of sulphur; the same means are to be used in setting them as in the hemiptera.

THE METHOD OF COLLECTING INSECTS CALLED HYMENOPTERA.

The remarks which have just been made on the libellulæ do not apply to insects of this order, the major part of them being armed with stings; some of which are, however, harmless, though others are venomous. The principal genera are, the tenthredo, saw-fly; ichneumon, ichneumon-fly; sphex, ichneumon-wasp; vespa, wasp, hornet; apis, bee; formica, ant; sirex, and chrysis. The tenthredines are found on trees and flowers in their caterpillar state; they feed on the leaves of plants. The ichneumons are found in the same manner; in their caterpillar state, they live chiefly in the bodies of other insects, particularly in the caterpillars of the moths and butterflies, as has been already mentioned. The sphex resides principally in sand-banks, it is also caught on flowers, shrubs and fruits, and about hedges; this insect catches and kills others, which it buries in the sand, having previously deposited its eggs in them. Wasps, bees, and ants, are found on flowers and fruits, and almost on every sweet substance. The chrysis, of which many species are exceeding beautiful, is found flying about old walls, posts, sand-banks, &c. in which it builds its nest. Wasps and bees are the only winged insects that have any great degree of poison in them, they should therefore be taken with the forceps before described, and handled cautiously on account of their stings, which are dangerous. Some, as the mytilla, naked bee, have stings, but no poison, and are to be found on the flowers of umbelliferous plants, when the sun shines hot in the middle of the day; at which time others, as the chrysis, &c. are also to be met with: when caught, a pin is to be stuck through them whilst in the net. It is very difficult to kill these insects without injuring them in some respect; boiling water hurts their wings, and the fine hairs with which many of them are covered; spirits of wine or turpentine prove immediately fatal to some, whilst others are scarce affected by them; and letting them remain transfixed till they are dead, will probably be thought too cruel; it is said, that the best method hitherto practised, is to stick them through with a needle dipped in aqua fortis; the sphinges, and other large moths, are likewise killed in the same manner with the least injury: the reader will adopt either of these methods, or any other he may deem expedient. When dead, their wings are to be expanded, and kept in as natural a position as possible.

THE METHOD OF COLLECTING INSECTS CALLED DIPTERA.

This order contains various kinds of flies and gnats; the former abound in almost every place, but they are found more particularly on all kinds of plants and flowers, especially on the umbelliferous ones, about the tops of trees, little hills, &c. Some of them fly about cattle of various kind, in the skins of which they deposit their eggs, as the oestrus bovis, &c. These insects are easily killed by a few drops of spirit of turpentine: their wings are to be expanded so that their bodies may become apparent; a little brace should be placed underneath them, to prevent their bodies being too much incurvated in drying, which they are very apt to be. Many of these are most easily taken when they begin to feed; for, in the middle of the day they are so quick and active, that it is almost impossible to catch them.

With regard to the last order of insects, distinguished by the term APTERA, they are so common, and the places they inhabit so generally known, that any information on the means of collecting them must be superfluous. Under this class are included spiders, scorpions, centipes, crabs, lobsters, &c. &c. Most of these require to be preserved in some kind of spirit; spirit of wine, proof spirit, or geneva, are to be preferred, on account of their pellucidness; though rum or brandy may, if no other spirit be at hand, answer the purpose of preserving, though not that of exhibiting them with equal advantage.

Those of the genus cancer, after being well dried or carefully baked, may be conveniently preserved in store boxes, or properly arranged in a cabinet collection. The smaller kinds of insects in general, as well as those of the order aptera, are best disposed of between talcs in sliders; such, for instance, as the termes pulsatorium,* the several poduræ, pediculi, pulices, acari, &c.

As the collector will have frequent occasion for the use of cork, both to line his boxes with, and to set his insects on, the follow-

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* According to Linnæus, this is the minute insect which has been long known by the English name of the death-watch, and described by a number of authors: Linnæus thus notices it; "frequens in domibus, invisum vestibus, herbariis, insectorum museis. Fœmina horologii instar pulsatoria in ligneis festucis." Syst. Nat. p. 1015. No. 2. Geoffroy, however, says he is confident that it is not from this insect, but from the dermestes domesticus, (Syst. Nat. p. 563, No. 12,) which makes the circular holes in furniture, that the ticking noise proceeds. Hist. des Insectes, Tom. I. p. 111. & Tom. II. p. 602. Neither of these are larger than the pediculus humanus. Again, on the respectable authority of Dr. Shaw, we are assured, that the insect properly called the death-watch is a coleopterous insect of the genus ptinus, Syst. Nat. p. 565. The Doctor says, "it is chiefly in the advanced state of the spring that this alarming little insect commences its sound—the prevailing number of distinct strokes is from seven to nine or eleven—these are given in pretty quick succession, and are repeated at uncertain intervals; and in old houses, where the insects are numerous, may be heard almost every hour of the day, especially if the weather be warm. The sound exactly resembles that which may be made by beating moderately hard with the nail on a table—It is about a quarter of an inch in length." This very able naturalist has distinguished the insect by the name of ptinus fatidicus, the beating ptinus, and supposes it to be the same with the dermestes tesselatus of Fabricius, and the ptinus pulsator of Gmelin. He also cautions us "not to confound this insect, which is the real death-watch of the vulgar, emphatically so called, with another insect, which makes a sound like the ticking of a watch, and which continues its sound for a long time without intermission: it belongs to a totally different tribe from the death-watch, and is the termes pulsa-

ing directions how to prepare it for these purposes will be found useful.

He may procure the cork in large pieces at any of the cork-cutters; these must be cut into smaller ones, and, in order to make the cork flat, it is to be held before the fire till the heat thoroughly penetrate it; the cork is then to be immediately placed betwixt two smooth boards, and a very heavy weight laid on it; in which situation it must remain till cold. Thus flattened, it is to be rasped on both sides, with such a rasp as is used by the bakers; afterwards, with a finer one; and, lastly, with a pumice-stone; by which it will be rendered perfectly smooth. If the cork be thick, and the purpose of it to line boxes, it may be sawed through the middle, and rasped as before directed.

torium of Linnæus." Every one will agree with the Doctor in his remark, that, "it is a very singular circumstance that an animal so common should not be more universally known." Nat. Misc. vol. iii.

Whichsoever of the three above described is the real insect, it is well known, that for a series of years the dread of it has excited the most uneasy sensations in the minds of the weak and superstitious; an unhappy prejudice which exists even to the present hour, and cannot be totally eradicated by all the powers of reason and argument. Sir Thomas Brown long since observed, "He that could extinguish the terrifying apprehensions hereof, might prevent the passions of the heart, and many cold sweats in grandmothers and nurses." Pseudodoxia Epidemica, Book ii. Chap. 7. With the feelings of these persons a well-known satirist sports in the following lines:

——— "a wood worm
That lies in old wood, like a hare in her form:
With teeth or with claws it will bite or will scratch,
And chambermaids christen this worm a DEATH-WATCH:
Because like a watch, it always cries click,
Then woe be to those in the house who are sick;
For sure as a gun, they will give up the ghost,
If the maggot cries click, when it scratches the post."

Swift's Invective against Wood.

As, without a due attention to the state of the atmosphere, the collector may make many fruitless excursions, it will be proper to point out to him the kind of weather best adapted for the purpose of ensuring success.

If the day prove fine, and the sun emit much warmth, insects are very brisk and lively; if, on the contrary, the weather should be cold or windy, it will be in vain to attempt catching them on the wing, as at such times insects in general take shelter within the herbage, and instead of flying upwards, which is usually the case when disturbed, they dart into the thickest underwood; or should they rise above the bushes, they are impetuously hurled by the current of the wind far beyond the reach of the net; and, were it otherwise, the collector would find the apparatus unmanageable. Harris says the garden white is as good a token for fine weather as may be; when these flies are out in the morning, it generally prognosticates a fine day.

Another poet has also diverted himself with the same subject:

——— "The weather's bell
Before the drooping flock told forth her knell.
The solemn DEATH-WATCH click'd the hour she died."
Gay's Pastoral Dirge.

It is remarkable, that though the ignorant despise the minuter parts of creation, as too insignificant to engage their notice, and venture to deride those better informed for their attention to such TRIFLING subjects; yet are those the very persons on whom REAL TRIFLES make the strongest impressions, and by whose credulity an apparently insignificant creature has been MAGNIFIED, so as to become an object of considerable importance in the scale of beings; for, as our great dramatist says of the JEALOUS:

——— "Trifles light as air
Are to the TIMID confirmations strong
As proofs of holy writ."

At day-break many insects are on the wing; and most kinds are observed in hot weather to come forth after rain, to enjoy the humidity of the air; this is the best time for collecting, as their wings are less subject to stiffen before they can be set.

The males of some, if not of every species of moths, and possibly of other insects, by a faculty to us incomprehensible, are able to discover the females, not only at a great distance, but in the most recluse situations. This circumstance has induced some collectors to endeavour to entrap such of the males as are not easily procured by any of the common methods: they enclose the female in a breeding box, and place it as near the usual haunts of the species as convenient; the males will generally be observed soon after fluttering on the box, and endeavouring to gain admission to the females. This artifice has been repeatedly practised with success on the fox and egger moths.

Every species has its distinct time for appearance, which is seldom accelerated or retarded a few days, unless by the unusual mildness or inclemency of the season. If a brood of insects be discovered at a certain season of the year, a brood of the same species will be found precisely at, or near the same period of the year following, except by accident they should have been destroyed. Notwithstanding the observation holds good in general, it is a fact that some insects are very variable in this respect; for instance, the sphinx convolvuli, unicorn hawk-moth, and the papilio hyale, clouded-yellow butterfly, were common about London in the year 1781, but have been very scarce since that time, especially the former; the papilio cardui, painted lady, sometimes disappears for several years. The papilio antiopa, grand surprize or Camberwell beauty, was first discovered in the year 1748, in Cold-arbour lane, Camberwell, and has occasionally disappeared for some years; a few seasons since several were taken in different parts of the kingdom; subsequent to which period, it is not known that even one specimen has been seen. It has been repeatedly ascertained, that, as with plants, so it is with insects, some kinds are confined to one particular spot of ground, and are not to be found in any other part of the same wood; consequently, the haunts being once discovered, the collector may be encouraged to expect meeting with some of the same species for several seasons successively.

Minute moths are to be found in winter as well as summer. It would be scarcely credible, did not experience prove, that when the frost is so intense, as to entirely subvert the appearance and almost annihilate the existence of vegetable productions, within its influence myriads of these delicately-formed creatures brave the inclement season, and exist securely within those habitations which they have the address to construct. A skilful entomologist may at this season in a few hours collect a number of the coleoptera, hemiptera, and lepidoptera orders; several of which are not to be obtained, but in very cold weather.

These insects usually shelter themselves among the moss and other extraneous matters growing on the trunks or branches of trees, or beneath the rotten bark; these substances should be shut close in a box or tin canister, to prevent the escape of those insects that may be revived by the warmth. To examine them, Donovan recommends spreading a sheet of writing paper on a table, and placing a lamp or candle, with a shade of transparent or oiled paper before you, so as to weaken the glare; separate the moss, and shake it loosely in your hand, and you will perceive many insects fall down on the paper. If they be too minute to admit of a pin being thrust through the thorax, they may be fastened with gum-water to small slips of paper.

GENERAL INSTRUCTIONS FOR FITTING UP A CABINET.

To those who delight in subjects of natural history, a good cabinet of insects is esteemed a valuable acquisition: if it be well constructed, and the several objects arranged with judgment, it certainly exhibits one of the most beautiful and admirable assemblages of objects in nature. Such, however, who are disposed to make a collection sufficiently extensive to form a complete one, will find it necessary to devote a great deal of time to the purpose, as well as to be endued with a considerable share of perseverance and ingenuity; those who are possessed of affluence will find it far less difficult to acquire one. The cabinet, to appear with that elegance which the subject deserves, should be of mahogany, well seasoned, and made by a good workman in such a manner that all the joints may fit with the greatest nicety; the form and size may be according to fancy, or the extent of the collection intended to be made.

To form a cabinet sufficiently capacious to receive specimens of all the English insects hitherto discovered, those excepted which, as before observed, are better preserved in spirits or between sliders, I would recommend one on the following plan:

The height may be about three feet four inches, the width two feet four inches, and the depth one foot four inches, inclosed with folding doors, and provided with a good lock. The inside to be partitioned down the middle, so as to admit of a range of twelve square drawers on each side; under these, two or three drawers may be fitted extending the whole width, to admit the larger kinds of insects, such as the sphinges, cancri, &c. the sides and backs of all these drawers should be of cedar, and the fronts mahogany, with a brass ring or button to each. The cork with which their bottoms are lined, must be chosen as free from cracks as possible, and, after being washed several times with a solution of corrosive sublimate in spirit of wine, to destroy the animalcula, glued on to prevent its warping. The whole surface must be made perfectly smooth and level, and this, as well as the sides, covered with imperial paper carefully pasted on, and afterwards moistened with alum-water. The paper should be exactly ruled into squares proportioned to the size of the insects they are intended to contain; and the names of each order and genus affixed according to the system of Linnæus. By way of embellishment, the edges may be lined all round the drawers with narrow slips of some kind of ornamental paper. The fore-part of each drawer should have a thin partition to admit of a proper quantity of camphor, with a number of small air-holes for the more ready diffusion of its effluvia to the insects contained in the drawer: the tops of these partitions must be closed with thin slips of wood laid on them and fitted with nicety, but not glued. To prevent the admission of dust and air, and exhibit the contents to advantage, the top of each drawer must be glazed with the finest glass, fitted into a frame of the same size as the drawer, made either to slide in a groove, or let in on a rabbet.

Having proceeded thus far, it will be adviseable to let the cabinet be thoroughly aired, before any insects are deposited in it, and to be particularly careful that all the insects so deposited be as free as possible from moisture; if the cabinet be then constantly kept in a dry situation, the camphor occasionally renewed, and the air excluded, there is every reason to expect that the several insects may be for a long time preserved in a state of perfection. If, notwithstanding all these precautions, little dusty particles should appear on any of the insects, which is a certain sign of the presence of animalcula, they should be gently wiped with a hair pencil dipped in spirit of wine, or carefully removed into a chip box and placed on the side of a Bath stove for a short time; by these means, if early attended to, they will be sufficiently baked to prevent future injury. A strict adherence to the above particulars, enabled me to preserve the contents of the cabinet formerly in my possession, now the property of Sir John St. Aubyn, Bart. F. R. & L. S. for several years in the most perfect condition, though containing considerably above 2000 articles. Within the same space of time, to my certain knowledge, several valuable collections have been either totally destroyed, or very materially injured; as when once the depredations commence, the destruction proceeds with rapidity, if not speedily prevented.

Those who are desirous of enriching their collection with the productions of other climes, will require a cabinet much more extensive, or, as the subject may be said to be inexhaustible, may devote several to exotic insects only. The collection made by Mr. Drury being, I believe, the most superb which has ever appeared in this kingdom, it may prove agreeable to many of my readers to give them a concise account of it. It is contained in five large cabinets, and consists of two divisions; first, those found in this country, and, secondly, those procured from various quarters of the globe. The English collection contains 2324 different insects, and the foreign one 5066; total, 7380: the latter comprises of coleoptera, 1716; hemiptera, 676; lepidoptera, 1739; neuróptera, 122; hymenoptera, 472; diptera, 312; aptera, 29. The whole of this magnificent collection is regularly arranged, according to the Linnean system, in 144 drawers. Some of the most beautiful objects in this collection are exhibited and fully described in a work published by Mr. Drury, in three vols.

quarto, containing on 150 plates about 700 elegantly coloured specimens.

The climate of Asia is particularly favourable to the production of numerous articles in the several branches of natural history unknown to, or not natives of Europe; especially those of the lepidoptera order of insects, numbers of which are remarkably large, and exhibit a variety of the most beautiful colours. This induces gentlemen, previous to their departure for India, to furnish themselves with cabinets at a considerable expense, anticipating the satisfaction they shall enjoy during their residence there, in arranging and depositing therein the several articles they purpose collecting, and entertaining their friends with a view of them. Besides this, they receive commissions from their European friends to collect and remit to them as many as they can, neither party conceiving that this would be attended with any considerable degree of trouble or inconvenience. It may, therefore, not be amiss to introduce here what the Rev. Mr. John, one of the Danish missionaries at Tranquebar, says on the subject.* " The rainy season is in the highest degree injurious to collections in every part of natural history, shells and minerals excepted. To obtain a permanent cabinet, if not impossible, is at least very difficult and expensive. Insects, unless carefully preserved in close cases, well secured from the accession of the smallest particle of air, are soon covered with mouldiness; nor are dried fish, stuffed birds, skins of animals, plants, &c. exempted from this inconvenience; if not frequently exposed to the rays of the sun or dried in ovens, myriads of animalcula in a short time form a settlement and inevitably destroy them. All the cabinets received from Europe, lined in the accustomed

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* Neuere Geſchichte der Miſſions Anſtalten. 48 stück. Halle 1796.

manner with cork or deal, are here on this account totally useless, besides their being soon disjointed by the heat of the climate. Sail cloth, well pitched and extended on frames, is far better calculated to answer the purpose; a number of these may be placed one above another, at a convenient distance, and the whole supported on light feet: to render them more pleasant to the eye, the linen may be covered as most agreeable either with white or coloured paper. Even the echini, and the smaller marine plants, attract so much dampness as to lose their colours and spiculæ, and fall to pieces, especially if they have not for some time been previously soaked in fresh water, in order to deprive them of their saline particles. Stuffed birds, &c. lose their feathers or hair, and the more soft and tender parts fall off. Consequently, if no ships go from hence during the month of October, but are detained till February, the major part of what I have collected for such of my friends in Europe who are admirers of the wonderful works of the Creator, will be lost to myself and them, besides subjecting me to the imputation of a want of attention and gratitude for favours previously received, than which nothing can be farther from my heart."

The above remarks, it is hoped, will afford some useful hints to gentlemen intending to visit India; as well as plead in justification of those who, unacquainted with the difficulty of preserving collections in so warm a climate, have previous to their departure precipitately made promises to their friends, which for want of being realized, have too frequently exposed them to unmerited censure.

A
COPIOUS LIST
OF
MICROSCOPIC OBJECTS.

In the introductory part to our author's list of objects in Chap. X. he very justly observes, that from the nature of the subject the list must be very imperfect, &c. it is not with the vain idea of rendering that complete which he has left imperfect, and which indeed must ever remain so, that the following general list is introduced; but principally with the view of still farther assisting the tyro, and pointing out a variety of articles, that might not otherwise so readily occur to him. In most instances, I have mentioned where the objects may be sought for with a probability of success; to have described them would have exceeded my limits. The specimen here given, will convince the reader, that it would be no very difficult task, so to enlarge this list, as to constitute a volume; but, it is presumed, that in its present state it will be found sufficiently extensive, and of considerable utility. To those who are already conversant with the subject, it may prove acceptable as a kind of index to assist their memories; and to such as may be disposed to form a cabinet, it will serve the purposes of directing them in their choice of the principal objects, and exhibiting some idea of the manner in which they are to be arranged.

I. ANIMALS, AND THEIR PARTS.

THE HUMAN SPECIES, QUADRUPEDS, &c.

The human hair
Horse hair
Hog's bristles
Mouse hair
Smellers of cats, tygers, &c.
Cuticle, or scarf skin of the human body
The skin itself
Membrana adiposa
Muscular fibres
Nerves
Arteries and veins
Intestines or guts
Lacteals
Lympha ducts
Lungs
Liver
Pancreas, &c.
Brain
Eye, its coats, humours, &c.
Nose, its ossa spongiosa, &c.
Ear, its hair, wax, tympanum, &c.
Tongue, its fibres, nervous papillæ, &c.
Blood, its globules, circulation, &c.
Nails and hoofs in thin slices
Bones, &c. &c.

OBJECTS PECULIAR TO BIRDS.

Feathers and their plumage
Pith of ditto cut transversely
Red combs and gills of cocks
Scaly skin of the legs
Web or membrane of water-fowl
Fleshy fibres, particularly the gizzard
Eggs, their beautiful teints
Coloured iris of the eye in some, &c.
The breast bones and scapulæ of small birds; to which may be added,
The membranaceous wings of the bat

OBJECTS PECULIAR TO FISHES.

Many of these exhibit most beautiful objects, from the elegant variety of the colours and teints of their skins and scales
Their spines
Fins
Fleshy fibres
Sperm or hard roe
Teeth
Brain
Eye, its iris
Lungs and other viscera
Gills
Circulation of the blood in the fins and tails of small fishes
Shells of most kind of shell-fish
Fimbriæ or fringed extremities of shells, &c.

INSECTS.

1. *Coleoptera.*

The entire insect if not too large
The head
Antennæ
Wings
Elytra
Legs, &c.
Scarabæus auratus, rose-chaffer; on flowers
Dermestes domesticus, the death-watch of Geoffroy
——— pulicaris, flea beetle; on flowers
Ptinus pectinicornis; in old trunks of willows
—— fur; very destructive in cabinets
—— fatidicus (Shaw) death-watch, see page 688.
Gyrinus natator, water-flea
Byrrhus scrophularia; on flowers
Silpha pustulata; on trees
—— aquatica
—— pulicaria; frequently running on flowers
Cassida viridis; on verticillated plants and thistles
——— nebulosa; on thistles.
——— nobilis
Coccinella, 2 punctata; on alder and other trees
——— 5 punct. in gardens
——— 7 punct. lady-cow or lady-bird
——— 9 punct. on trees
——— 14 punct.
——— 16 punct.
——— 22 punct.
——— 14 guttata; in woods
——— 2 pustulata; on trees and flowers
Chrysomela tanaceti; on tansy

Chrysomela alni; on common alder
——— betulæ; on birch trees
——— polygoni; on grass
——— polita; on willows
——— populi; on poplar trees
——— sanguinolenta; in woods
——— hyoscyami; on henbane
——— exsoleta; in gardens
——— 12 punctata; } on asparagus
——— asparagi; }
Curculio cyaneus; on willows
——— cerasi; on black cherry trees
——— pruni; on cherry trees
——— acridulus; on plants of the genus tetradynamia
——— granarius, weevil
——— dorsalis; on the lesser celandine
——— pini; on Scotch fir
——— lapathi; on docks, particularly water dock
——— scaber; on nettles
——— quercus; on leaves of oak
——— viscariæ; on lychnis viscaria
——— pericarpius; on fig-wort
——— betulæ; on birch and alder
——— beccabungæ; on veronica beccabunga
——— alni; on leaves of alder
——— fagi; on beech trees
——— pomorum; on apple trees
——— nucum; in hazel nuts
Curculio scrophulariæ; on fig-wort
——— tortrix; in the twisted leaves of poplars
——— pyri; on pear trees
——— argentatus; in gardens
Cerambyx moschatus;* on willows, roses, &c.
Lampyris noctiluca; glow worm
Cantharis ænea; on flowers
Elater castaneus; on the bark of trees in woods
—— sanguineus; on the bark of trees
Cicindela riparia; } on wet sandy ground
——— aquatica; }
Dytiscus cinereus; } water
——— sulcatus; }
Carabus granulatus; in fields near London
——— crepitans; under stones
——— 6 punctatus; on sand near brooks
——— 4 maculatus; on sandy banks of rivers
Mordella aculeata; on flowers
Staphylinus murinus; on horse-dung
——— riparius; on wet sand
——— chrysomelinus; on sand and near walls
Forficula auricularia, earwig
——— minor, small ditto

2. *Hemiptera.*

Parts to be viewed the same as the Coleoptera
Blatta orientalis; in bakehouses and near chimnies
Gryllo-talpa, mole-cricket; chiefly under ground
Gryllus domesticus, house-cricket
——— campestris; under ground
——— grossus, common grass-hopper
——— verrucivorus, great green grass-hopper
Cicada cornuta; on trees, &c.
—— spumaria, black-headed frog-hopper, cuckow-spit, or froth-worm; in froth on sundry plants
—— viridis; on water plants
—— ulmi; on elms
—— rosæ; on rose trees
Notonecta glauca, common boat-fly; swims on its back in smooth water
——— striata, brown boat-fly; on water
——— minutissima, little boat-fly; swims on its back
Nepa cinerea, water scorpion; on water
—— cimicoides; on water
—— linearis; on stagnant water
Cimex lectularius, bed bug
—— scaraboides; on flowers in meadows
—— corticalis; on trees
—— betulæ; on birch trees
—— filicis; on fern
—— baccarum; on gooseberry bushes
—— personatus; in houses
—— hyoscyami, scarlet bug; on henbane

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* I have caught great numbers of these on white rose trees and rasp-berry bushes, in the vicinity of London; their smell has to me always appeared approaching nearer to that of oil of rhodium than of musk.

Cimex umbratilis; on flowers
—— striatus; in woods near Hampstead
—— populi; in woods, particularly on the trunk of the poplar
—— abietis; on Scotch fir
—— lacustris; runs quick on still water
—— stagnorum; on stagnant waters
Aphis ribis, currant louse; on the bushes
—— ulmi, elm
—— sambuci, elder
—— rumicis, dock
—— acetosæ, sorrel
—— lychnidis, campion
—— rosæ, rose
—— tiliæ, lime
—— brassicæ, cabbage
—— sonchi, sow thistle
—— cardui, thistle
—— tanaceti, tansey
—— absinthii, wormwood
—— jaceæ, knapeseed
—— betulæ, birch
—— fagi, beech
—— quercus, oak; under the bark
—— salicis, willow
—— populi, poplar
—— aceris, maple; on the leaves
—— atriplicis; rolled up in the leaves of the grass-leaved orach
Chermes graminis; on grass
——— pyri; on pear trees
——— scorbi; on mountain ash
——— urticæ; on nettles
——— alni; on common alder
Chermes quercus; on leaves of oak
——— abietes; on fir
——— fraxini; on ash trees
Coccus hesperidum, greenhouse bug; on orange trees
——— betulæ; on the divarications of the branches of birch trees
——— philarides; on canary grass
Thrips junipera; on bark of old trees
—— fasciata; on flowers
—— physapus; on dandelion, &c. p. 350.

3. *Lepidoptera.*

Their wings, scales, and feathers, tongue or proboscis, head, eyes, antennæ, chrysalides, eggs, legs, &c.
Papilio cardamines, orange tip; in hedge sides
——— Io, peacock; in lanes and hedge sides
——— Mæra, great Argus or wall; on walls and banks
——— galathea, white marbled; in meadows
——— cardui, painted lady; on furzes and teazles
——— Iris, purple emperor; in woods
——— polychtoros, large tortoise-shell; in lanes
——— urticæ, small tortoise-shell; on banks
——— maturna, heath fritillary; on heaths
——— cinxia, glanville or plantain fritillary; meadows
Papilio paphia, silver wash or great fritillary, in woods
——— aglaia, dark green fritillary; in woods
——— euphrosyne, pearl border fritillary; in woods
——— quercus, purple hair streak; in bushes
——— rubi, bramble or green; in woods
——— pamphilus, small gate keeper; in meadows
Sphinx ocellata, eyed hawk moth; on willows
——— populi, poplar hawk moth; poplars and willows
——— tiliæ, lime hawk moth; on lime tree bark
——— convolvuli, unicorn hawk moth; in fields where bindweed grows
——— ligustri, privet hawk moth; in privet hedges
——— atropos, jasmine hawk moth, bee-tyger, or death head; in potatoe fields
——— elpenor, elephant moth; on vines, convolvulus, &c.
——— stellatarum, large bee moth, or humming bird; in gardens on flowers
——— filipendulæ, burnet moth; on grass in meadows
Phalæna pavonia, emperor; on osier grounds
——— rubi, fox; near woods
——— pini, pine lappet; on pines
——— vinula, puss; on barks of trees
——— neustria, lacky; thorns
——— caja, great tyger; on banks

Phalæna villica, cream spot tyger; on banks which face the rising sun

——— monacha, black arches; in woods

——— salicis, white sattin; in willow bark

——— zigzag, pebble; ibid.

——— cossus, goat; p. 334

——— libatrix, furbelow

——— jacobææ, cinnabar or pink underwing; commons

——— pronuba, large yellow underwing; in gardens

——— festucæ, gold spot; in ditches near marshes

——— psi, grey dagger; in bark of willows

——— meticulosa, angled shades; on nettles

——— aceris, sycamore tussock; near sycamores

——— exsoleta, sword grass; in marshes

——— oxyacanthæ, Ealing's glory; in hedges at Ealing

——— pisi, broom, or favourite; in meadows

——— amataria, buff argus; in lanes

——— syringaria, Richmond beauty; in hedges

——— prunaria, orange; in lanes and hedges

——— verticalis, mother of pearl; on nettles

——— evonymella, small ermine; in orchards

——— salicella, rose; gardens

——— sarcitella; frequent in houses

——— granella; in houses and granaries

Phalæna pomonella, codling or apple tree; in orchards

——— didactyla, brown-feathered; among nettles

——— pentadactyla, white-feathered; in woods

——— hexadactyla, many-feathered; on the lonicera, &c.

4. *Neuroptera.*

Their wings, head, eyes, antennæ, &c.

Libellula depressa

——— Ænea

——— grandis

——— forcipata

——— virgo

——— puella

Ephemera vulgata

——— vespertina

——— culiciformis

——— horaria

——— striata

Phryganea bicaudata

——— nebulosa

——— striata

——— rhomboidica

——— flavilatera

——— nigra

——— longicornis

Hemerobius perla, golden eye; on plants, page 206

——— chrysops

——— sexpunctatus

——— formicarum

Panorpa communis; meadows

5. *Hymenoptera.*

Wings, sting, proboscis, &c.

Cynips glecomæ; in tubercles on leaves of ground-ivy

Cynips quercus baccarum; in small tubercles on the under side of oak leaves

——— quercus folii; in large tubercles on oak leaves

——— quercus petioli; in tubercles on the petiolus of oak leaves

——— quercus gemmæ; in the large imbricated galls on the extreme buds of oak trees

Tenthredo lutæa; on willow, alder, birch

——— rustica; on willows

——— scrophulariæ; on figwort

——— rosæ; on rose trees

——— cynosbati; on hips

——— capræææ; on willows

Ichneumon comitator; in wasps nests

——— manifestator; woods

——— puparum; in the chrysalides of butterflies

——— aphidum; breeds in the bodies of aphides

——— globatus; breeds in white silky balls about one inch long, which are found on different plants in meadows

——— glomeratus; breeds in the caterpillar of the cabbage butterfly

——— pectinicornis; in the chrysalides of butterflies

Sphex viatica

——— cribraria

Chrysis ignita; in walls

Vespa crabro, hornet; builds in hollow trees

——— vulgaris, common wasp

——— coarctata, small wasp

Apis centuncularis; builds in old trees

—— rufa, small field bee

—— mellifica, common hive bee

—— manicata; on flowers

—— conica; builds on the ground

—— terrestris, humble bee; builds deep in the ground

—— subterranea, great humble bee

Formica herculeana, horse ant, large

—— rufa; in gardens

—— fusca, brown, common ant

—— nigra, black

—— rubra, little red ant

6. *Diptera.*

Oestrus bovis, breeze or gad fly, see page 294, note

—— hæmorrhoidalis, see page 295, note

—— ovis, grey fly, see page 296, note

Tipula crocata; in meadows

—— lunata; ibid.

—— cornicina; ibid.

—— plumosa, sea tipula, resembles a gnat, and is frequently mistaken for it

—— littoralis; on trees

—— monilis; in meadows and on windows, &c.

Musca chamæleon, p. 248

—— morio; in gardens

—— pyrastri; ibid.

—— menthastri; flowers

—— pipiens; on mint, &c.

—— inanis; on flowers

Musca pellucens; on rose tree

—— cæsar; in woods and gardens

—— cadaverina; on flesh

—— vomitoria, blue flesh fly

—— carnaria, common flesh fly

—— domestica, common house fly

—— cellaris; frequently found dead in wine and vinegar

—— putris; breeds in cheese and dung

—— stercoraria; on dung

—— vibrans; on trees

—— flava; on flowers

—— solstitialis; on thistles

Tabanus bovinus, great horse fly

—— pluvialis; in meadows

Culex pipiens, common gnat, see page 187, note 623

—— bifurcatus; in watery places

—— pulicaris; in gardens in the spring

Conops calcitrans, differs from the common fly, in having a sharp hard proboscis, with which it strikes our legs in autumn

—— macrocephala; in meadows

Asilus craboniformis, hornet fly; in wet meadows

—— forcipatus; in gardens

—— morio; in wet woods

Bombylius major, humble bee fly, sucks flowers without resting on them

—— medius; hovers in the air like a hawk, and darts with great celerity

Bombylius minor; in Caen wood, near Hampstead

Hippobosca equina; fastens on dogs and cattle

—— hirundinis; in swallows nests

7. *Aptera.*

Lepisma saccharina; in the joints of sash windows that are wet and seldom opened

Podura viridis; on plants in April

—— plumbea; on trees, solitary

—— villosa; on stones

—— aquatica; numerous on the leaves of aquatic plants

Termes pulsatorium, the death-watch of Linnæus, p. 688, note

Pediculus humanus, common louse, see p. 619

—— pubis, crab louse

—— bovis, cattle

—— vituli, ibid.

—— corvi, raven

—— gallinæ, capon

—— columbæ, pidgeon

Pulex irritans; see page 615

Acarus reduvius, sheep louse or tick

—— ricinus, dog tick

—— passerinus; on many species of small birds

—— aquaticus; on stagnant water, swims quick

—— holosericeus, scarlet spider; on the ground and on plants

—— coleoptratorum, beetle-

tick; hundreds are found on the belly of a beetle
Acarus longicornis; under stones, &c.
Phalangium opilio, long-legged spider
——— cancroides, scorpion tick; on garden pots, sometimes in houses
Aranea cucurbitina; on fruit trees
——— labyrinthica; in fields
——— domestica, house spider
——— redimita; in gardens
——— senaculata, large; on walls, &c.
——— scenica, black; on old walls and windows; spins no web
——— aquatica, pale brown
——— viatica, resembles a crab, moves slow, &c.
Cancer pisum, pea, size of a pea; in muscles
——— minutus, minute, smaller than the preceding; among sea weeds
——— longicornis, long horned, size of the last
——— plati-cheles, great clawed, size of a horse bean
——— Bernardus, hermit; in the deserted shells of wilks, &c
——— gammarus, lobster
——— homarus; on the coast of Ireland
——— astacus, cray-fish
——— serratus, prawn
——— squilla, white shrimp
——— crangon, shrimp
——— linearis, linear shrimp
——— atomos, atom shrimp
——— locusta, locust; frequently skipping in summer on the sea shore
Cancer mantis; Weymouth
——— pulex, water flea; in rivulets
——— salinus; in Lymington salt water
Monoculus apis; in fish ponds and ditches
——— pulex, very minute; frequent and numerous in stagnant water
——— quadricornis
Oniscus asilus, sea louse
——— entomon, sea wood-louse; on the coasts
——— aquaticus; in clear springs
——— asellus, millepes or wood louse; in old walls, &c.
——— armadillo; under stones
Julus terrestris, feet 200; under stones
——— sabulosus, feet 240

VERMES.

1. *Intestina.*

Gordius aquaticus, like a horse hair; in water and clay
——— lacustris; in the liver of the pike
Ascaris vermicularis; at the bottom of lakes, and in the intestines of children and horses
——— lumbricoides; in the human intestines
Lumbricus terrestris, earth worm; in the ground and in the human intestines
——— marinus, sea worm
Fasciola hepatica, gourd worm; in ditches, rivulets, and in the liver of sheep
Fasciola intestinalis; in the intestines of fishes
——— barbata; in the intestines of the sepia loligo
Sepunculus nudus; in the sea
Hirundo medicinalis, common leech; in shallow waters
——— sanguisuga, horse leech; in fresh water
——— geometra; in fresh water
——— muricata, sea leech

2. *Mollusca.*

Limax ater, black snail; in moist shady places
——— rufus, red; at the foot of mountains
——— maximus, large grey; in thick woods
——— agrestis, small grey; on cabbages
——— flavus, amber; on plants
Doris argo, sea lemon
——— verrucosa; Aberdeen
——— elutrina; Anglesea
Aphrodita acculeata, sea mouse; often found in the stomach of a cod
——— squamata; Anglesea
——— minuta; ibid.
Nereis noctiluca, scarce visible to the naked eye; shines by night in the sea, so as to make the water appear on fire
——— locustris; in clayey water
Ascidia rustica; Scarborough
Actinea sulcata; rocks of Cornwall and Anglesea

Holothuria pentactes; in the deep
Lernea cyprinacea; in fish-ponds, adhering to the sides of carp
——— salmonea; adheres to the gills of salmon
——— asellina; in the gills of cod, &c.
Sepia officinalis, ink or cuttle-fish; in the sea
—— sepiola; off Flintshire
Medusa cruciata
——— aurita, sea nettle
——— capillata, sea lungs
Asterias rubens, five-fingered star fish
——— glacialis, common ditto
——— oculata, dotted ditto
——— minuta; Denbigh
——— hastata; Cornwall
——— nigra; ibid.
Echinus esculentus, sea hedge-hog; on the coast, near Scarborough
——— spatagus, sea egg; on the Yorkshire coast

3. *Testacea.*

Chiton crinitus, hairy chiton; Aberdeen
——— marginatus; in the sea, at Scarborough
——— levis, lock broom; West Ross, North Britain
Lepas. Animal, triton
——— balanus; adhering to rocks and shells
——— balanoides, acorn fish; frequently adheres to oysters
——— tintinabulum; on bottoms of ships
Lepas anatifera, barnacle, see page 341
Pholas. Animal, ascidia
——— dactylus, piddock; in stones, shines by night
——— crispatns; frequent on the Yorkshire coast
Solen. Animal, ascidia
—— siliqua; frequent on the shore near Scarborough
—— vagina; Anglesea
—— pellucidus; ibid.
—— legumen; ibid.
Tellina. Animal, tethys
——— cornea, size of a pea; in pools of fresh water
Cardium. Animal, tethys
——— echinatum; on the Yorkshire coast
——— edule, common cockle
Mactra. Animal, tethys
——— solida; on the Yorkshire coast
——— lutraria; sea, at the mouth of rivers
Donax. Animal, tethys
——— trunculus; on the coast near Scarborough
Ostrea maxima, large scallop; on the Irish coast, and near Portland
——— obliterata, small scallop
——— edulis, common oyster
Anomia truncata; in lime-stones
——— crispa; in bluish lime-stone, in Craven, and other parts
——— squamula; on oysters, crabs, and lobsters
——— ephipium; adhering to oyster shells
Mytilus. Animal, ascidia
——— rugosus; in lime-stone
——— edulis, common muscle
——— cygneus; in many lakes in the north
Buccinum. Animal, limax
——— lapillus, larger English purple fish; on the shore
——— minimum, less than a pea
Helix, snails. Animal, limax
—— lapicida; in woods in Lincolnshire
—— planorbis; in rivulets
—— cornea; in still rivers and pools
—— vivipera; ibid.
—— putris; in rivers and pools
Serpula. Animal, terebella
——— spirorbis; adheres to sea weeds on the coast
Sabella. Animal, nereis
——— alviolata, English tubular sand coral; on the Yarmouth coast, and on Peington strand, Devon

4. *Lithophyta.*

Coral, calcareous, fixed, built by animals
Madrepora. Coral, with cavities, lamellosa-stellated. Animal, medusa
——— musicalis; on the Irish coast
Millepora. Animal, hydra
——— fascialis, stony foliaceous coralline; adhering to an oyster shell, on the coast of the Isle of Wight

Cellepora, coral, submembranaceous, composed of round shells. Animal, hydra

——— pumicosa, appears in the microscope like a pumice-stone; found on the sickle coralline, like white sand

5. *Zoophyta.*

Gorgonia placomus, warted sea fan; on the Cornish coast

——— anceps, sea willow

——— flabellum, Venus fan

Alcyonium. Florets, hydræ, between the cortex; epidermis vesicular, porous

——— digitatum, dead-man's hand; frequently taken up by fishermen trawling for flat fish on the Kentish coast

——— schlosseri; on the Cornish coast

——— ficus, sea-fig; near Sheerness

Spongia oculata, branched sponge; on the coast

——— dicotoma, forked sponge; on the Cornish and Yorkshire coasts

——— lacustris, creeping sponge; at the bottom of lakes in Westmoreland

——— fluviatilis, river sponge; in the Thames, Cam, &c.

Flustra foliacea, broad-leaved horn-wrack; on the coast

Tubularia indivisa, tubular coralline

——— ramosa, small rarified tubular coralline

——— fistulosa, bugle coralline

——— campanulata, creeping, extremely minute

Corallina officinalis, coralline of the shops; fixed to rocks and shells, by stony joints

——— rubens, crested or coxcomb coralline, like moss growing in round tufts, resembling a bird's crest; the microscope shews the filaments to be dichotomous

Corallina corniculata, white slender-jointed coralline; adheres to small fuci

Sertularia rosacea, lily-flowering coralline; on oysters

——— pumila, sea-oak coralline; about Sheerness

——— abietina, sea-fir; on oysters, muscles, &c.

——— argentea, squirrel's tail; on oysters in the Isle of Shepey

——— cornuta, very minute

—with many others

Vorticella, see page 396 & seq.

Hydra, see page 363 & seq.

Tænia solium; in the intestines of various animals

——— vulgaris, common tape-worm; in the intestines of men and brutes

Animalcula infusoria, see page 428 & seq.*

II. FOSSILS.

Ketton or kettering stone

Spar opake; in mines in Wales, Derbyshire, &c.

——— refracting; in lead mines in Derbyshire, &c.

——— diaphonous; in various parts of the kingdom

——— stalactitical, Knaresborough, &c.

Fluor transparent, diaphonous, resembling emeralds, saphires, topazes, amethysts, &c.

METALS.

Aurum nativum; said to be found in some rivers in North Britain

Argentum mineralizatum; in small quantities in lead and copper ores

Plumbum galena, lead glance; in various parts of England

——— stibiatum, antimonial lead ore

——— crystallinum, lead crystals

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* Those who are desirous of seeing well delineated and elegantly coloured figures of a variety of curious objects among the insect class, particularly such as require investigation by the microscope, will be amply gratified by having recourse to Donovan's History of British Insects. From the Naturalists Miscellany, by G. Shaw, M. D. F. R. & Vice Pres. L. S. numbers of beautiful subjects may likewise be selected.

Plumbum spatosum, lead spar
——— calciforme, lead ochre
——— nativum, native lead
Cuprum nativum
——— cæruleum montanum, mountain blue; in the mines of Derbyshire
——— viride montanum, mountain green; in copper mines of England, Ireland, and the Isle of Man
——— rubrum, glass copper ore; generally found with native copper
——— cinereum, grey copper ore
Ferrum crystallinum, crystalline ore; Forest of Dean, Langron in Cumberland
——— cærulescens, bluish ore
——— micaceum, glimmer

SEMI-METALS.

Vismutum ochra, flowers of bismuth
——— mineralizatum, bismuth ore
Antimonium striatum, striated antimonial ore
——— rubrum, red antimonial ore

PETREFACTIONS.

Animals, or parts of animals, changed into a fossile substance

Vermes.

Helmintholithus ammonita, nautilus; in strata of earth and stones, on the sea-shore, &c.
——— anomites; in great abundance, particularly at Sherborne in Gloucestershire
——— gryphites; in chalk hills, &c.
——— judaicus; in many parts, particularly chalk pits in Kent
——— echinites; Surrey, Essex, Kent, Middlesex, in chalk and gravel pits
——— astrion, sea-star; in chalk pits, &c.
——— astroites, star stone; Gloucestershire, Norfolk, &c. and many more.

Vegetables.

Phytolithus plantæ; grass, reeds, horse-tail, &c. found in the black slate called plate, immediately above the pit coal, in various parts of England
Phytolithus filices, ferns; ditto, Newcastle, &c.
Rhizolithus, roots of trees and plants buried in the earth
Lithophyllum, leaves of trees; at Knaresborough, also impressed in stone
Carpolithus, fruits, particularly impressions of the cones of pines, hazel, oak

Fishes.

Ichthyolithus siliquastra, fossile pods, often resembling half the pod of a lupine, &c. sometimes extremely minute, at other times near two inches long.
——— vertebra, of various genera, often in pits and quarries, particularly at Richmond in Surrey, on the cliffs of Shepey Island, &c.

Insects.

Enthomolithus cancri, claws, or parts of claws; in pits in several parts of England

Shrubs.

Graptolithus dentrides, representing shrubs, plants, or moss; on various stones, slates, and flints, in many parts of England, &c.

III. VEGETABLES.

Having thus enumerated a considerable variety of articles in the animal and fossile kingdoms, the only part which remains to be noticed is that of vegetables. To any person possessing but a superficial knowledge of botany, it must be obvious that this branch of natural history is extensive in the extreme; and that, consequently, to point out but a small number of such plants as form interesting objects for the microscope, would greatly extend this list, already sufficiently large; for,

" How incompetent is human effort to portray the beauties of this sublime subject! How inadequate the most descriptive talent to approximate to our view the vegetative profusion contained within the recess of nature! How limited have been our public researches! How contracted the knowledge which has been as yet obtained! What an incomprehensible store remains yet concealed, impenetrable to mortal view!"*

From a source so abundant, the botanist will be under no difficulty in selecting for himself; those who have not made the science a part of their studies, will be materially assisted by having recource to the elegant figures and their descriptions in the Botanical Magazine, by W. Curtis, F. L. S. the well-known author of Flora Londinensis; and English Botany, by J. E. Smith, M. D. F. R. & Pres. L. S. published by Jas. Sowerby, F. L. S. I shall, therefore, just mention in general terms those parts of plants which are peculiarly adapted for microscopical investigation. These are as follow:

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* Observations on the Structure and Economy of Plants, by R. Hooper, M. D. F. L. S. page 128. This work contains an ingenious display of the analogy which subsists between the animal and the vegetable kingdom.

- The trunk, composed of
    - Epidermis or cuticle
    - Cortex or outer bark
    - Liber or inner bark
    - Alburnum
    - Lignum or wood
    - Medulla or pith
- The root cut transversely or longitudinally
- Leaves and their fibres
- The parts of fructification, consisting of
    - The calyx or flower cup
    - corolla or foliation, containing the leaves or petals, and the nectarium
    - stamina or threads, their filaments and anthera or summit, and the pollen contained therein*
    - The pistillum or pointal, its germen, style, and stigma
    - pericarpium, seed vessel, or germen grown to maturity
    - semina, seeds and their parts
    - receptaculum, the base on which the fructification is seated

Of the various classes of plants, that called cryptogamia is eminently calculated for microscopical observation; comprizing the filices, the musci, the algæ, and the fungi. On these subjects Hedwig has produced a valuable work, entitled Theoria Generationis et Fructificationis de Plantarum Cryptogamicarum, of which a new and much improved edition has just appeared, and to which for further information I refer the reader.

A LIST OF MR. CUSTANCE'S VEGETABLE CUTTINGS, THAT USUALLY ACCOMPANY THE MOST COMPLETE SORT OF MICROSCOPES MADE BY MESSRS. W. AND S. JONES.

English oak. Evergreen ditto.
Norway oak. Ash.
Cedar. Cork.
Savin. Fir.
Ceanothus. Hazel.
Lime. Elm.
Elm root. Mulberry ditto.
Grape root. Lime ditto.
Beech. Birch.
Plum. Ivy.
Spanish elder. American climber
Cissampelos. Virgin's bower.
Magnolia grandiflora. Gelder-rose
Althæa frutex. Tulip tree.
Ash. Spanish chesnut.
Platanus orientalis. Viburnum lantana
Oak root. Ash root.
Asp root. Walnut ditto.
Grape vine. Indian turpeth.
China root. Jasmine.
Dog rose. Raspberry.
Barberry. Briar.
Elder root. Ditto branch.
Willow root. Ditto branch.
Mulberry. Fig.
Sycamore. Maple.
American dogwood. Ptelea trifoliata.
Ligneous night-shade. Sumach.
Apricot. Medlar.
Bay. Laurel.
Sea weed. Longitudinal cutting of plane tree.
Ditto of Spanish elder. Ditto of briar.
Common cane. Ditto with curious center
Bamboo cane. Sarsaparilla.
Longitudinal cuttings of sugar cane. Elder.

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* The pollen or meal is a fine dust designed for the impregnation of the germen; a small quantity of this meal being put into hot water and applied to the microscope, will exhibit the bursting of the elastic covering of each grain, and the escape of the smaller atoms, which is the true farina.

Rose tree. Mugwort.
*Longitudinal slices of elder.
*Ditto grape vine. *Transverse ditto.
*Dogwood. *Plane tree.
*Beech. *Grape vine.
*Spanish chesnut. *Walnut.
*Fig. *Ditto longitudinal.
Asparagus. Artichoke.
Thistle. Fennel.
Parsley. Ditto root.
Sunflower. Ditto root.
Agrimony. Eryngo.
Potatoe stalk. Centaurea.
Indian reed. Ditto corn.
Amaranthus. Bromelia pinguin.
Campanula. Monkshood.
Lavatera. Solidago.
Mugwort. Chrysanthemum.
Helianthus. Wormwood.
Bulrush. Portugal reed.
Burdock. Ditto.
Wild mustard. Aloe flower stalk.
Solomon's seal. Tulip.
Calamus aromaticus. Buckbean.
Gourd. Melon.
Crown imperial. Flower-de-luce.
Pine apple. White lily.
Asparagus. Ragwort.
Water flag. Sugar cane.
Stems of leaves of hog's fennel. Hemlock.
Chesnut. Wild turnip.
Stems of the leaves of red dock. Horse-radish.
Cabbage. Carrots.
Roots of phytolacca. Teasel.
Carrot. Fennel.
Stinging-nettle roots curiously variegated.
Roots of parsley and wormwood variegated.
Stalks of fern, with variations.

N. B. Those marked with an * Mr. Custance conceives prove Dr. Hill in an error, when he observed, that the pith of a shoot is not connected with the pith of the branch. See his Construction of Timber, &c. p. 103, 8vo edition.

SALTS, AND VARIOUS CHEMICAL PREPARATIONS.

SALTS.

Salt ammoniac, crude
—— ———— volatile
—— of amber
———— Benjamin, commonly called flowers of Benjamin
———— berberry
———— buckthorn
———— butcher's broom
———— carduus
———— chamomile
———— coral
Salt of cucumber
—— Epsom, so called
—— of fennel
—— gem
—— glauber's, vitriolated natron
—— of hartshorn
———— lavender
———— lead, commonly called sugar of lead
———— limons
———— liquorice
———— millepedes
Salt of mugwort
———— nitre, or salt petre
———— Peruvian bark
—— polychrest
—— Rochelle
—— of tartar
———— tartar vitriolated
———— tobacco
———— urine
———— wood sorrel
———— wormwood, and a great variety of others.*

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* To ascertain the true configurations of salts, particular attention should be paid to obtain them genuine; it may therefore be proper to apprize the reader, that some of those above enumerated are not easily procured in that state; consequently, though they exhibit pleasing figures, yet they may not be those of the real salt purposed to be investigated. Many hundred weights of some salts are annually manufactured, and sold under names very different from what they really are. Nor is this circumstance confined to salts only: for want of botanical knowledge, preparations of different plants have been frequently sold possessed of medical properties very different from those intended.

PREPARATIONS OF MERCURY.

- Acetated quicksilver
- Calcined ditto
- Calomel
- Muriat, commonly called corrosive sublimate
- Red nitrated, or red precipitate
- Sulphurated, or factitious cinnabar

MISCELLANEOUS.

- Camphor
- Crystals (called cream) of tartar
- Iron, ammoniacal, or martial flowers
- Verdigrise, ditto distilled
- Vitriol, blue, or vitriolated copper
- ——— green, or vitriolated Iron
- ——— white, or vitriolated zinc, &c. &c.

After having particularized so many of the works of NATURE, let us now pay some attention to those of ART. But what an humiliating contrast shall we meet with! If our design in viewing objects by the microscope be to discover beauty, harmony, and perfection, it will be necessary to limit our inquiries to the former, happily alone sufficiently abundant; if, on the contrary, we are desirous of discovering deformity and imperfection, we must confine ourselves to the latter. Even those works of art that appear to the unassisted eye as decisive proofs of consummate skill in the workman, and which excite our admiration for their apparent neatness and accuracy, when brought to this test, exhibit their real state; and, consequently, tend but to display the inferiority of the most finished performance of the ablest artist, when put in competition with the glorious productions of nature. The finest works of the loom and of the needle, if exhibited with the microscope, prove so rude and coarse, that were they to appear thus to the naked eye, so far from affording delight to our belles, would be rejected with disgust. But the more we inquire into the works of nature, the more fully are we satisfied of their divine origin: in a flower, for instance, we see how fibres too minute for the unassisted sight are composed of others still

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A valuable medicine, the extract of Hemlock, for instance, instead of being prepared of the conium maculatum, has been made in large quantities of the chærophyllum sylvestre, and thus administered! On this unpleasant subject I could enlarge, were it not digressing from that before us. Whilst such evils exist, need we wonder if the physician as well as the patient are often disappointed in the beneficial effects expected from the adhibition of medicines?

more minute, till the primordial threads or first principles are utterly indiscernible; whilst the whole substance presents a celestial radiance in its colouring, with a richness so superior to silver or gold, as if it were intended for the cloathing of an angel. and we have the highest authority for asserting, that the greatest monarch of the East in all his glory, was not arrayed like one of these. A very few specimens of art will, therefore, suffice.

The edge of the sharpest razor or penknife
Teeth of rasps and files
Threads of the finest screws
Finest engravings on gold, silver, copper, &c.
Coins, medals
Seals, intaglios
Best executed miniature paintings, prints, drawings, &c.
The finest laces, silks, and ribbons
Smallest needles, pins, &c.
Woolen and linen cloth, plain or printed; camblets, bombazeens, &c.
A drop of ink on paper
Paper, from the coarsest to the finest
The writing of the ablest penman
The finest specimens of the typographic art, &c. &c.

An inspection of a few of the above articles only will clearly demonstrate, that as in the moral and political world, so in the works of art, perfection is unattainable by mortal man. With the fullest impression of which truth in the mind of the editor, and an appeal to the candour of his readers towards those imperfections which they may have discovered in this performance, he shall now conclude with,

FINIS.

ADDITIONS.

THE following is a new, useful, and ready method of making globules for microscopes, differing from the customary one described in page 8, and is extracted from Mr. W. Nicholson's scientifical Journal of Natural Philosophy, Chemistry, and the Arts. No. 3, June 1, 1797. p. 134

" The usual method has been to draw out a fine thread of the soft white glass called crystal, and to convert the extremity of this into a spherule by melting it at the flame of a candle. But this glass contains lead, which is disposed to become opake by partial reduction, unless the management be very carefully attended to. I find that the hard glass used for windows seldom fails to afford excellent spherules. This glass is of a clear bright green colour when seen edgeways. A thin piece was cut from the edge of a pane of glass less than one-tenth of an inch broad. This was held perpendicularly by the upper end, and the flame of a candle was directed upon it by the blow-pipe at the distance of about an inch from the lower end. The glass became soft, and the lower piece descended by its own weight to the distance of about two feet, where it remained suspended by a thin thread of glass about one five-hundredth of an inch in diameter. A part of this thread was applied endways to the lower blue part of the flame of the candle without the use of the blow-pipe. The extremity immediately became white-hot, and formed a globule. The glass was then gradually and regularly thrust towards the flame, but never into it, until the globule was sufficiently large. A number of these were made, and being afterwards examined by viewing their focal images with a deeper magnifier, proved very bright, perfect, and round."

THE opake solar microscope has been made by the late Mr. Martin of larger dimensions than described in page 106. The illuminating lens, at AB, Plate V. Fig. 1, and the breadth of the mirror were about four inches and an half, instead of three inches, which gives more than double the light of the former; and, consequently, all the larger sort of opake and transparent objects, to the size of one and an half or two inches in diameter, as well as diverting objects painted on glass, like the magic lanthorn sliders, are shewn with the greatest distinctness, and has by Mr. Martin been called the MEGALASCOPE of the apparatus.

The same ingenious and learned artist applied a lattice of small squares about one-tenth of an inch, each square made of fine wire, or lines drawn strongly on glass in a circle of one inch in diameter, and placed these in the compound body of a microscope or telescope, in the focus of the glasses next to the eye. And having a copper-plate lattice of squares disposed into a circle, and to any size as may be wanted, the observer or artist may then with great facility make an exact drawing on the paper of the object observed. The same contrivance is applicable to the solar microscope. This he called the GRAPHICAL MICROSCOPE OR PERSPECTIVE.

Page 127, line 24—Any pocket telescope, the drawers of which are made to allow of a further extension than usual, may be used as a compound microscope for examining birds or insects alive, in a garden on the flowers, shrubberies, &c. from a window near to the objects. There are few pocket achromatic telescopes or perspectives, but what will define and magnify objects from about six feet to any distance from the instrument. The magnifying power is inversely as the distance of the object from the telescope, and, consequently variable in an infinite degree; on which account Mr. Martin named it the POLYDYNAMIC MICROSCOPE.

LIST OF THE PRICES

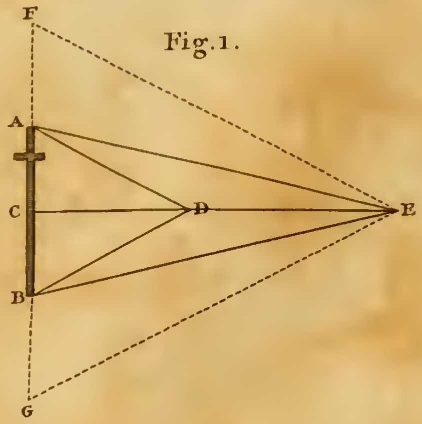
AT WHICH THE MICROSCOPES AND APPARATUS ARE MADE AND SOLD BY MESSRS. JONES, HOLBORN, LONDON.

Plate VIII.	Fig. 8.	A triple magnifier, tortoise-shell and silver	1	1	0
——	7.	A ditto to combine, in tortoise-shell	0	8	0
VI.	14.	A small pocket microscope for insects or flowers	0	7	6
——	1.	Dr. Withering's pocket botanical microscope	0	15	0
——	2.	Jones's universal pocket microscope, according to the apparatus, from 1l. 6s. to	2	10	0
II. B.	1 and 2.	Wilson's screw-barrel, or single microscope, 2l. 12s. 6d. to	3	13	6
——	3 and 4.	——— opake microscope,	2	2	0
VII. B.	3.	Ellis's aquatic microscope	2	12	6
VI.	3.	Lyonet's anatomical microscope	2	12	6
VII. A.	1, &c.	Cuff's double constructed microscope and apparatus, in a case	5	15	6
IV.	3.	Culpeper's compound microscope and apparatus, in a mahogany case	4	14	6
——	1.	Jones's improved universal ditto, and apparatus	6	6	0
——	2.	—— best and most improved ditto, with a greater variety of apparatus, packed in a mahogany case	10	10	0
		Ditto, with the additions of a set of micrometers and vegetable cuttings	12	12	0
VI.	4, 5, &c.	Transparent solar microscope and apparatus in brass, in a mahogany case	5	15	6
V.	1, &c.	Opake and transparent solar microscope and apparatus, with objects, &c. in ditto case	10	10	0
		Ditto with additional apparatus for large objects, called a megalascope, &c. 12l. 12s. to	16	16	0
III.	1, &c.	Lucernal microscope, as mounted by Adams, with apparatus, complete	20	0	0
IX.	3 and 4.	Jones's improved ditto, with or without rack-work to the stage, and other additions, from 12l. 12s. to	18	18	0
——	6.	Lanthorn microscope	6	6	0
VIII.	3.	Pocket achromatic 20-inch telescope and microscope	3	13	6
IX.	1 and 2.	Cutting engine for slices of vegetable objects	3	3	0
II. A.	10.	Micrometers on pearl or glass, in sets, from 10s. 6d. to	2	2	0
Ivory sliders prepared for transparent objects, per dozen			0	12	0
Custance's fine vegetable cuttings in large ivory sliders, from a set of six sliders to four dozen, per dozen			1	10	0
Bottles of salts for configurations, packed in mahogany portable cases, according to the number, from 2l. 2s. to			5	5	0

Magazines of microscopical apparatus, with collections of objects, fitted up to any extent and to order.

INDEX.

Fig. 1.



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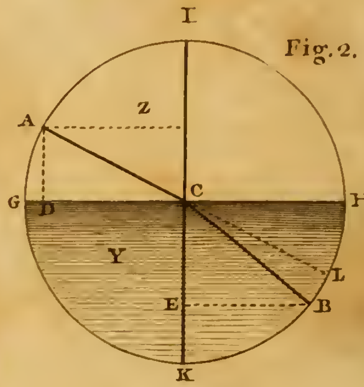

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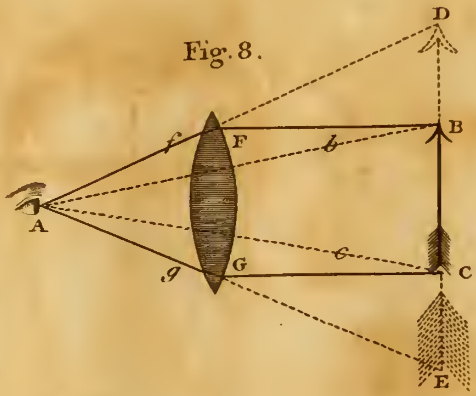

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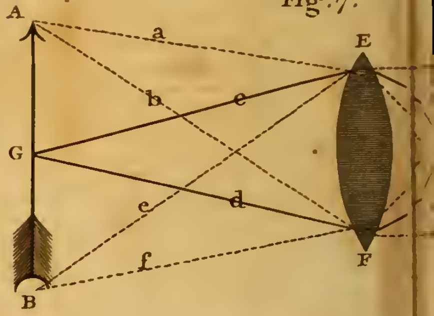

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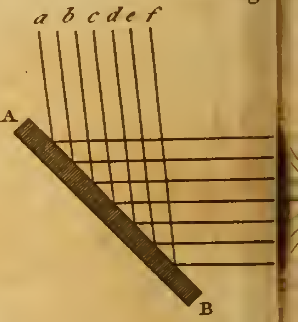

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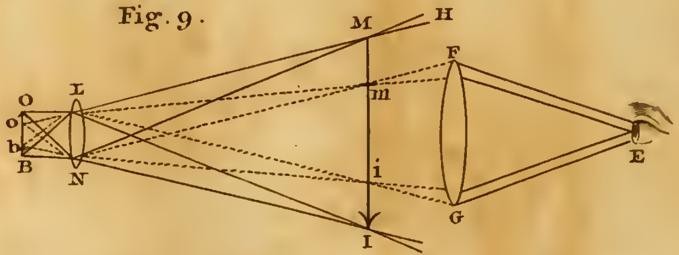

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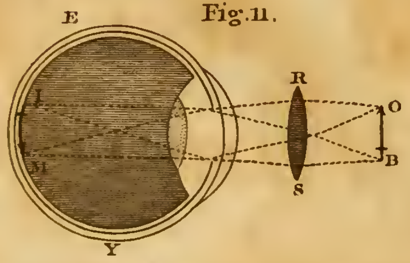

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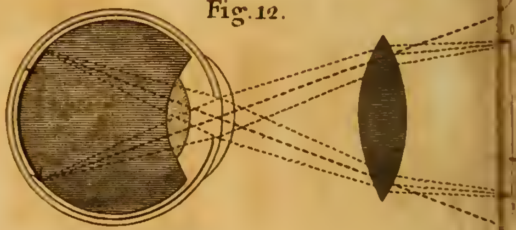

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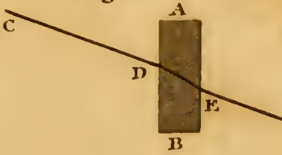
PLATE. I.

Fig. 3.

Fig. 4.



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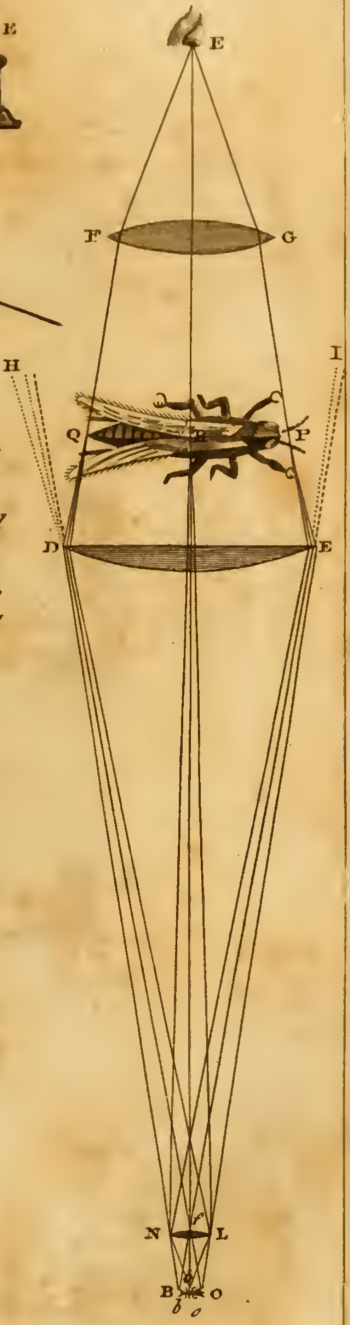

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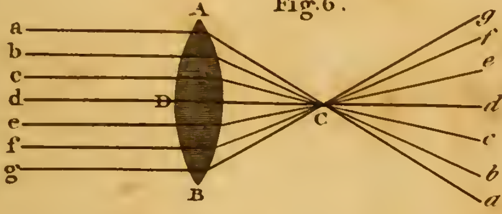

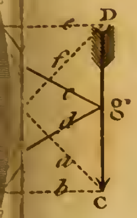

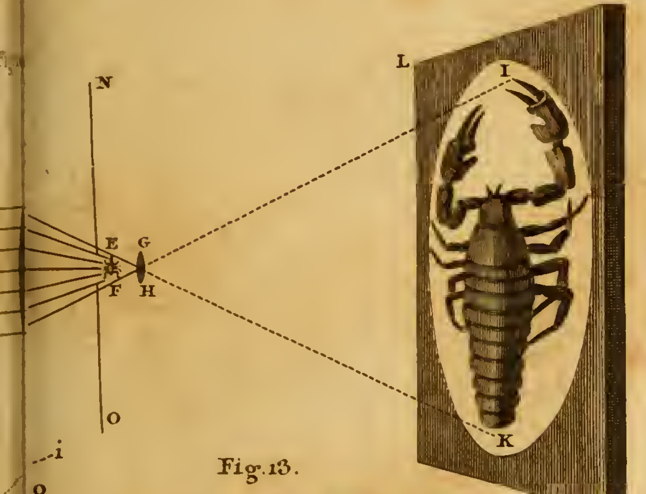

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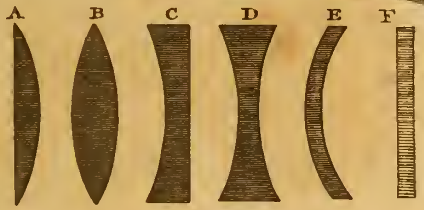
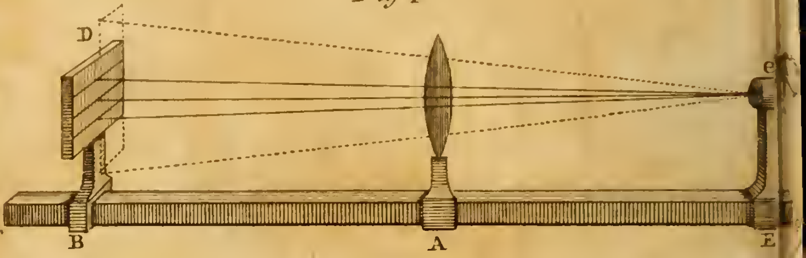


Jn. Lodge sc

N°60. Fleet Street, as the act directs, May 20. 1787.

Fig 1.



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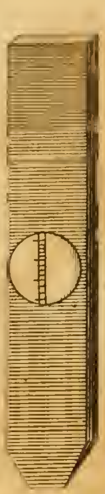

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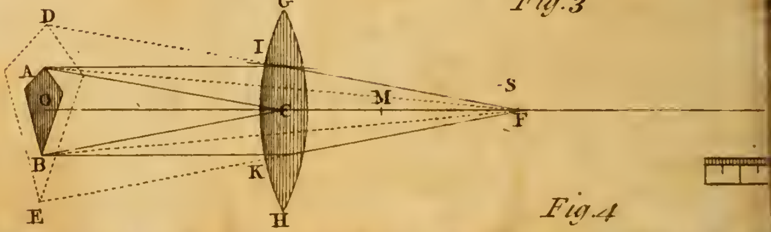

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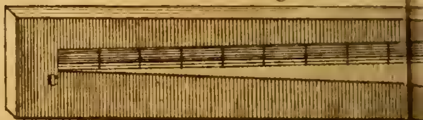

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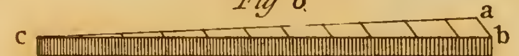

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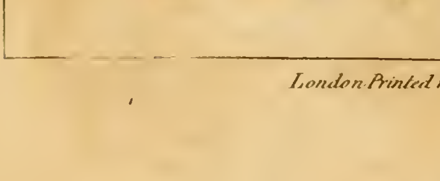

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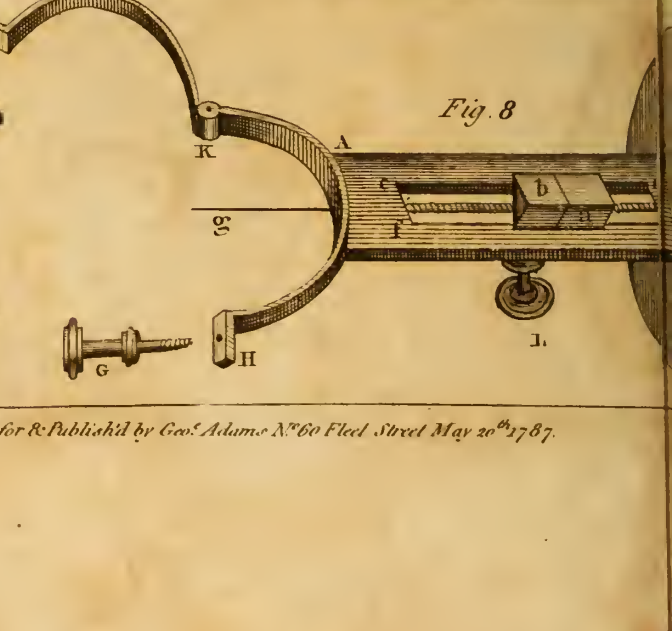

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Pl. 2 A.

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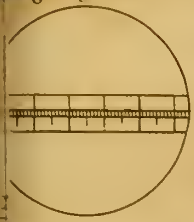

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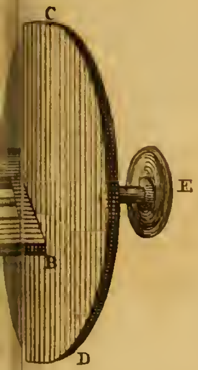

Goodnight sculp.

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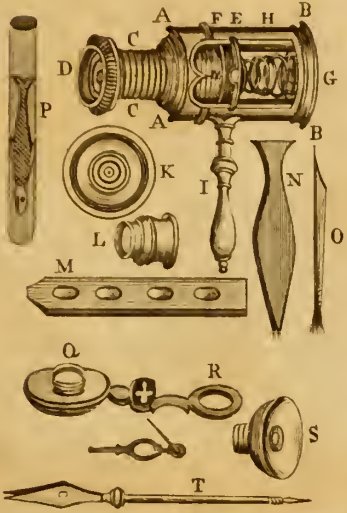

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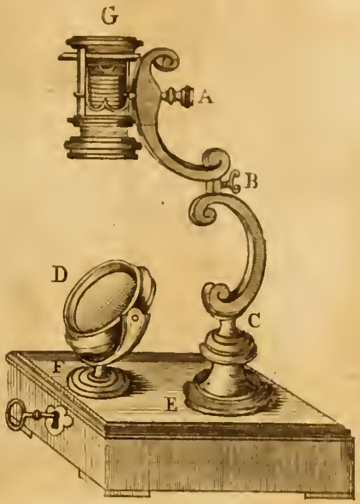

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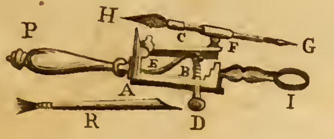

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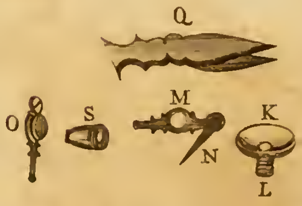

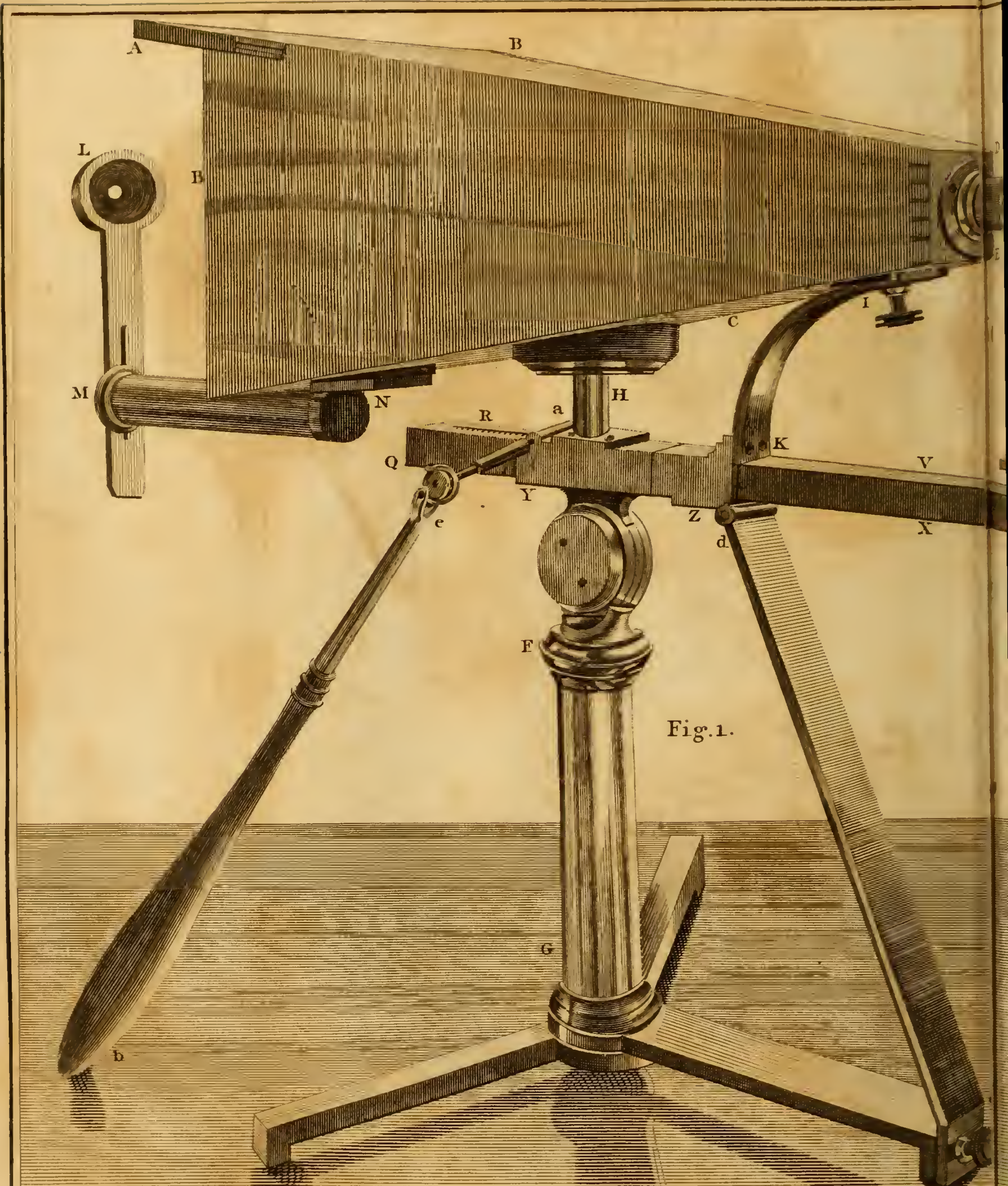

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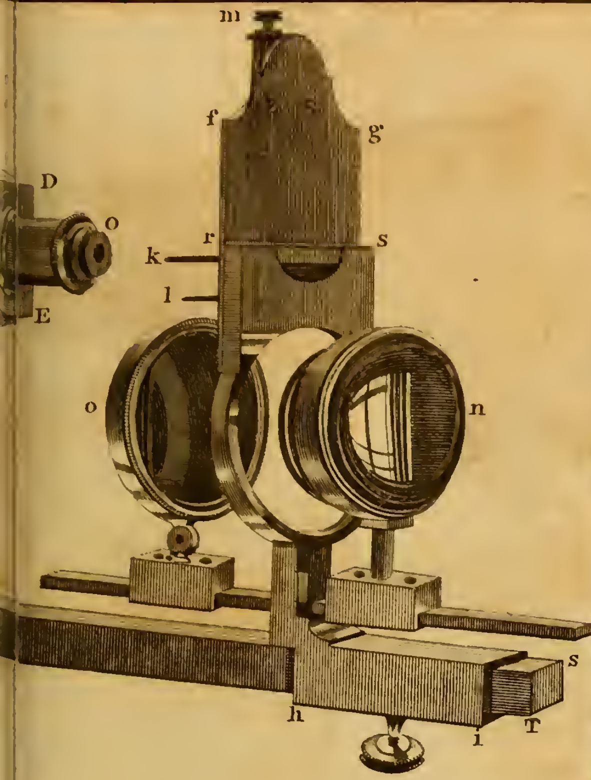

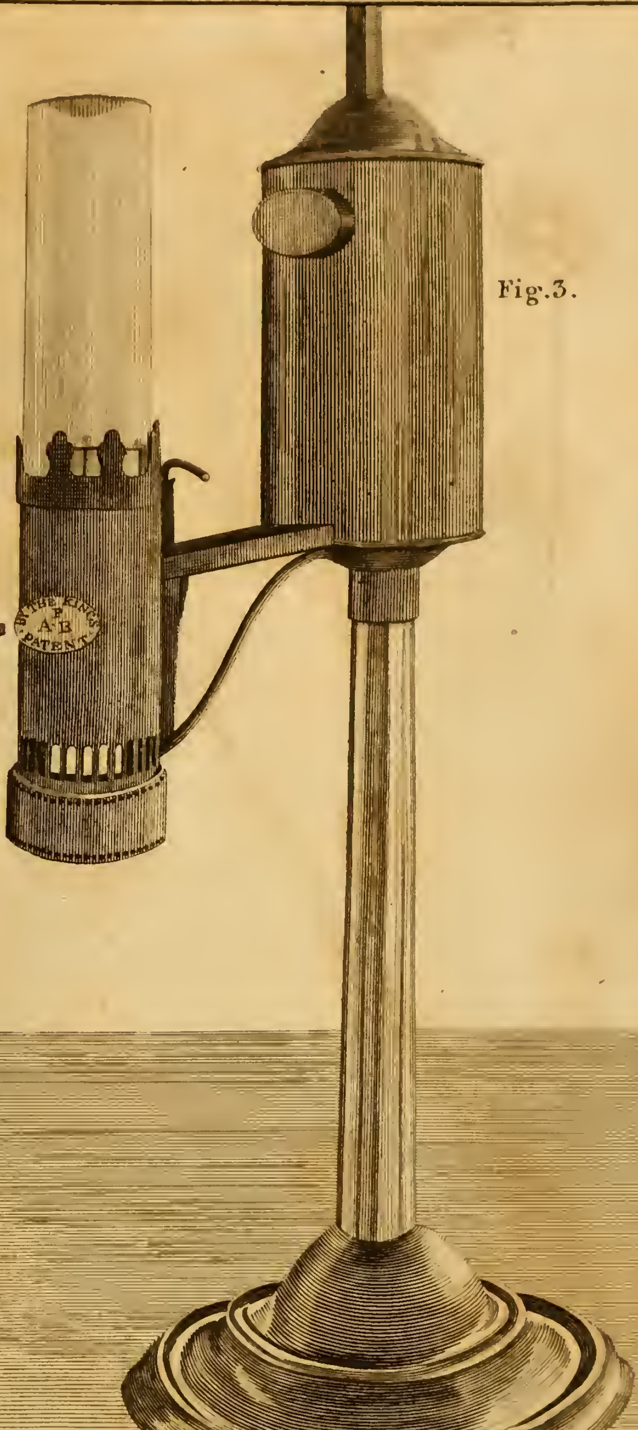

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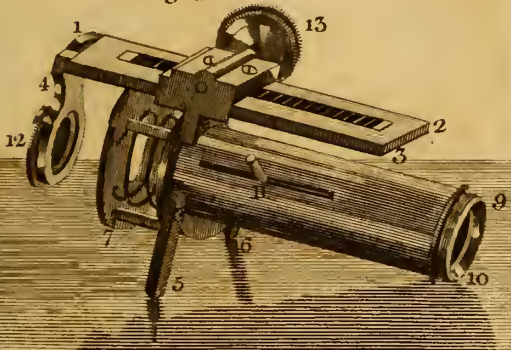

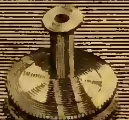

Fig. 2.

Fleet Street, as the act directs. May 20.1787.

J. Lodge sculp

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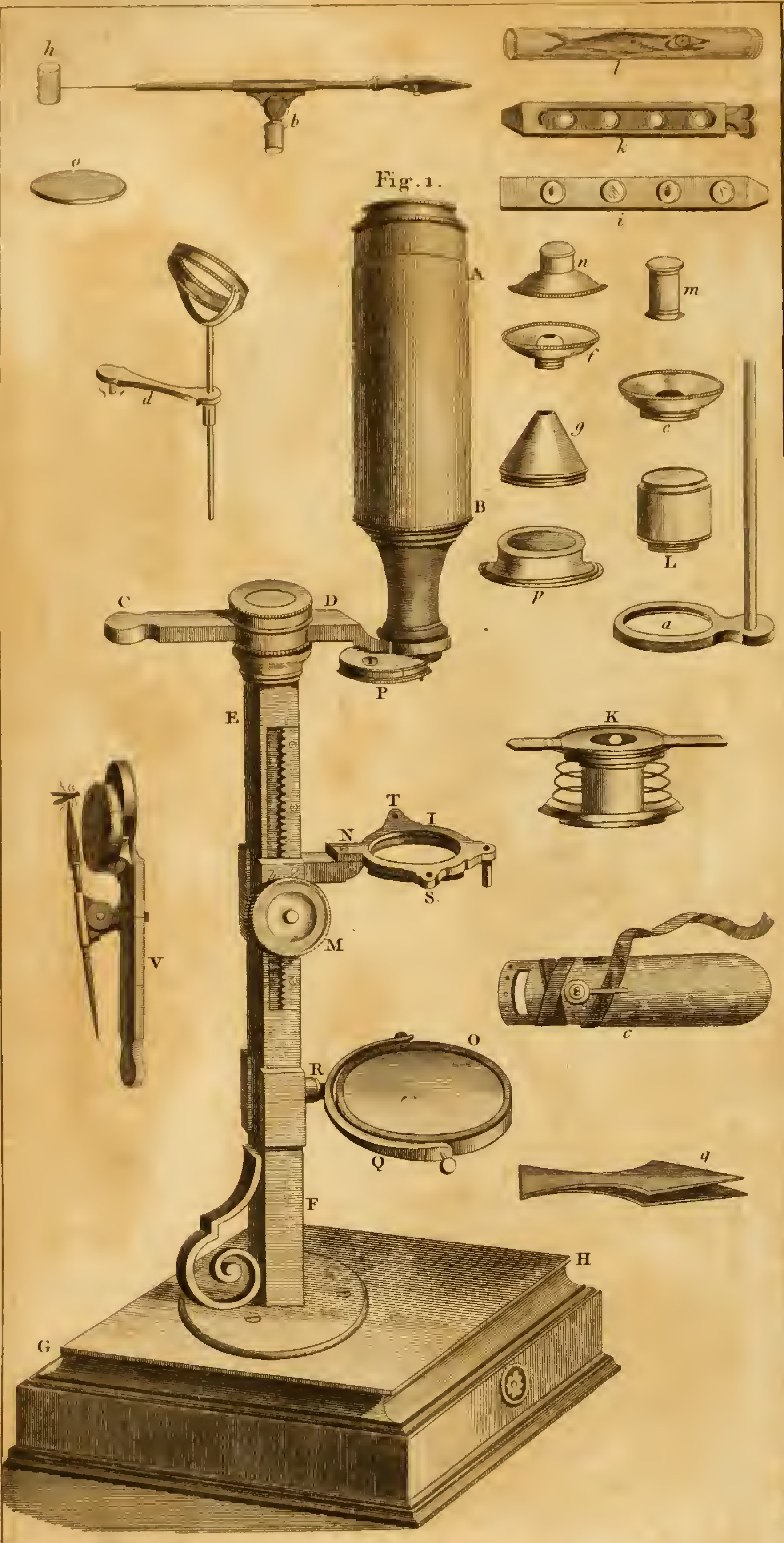
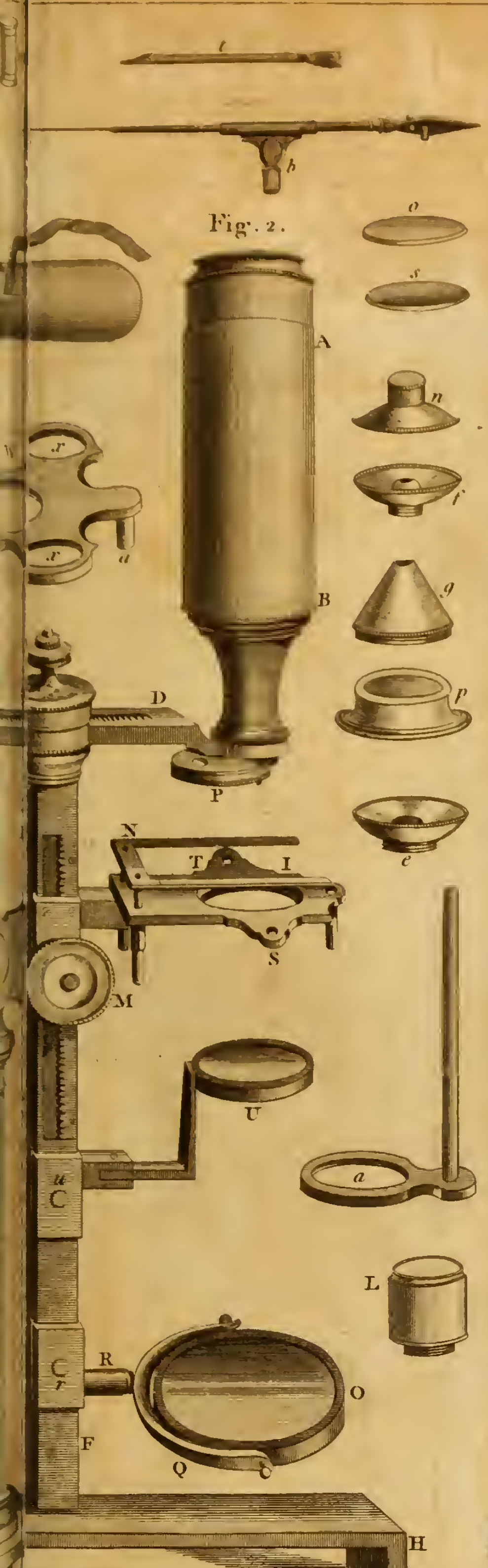


JONES'S *IMPROVED COMPOUND MICROSCOPE AND APPARATUS.*

JONES'S *MOST*
MICROSCOP

London, *Printed for & Published by* F. Kanmacher, and W. & S. Jones

Fig. 2.



IPROVED COMPOUND
AND APPARATUS.

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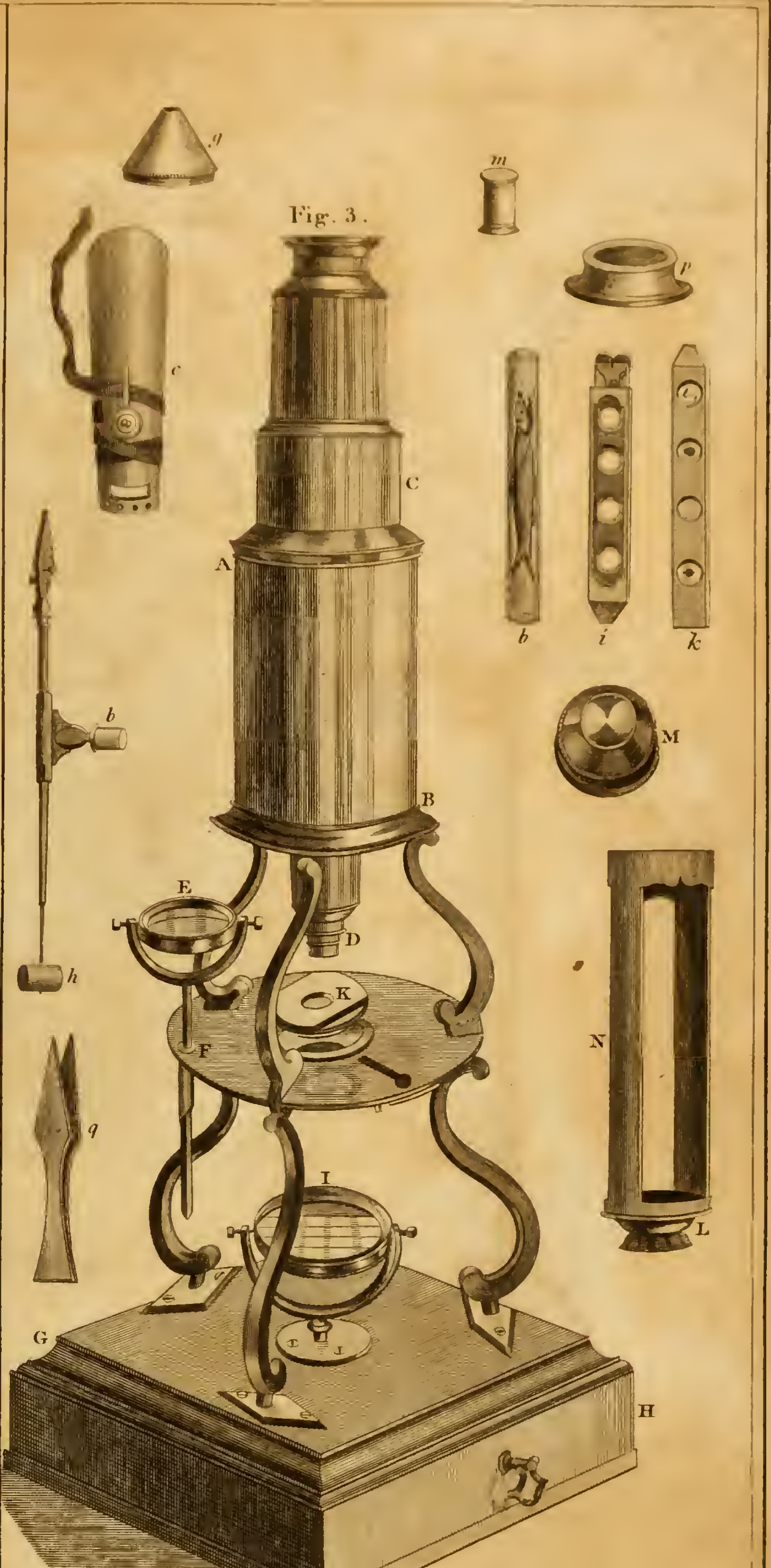

CULPEPER'S MICROSCOPE
AND APPARATUS.

Holborn as the Act directs, 1st October 1797.

J. Hawkins

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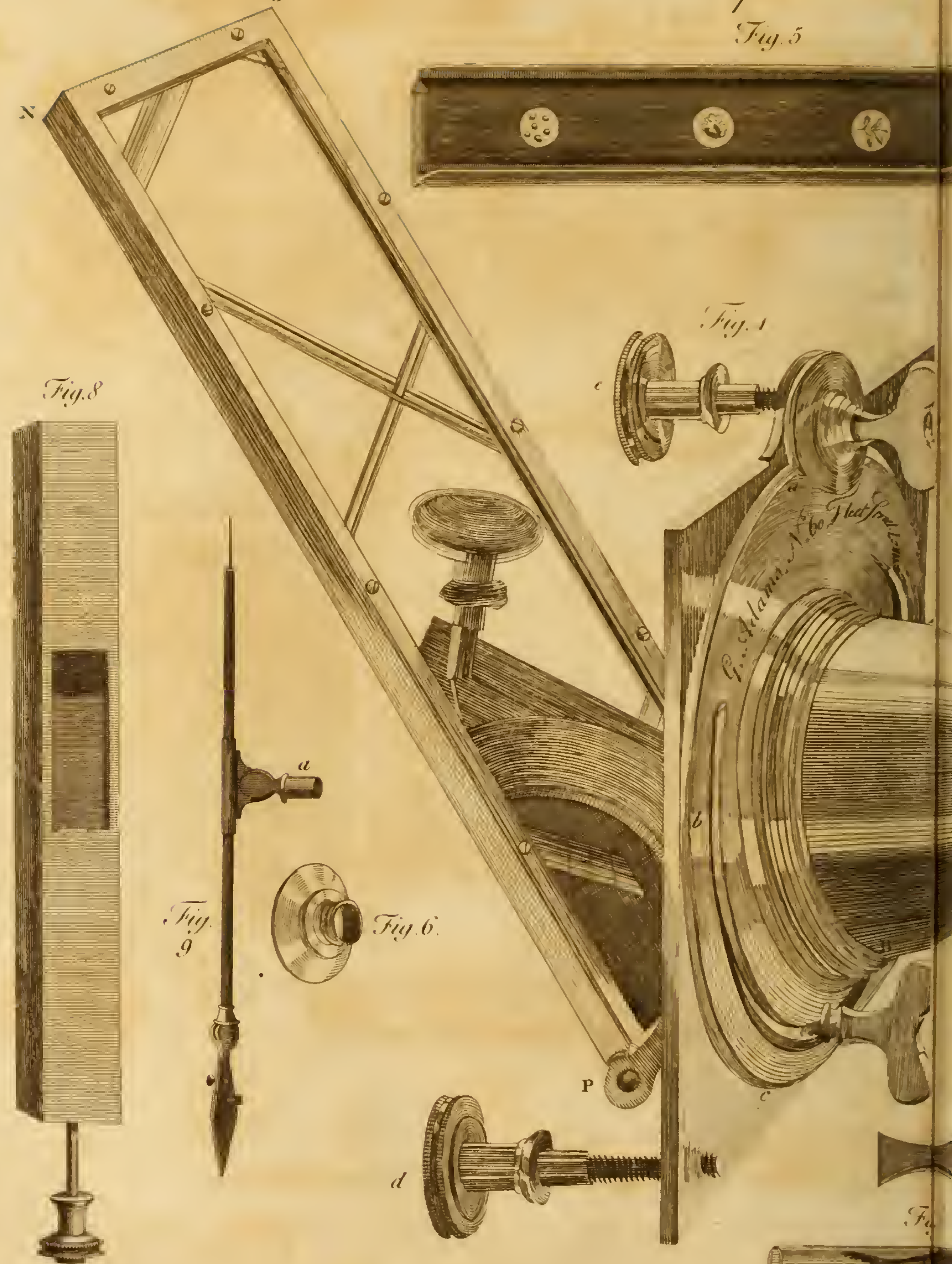

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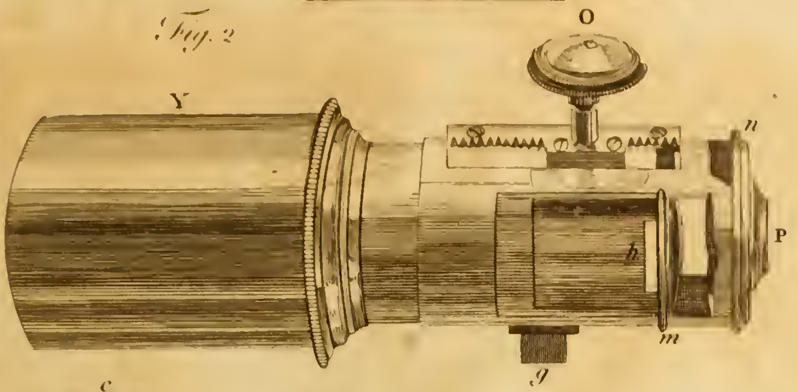
Fig. 1

Fig. 2



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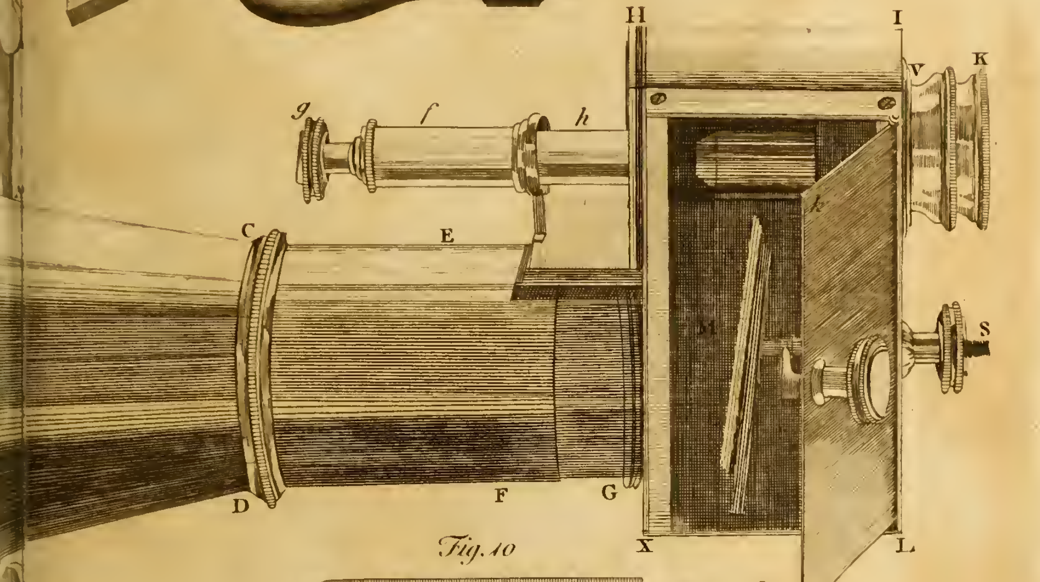

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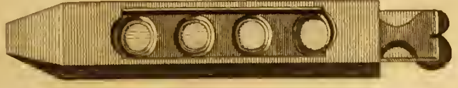

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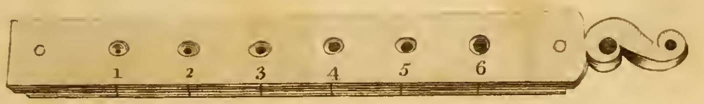

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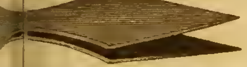

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Fig. 7

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Fig. 14

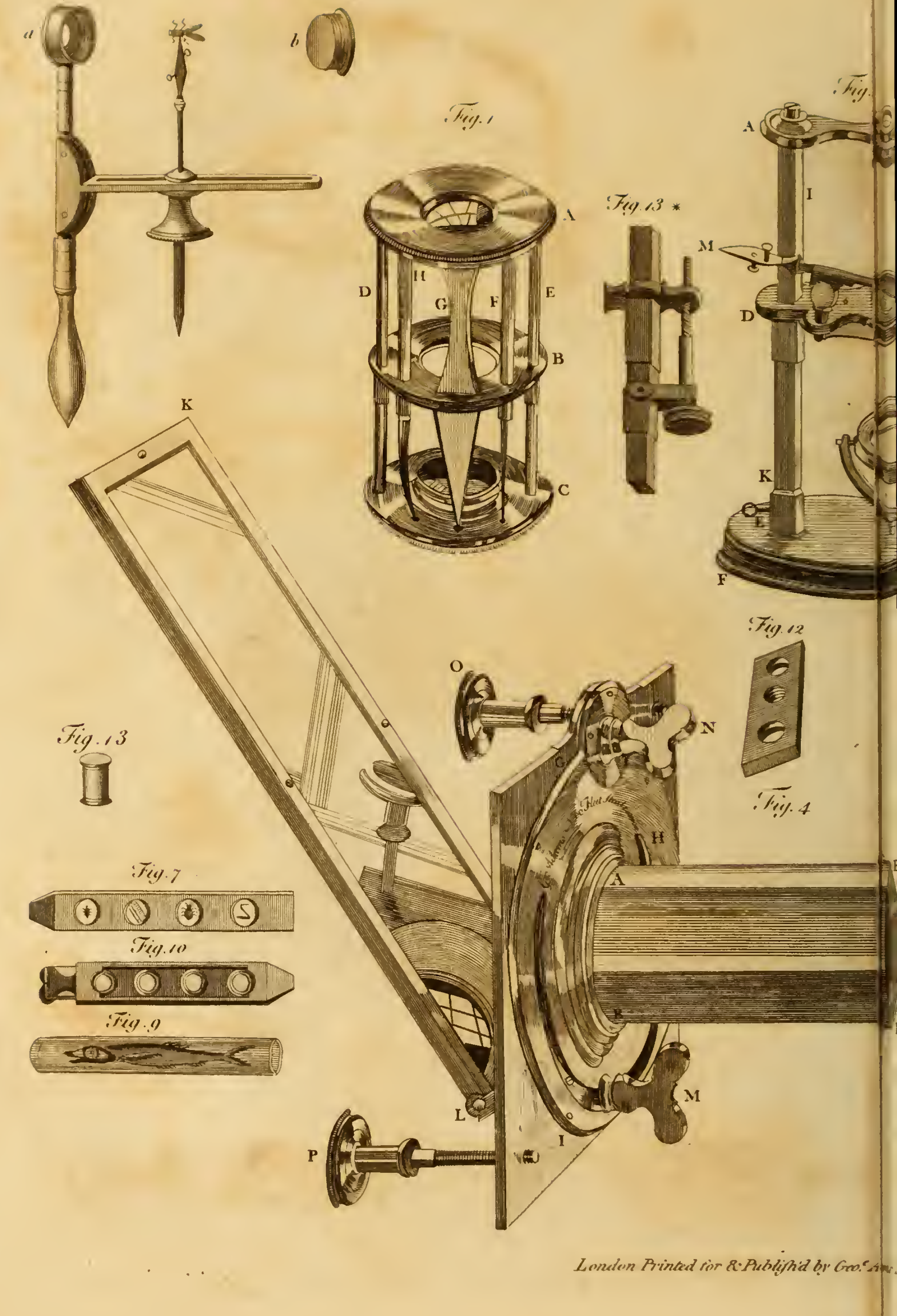

Fig. 1

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Fig. 3

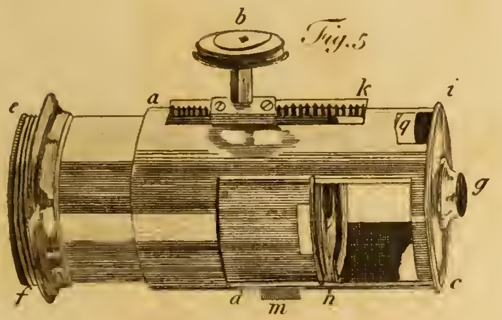

Fig. 5

Fig. 6

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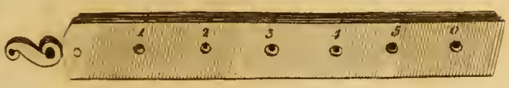

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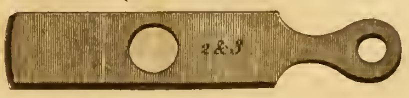

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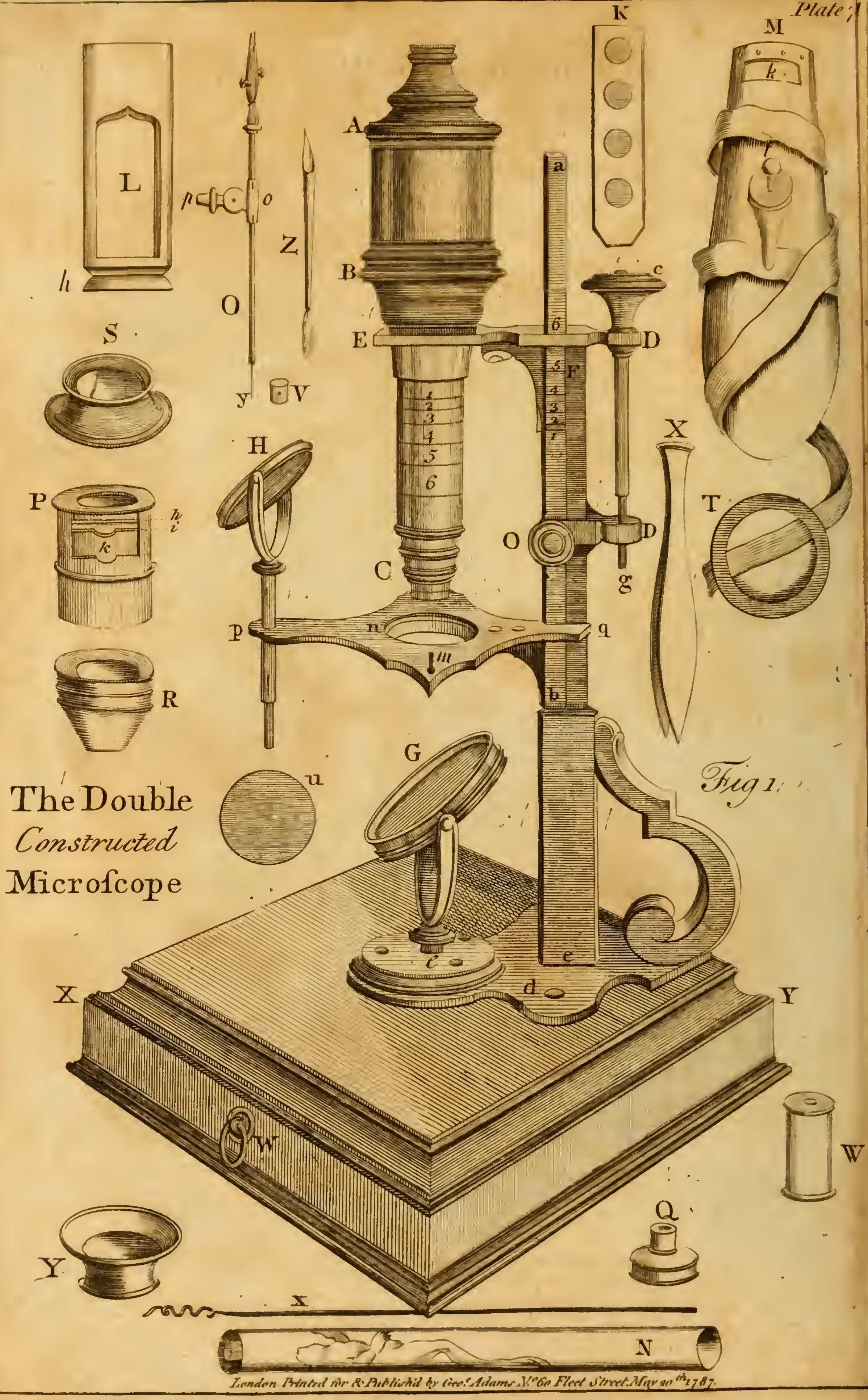

The Double
Constructed
Microſcope

London Printed for & Publishd by Geo.s Adams No 60 Fleet Street Mar 20th 1787.

Mr. Ellis's Aquatic Microſcope

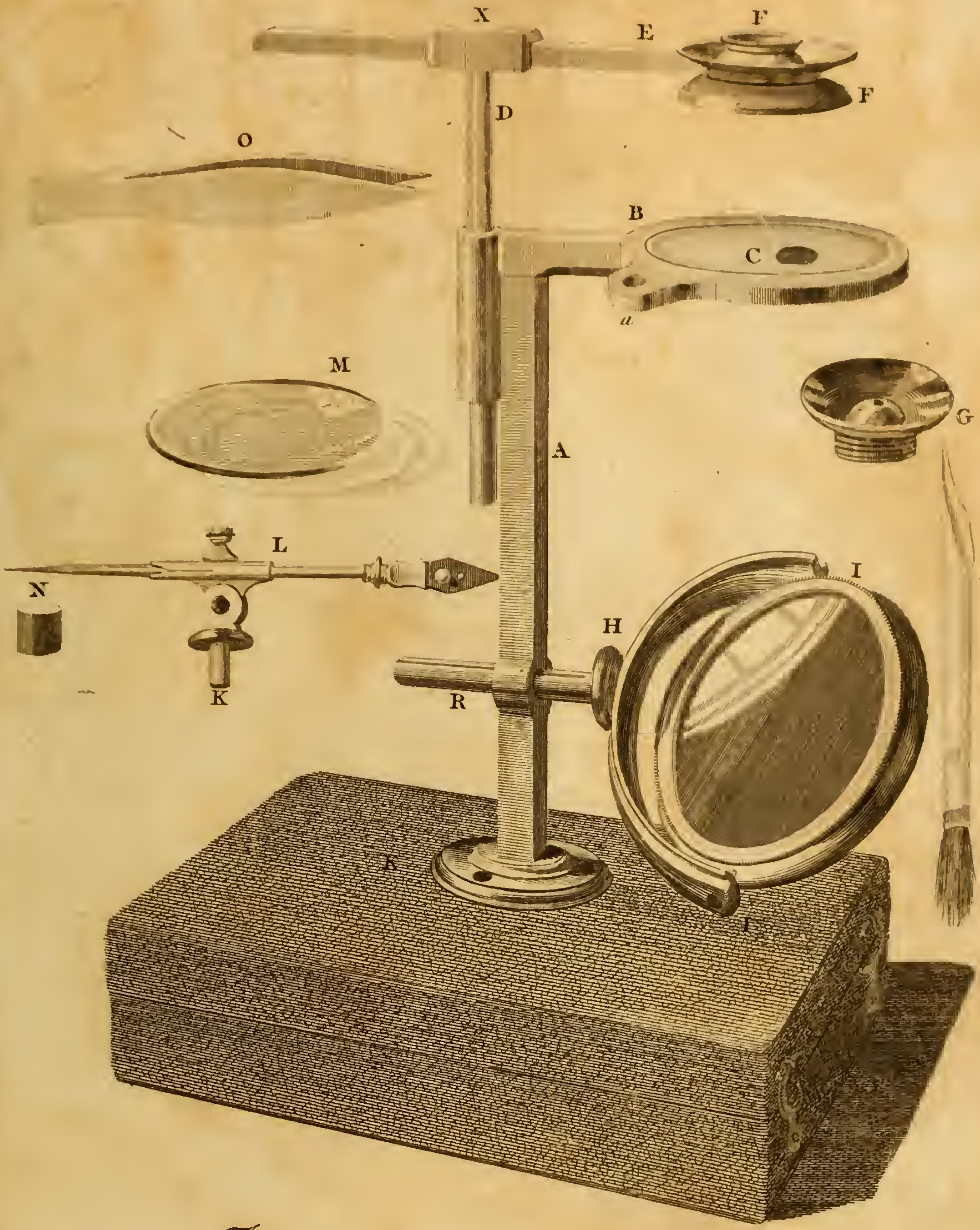

Fig 1

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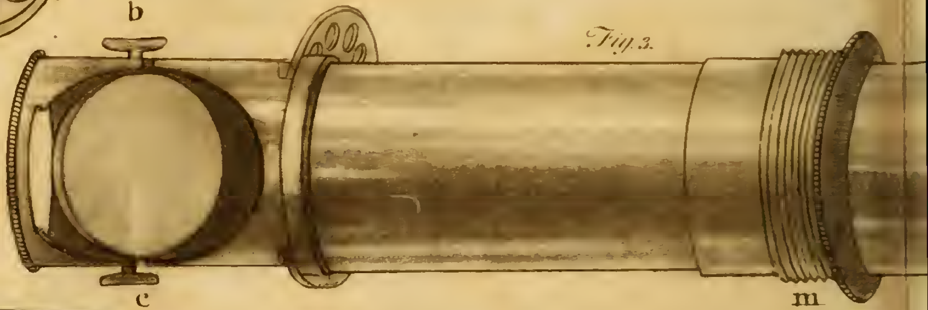
Fig. 2.



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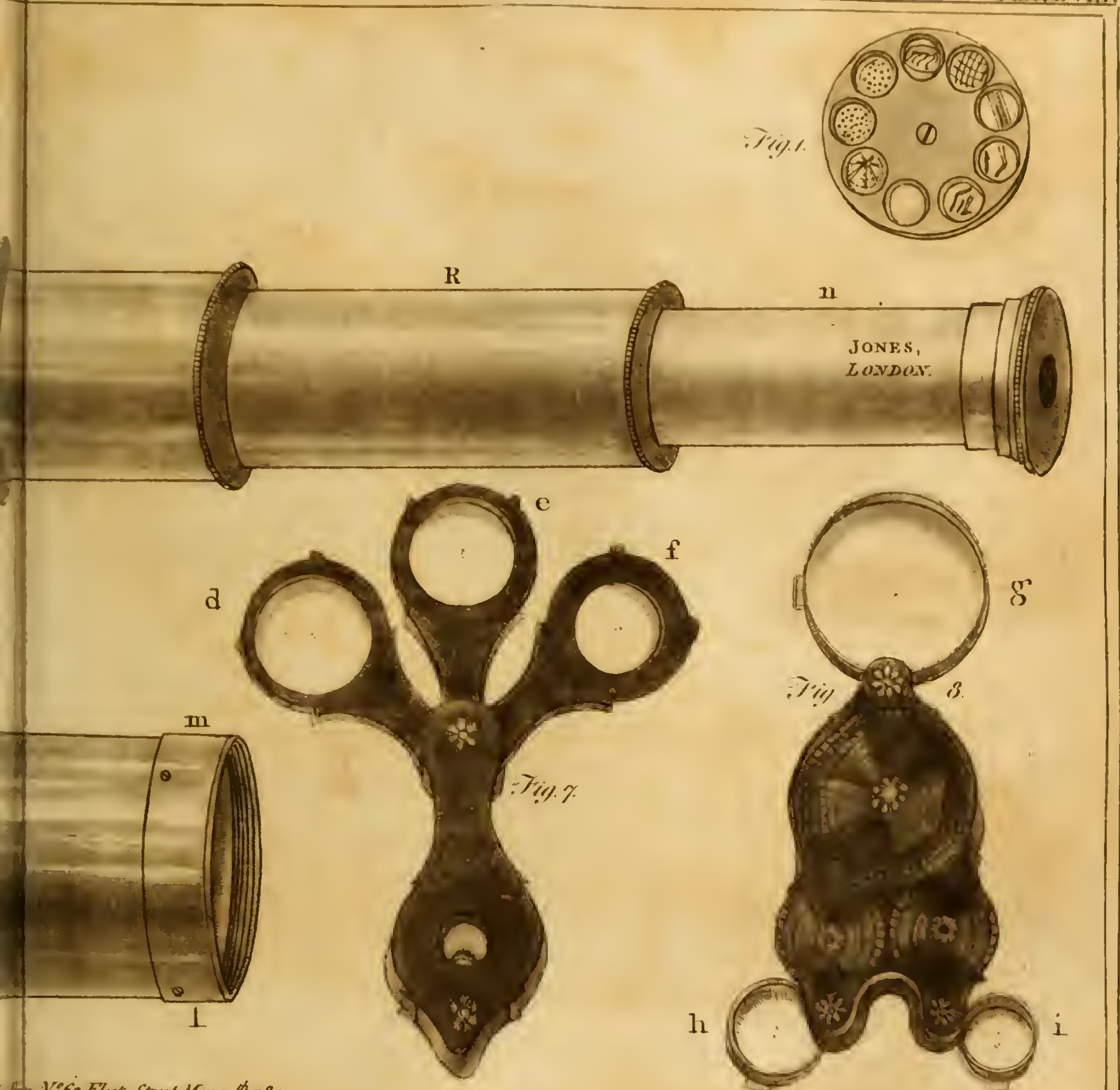

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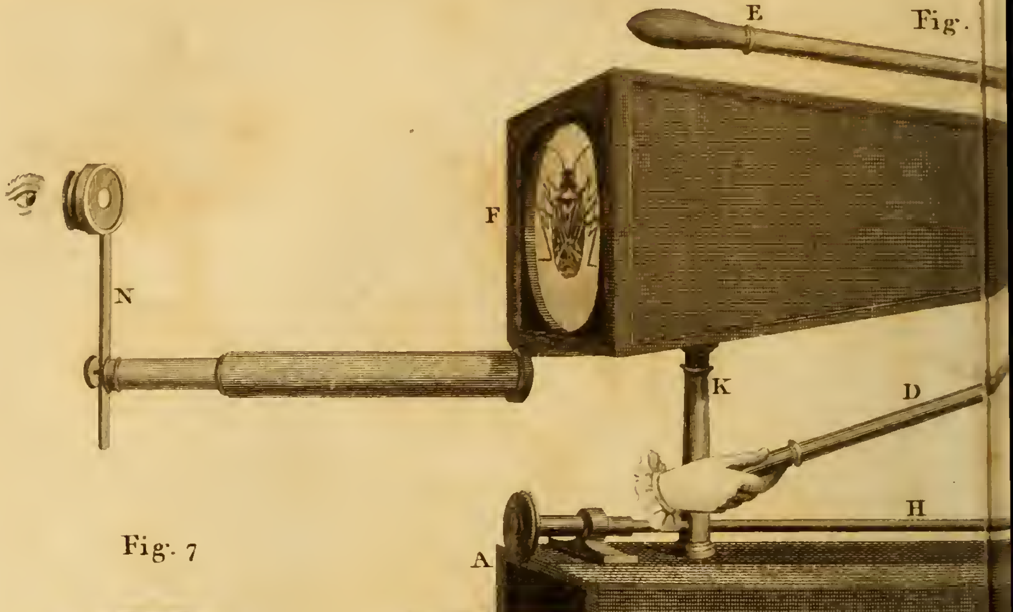

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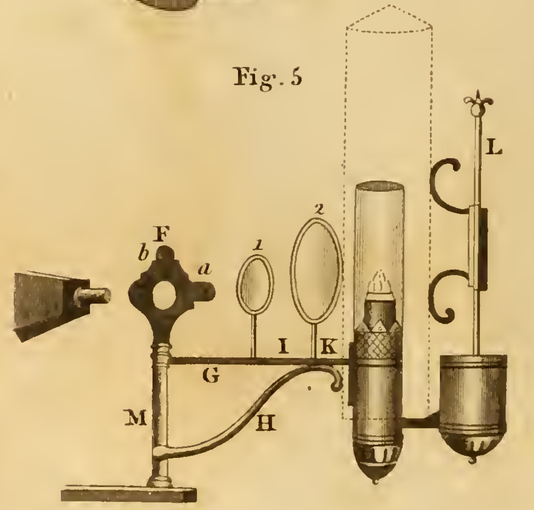

Fig. 2

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London. *Printed for & Published by* W. & S. Jones, *135 Holborn*,

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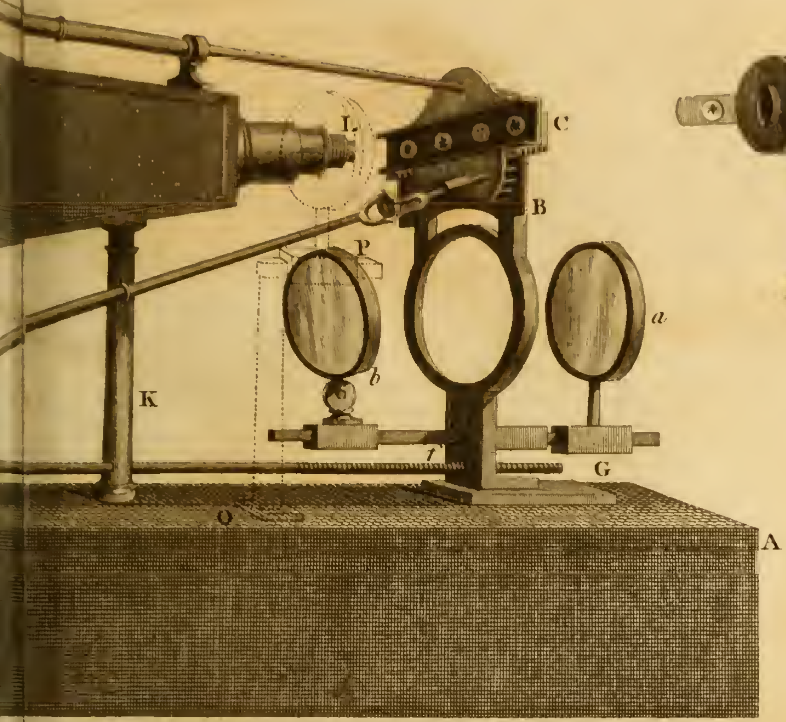

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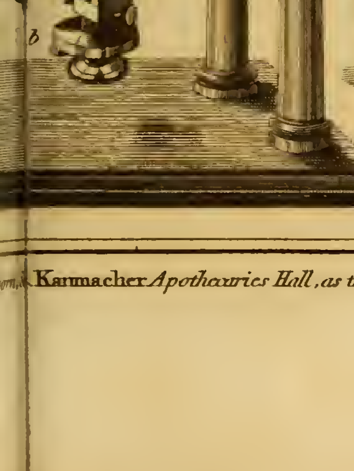
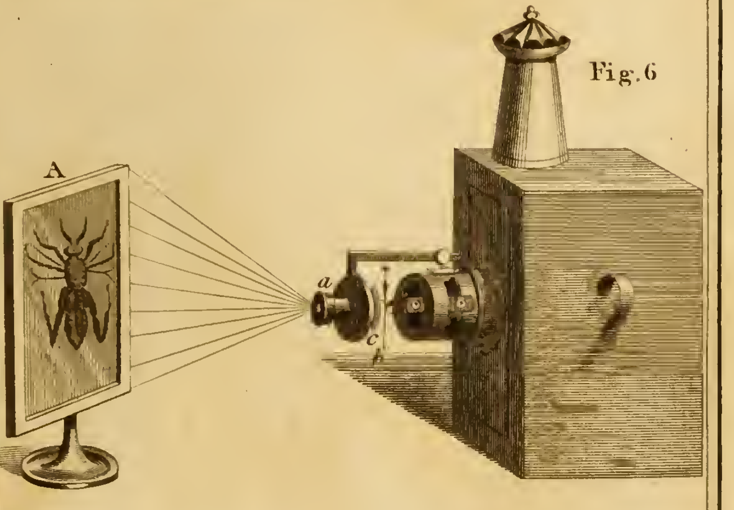


Fig. 6



Kanmacher *Apothecaries Hall, as the Act directs, 1st December 1797.*

Jn. Lodge sc.

Fig. 1.

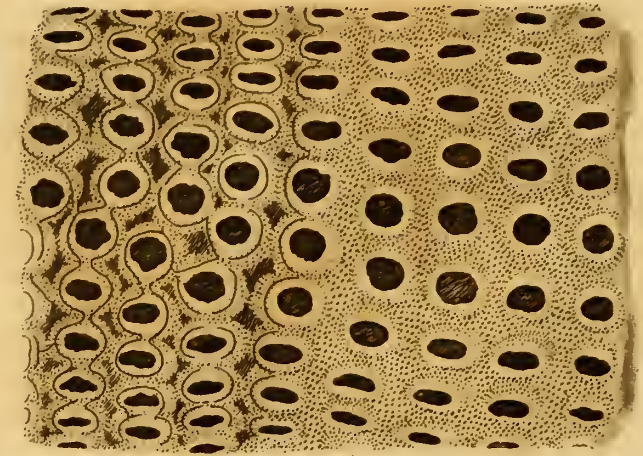


Fig. 2.

Fig. 7.

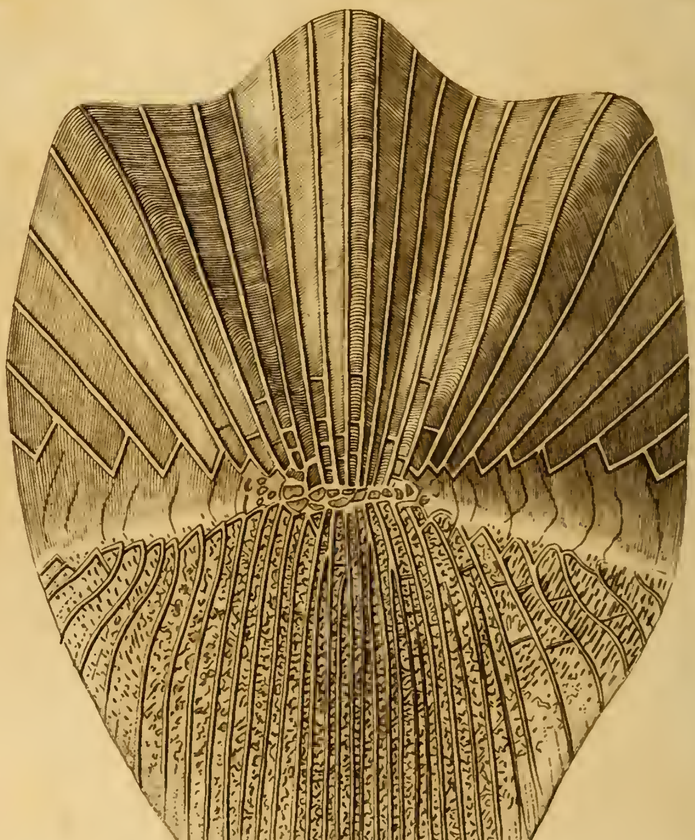


Fig. 8.

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PLATE X.

Fig. 4.

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Fig. 6.

Fig. 5.

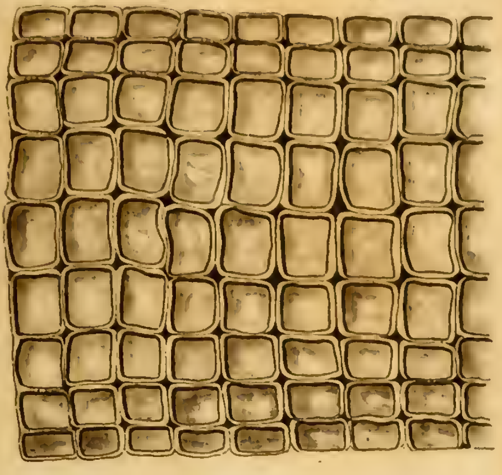


Fig. 9.

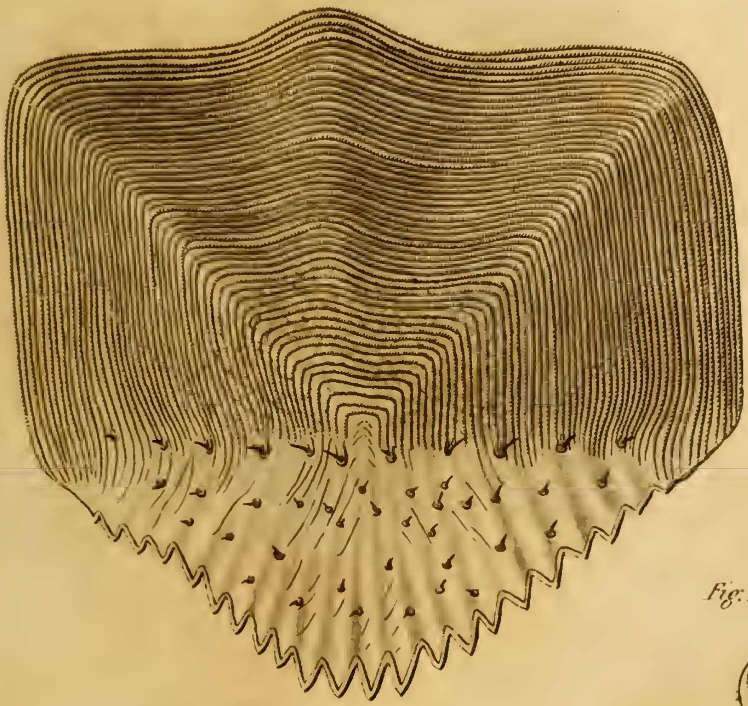


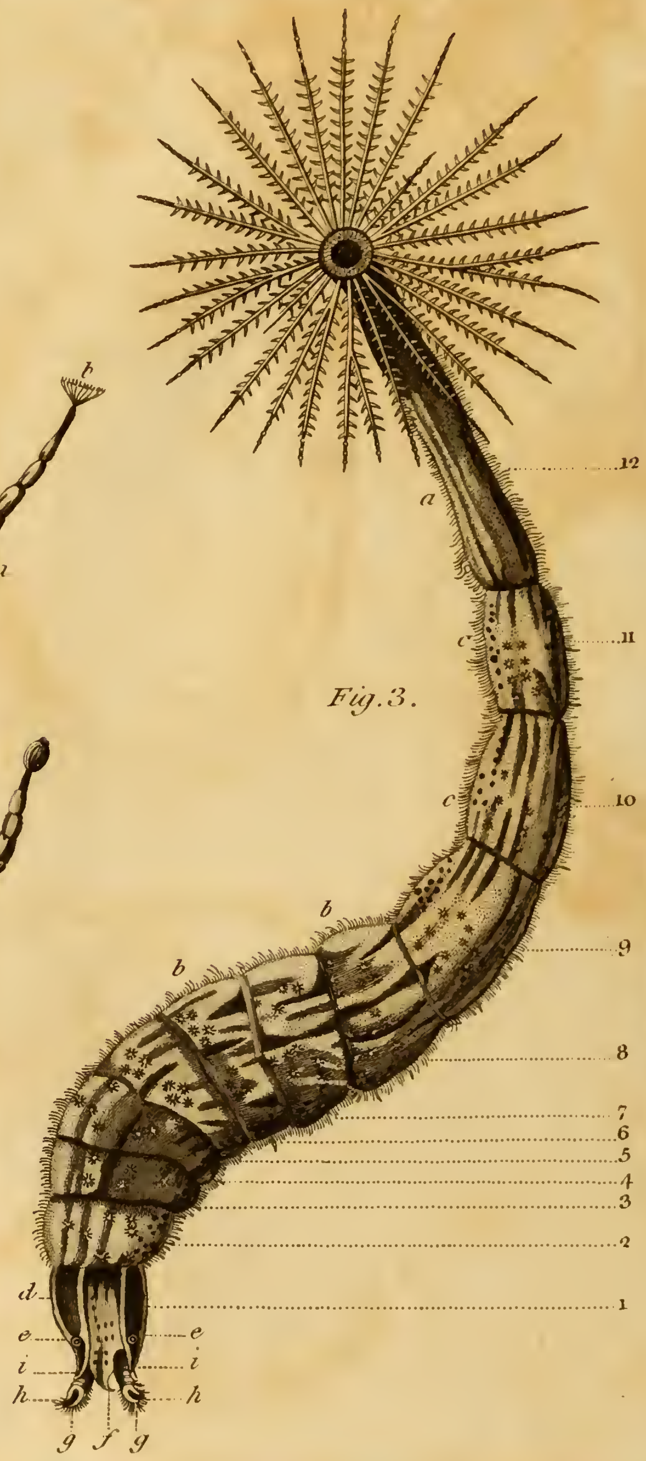
Fig. 10.

ams N°60 Fleet Street May 20th 1787.

Fig. 1.

Fig. 2.

Fig. 3.



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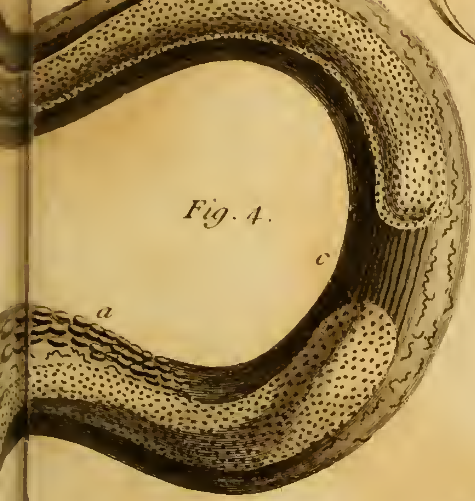

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 10.

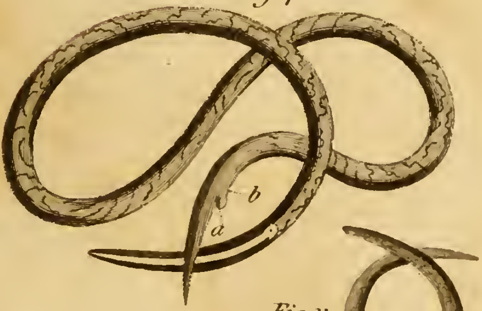

Fig. 7.


Fig. 11.

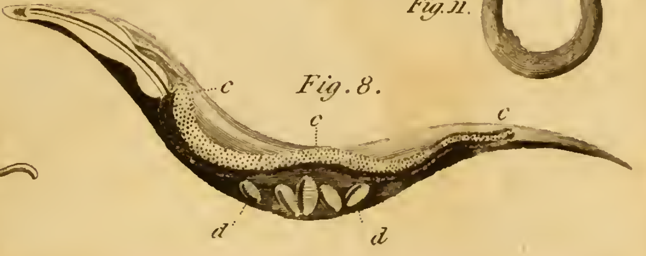

Fig. 8.


Fig. 9.

s N° Fleet Street. as the act directs. May 20.1787.
J. Lodge sc.

Fig. 1. Fig. 2.

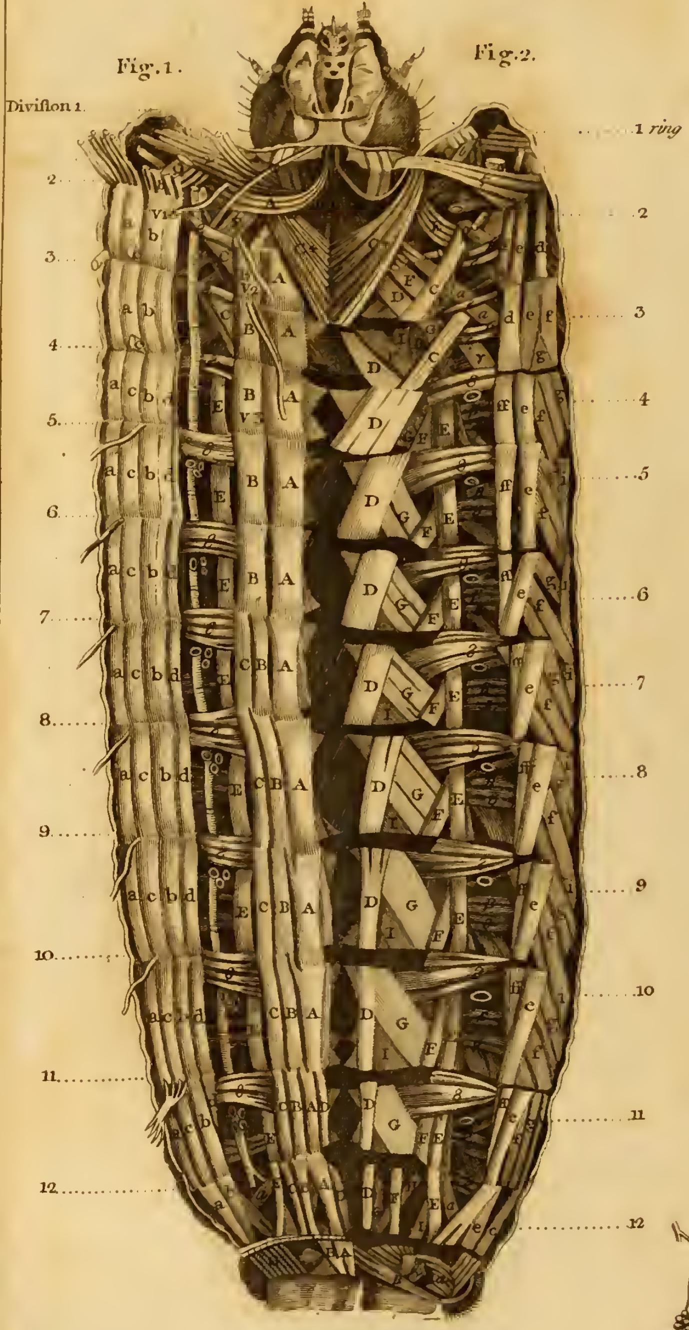

Fig. 6.

Fig.

G. Mune del.

London. *Printed for & Published by* George Adams,

Fig. 5.

Fig. 1. Fig. 3.

N°o Fleet Street, as the act directs. May 20 1787.

Jn.º Lodge sculp.

Fig. 3.

Fig. 4.

Fig. 2.

Fig. 1

Fig. 1

Fig. 2

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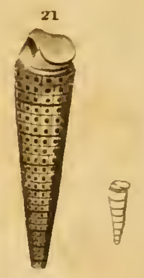

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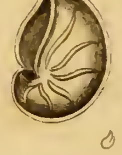

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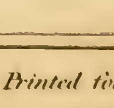

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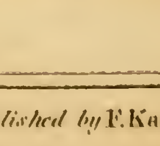

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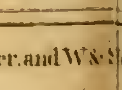

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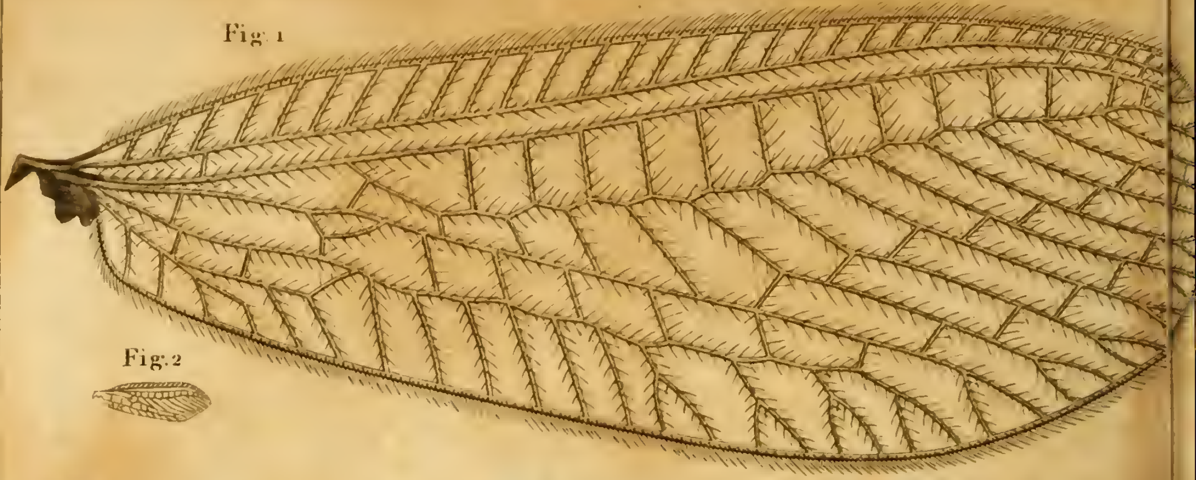
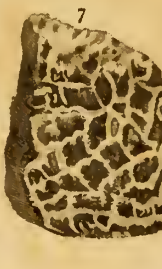
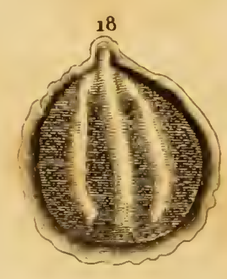
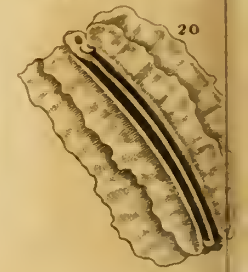
PLATE XIV.

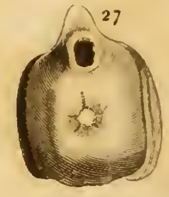
nes, 135 Holborn, as the Act directs, 1st November 1797.

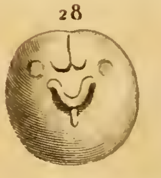


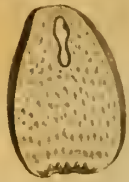












London. *Printed for & Published by* W. & S. Jones, *135 Holborn, and* F.Ka

F ncher, *Apothecaries Hall, as the Act directs, November 1st 1797.*

Fig. 7.

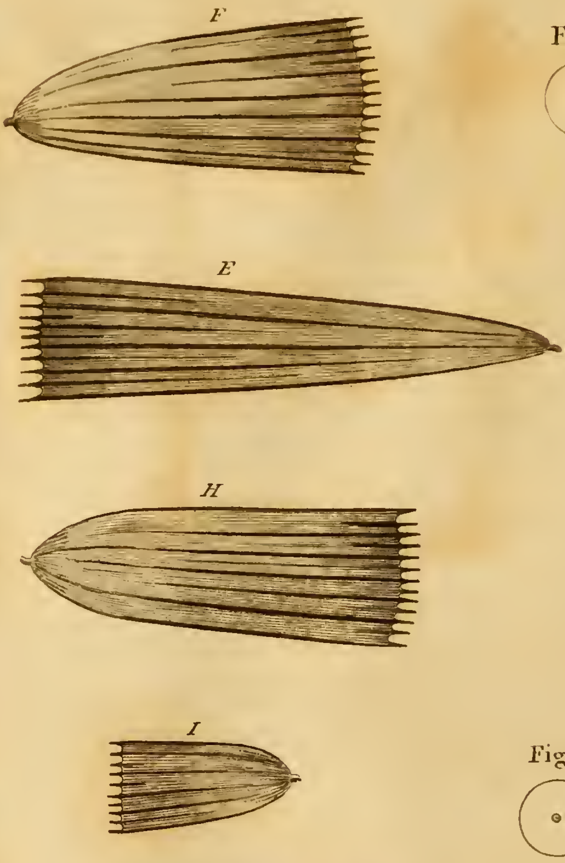


Fig. 8.

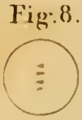
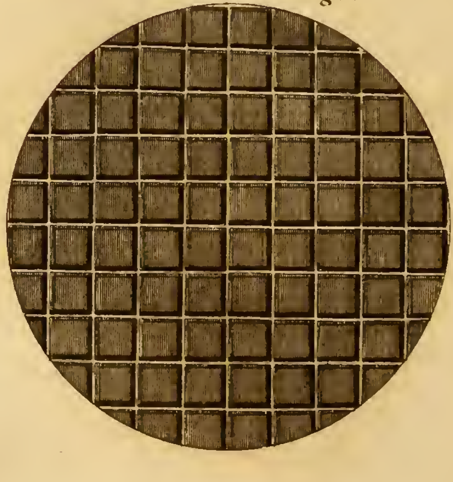


Fig. 6.

Fig. 5.



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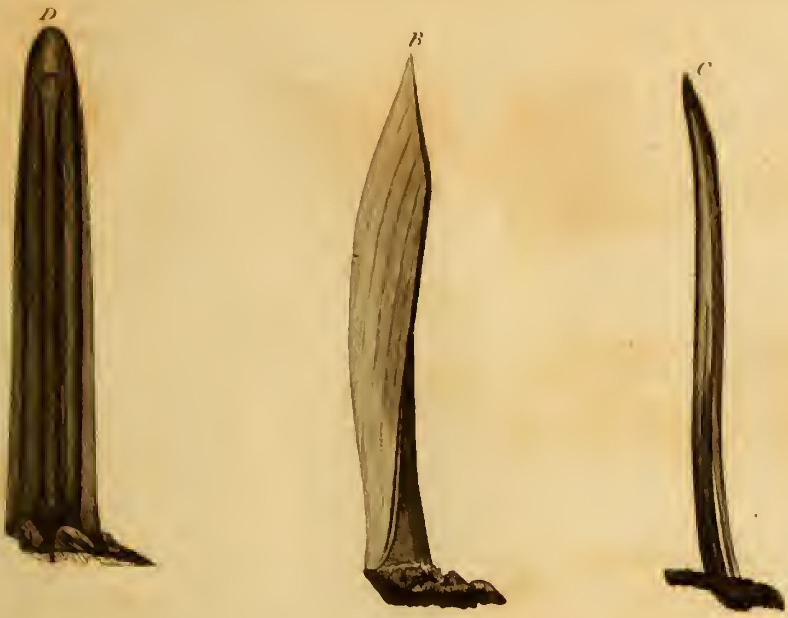

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Fig. 2.

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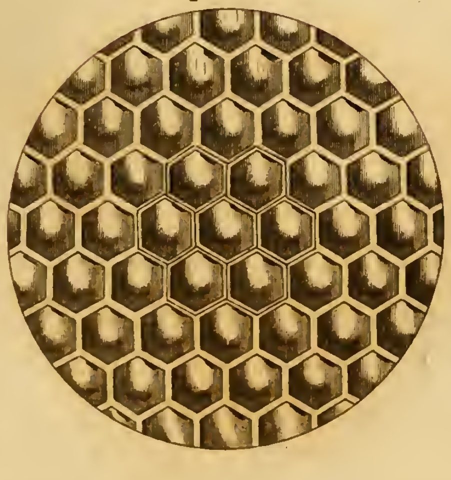

N° 60. Fleet Street as the Act directs. May 20. 1787

Jn. Lodge sc.

Fig. 2.

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Fig. 3.

ders. 60 Fleet Street, May 20th 1787.

Fig. 2.

Fig. 3.

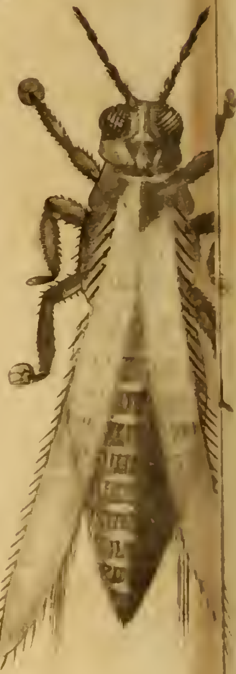


Fig. 4.

Fig. 5.

London Printed for & Publish'd by Geo:

Fig. 1.

Fig. 6.

ams N.º 60 Fleet Street May 20th 1787.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 7.

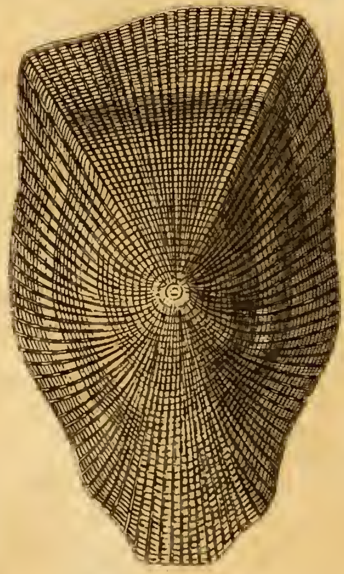
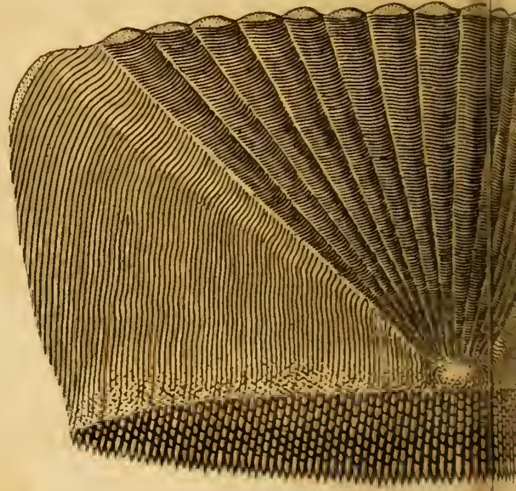


Fig. 8.

Fig. 9.



T. Milne del.

London. *Printed for & Published by* George Adams. No 6

PLATE XIX.

3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 10.

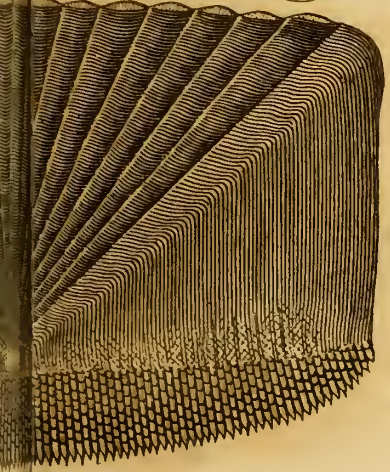


Fig. 11.

Fig. 12.

s.Nº Fleet Street. as the act directs. May 20.1787.

Jnº Lodge sc.

Fig. 1.

T. Milne del.

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PLATE XX

V.º 60. Fleet Street, as the Act directs. May 20.1787.

Jnº Lodge sc.

Fig. 1.

Fig. 5.

Fig. 8.

Fig. 6.

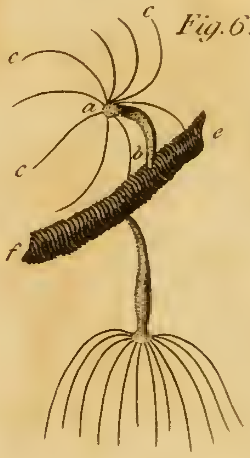

Fig. 2.

Fig. 3.

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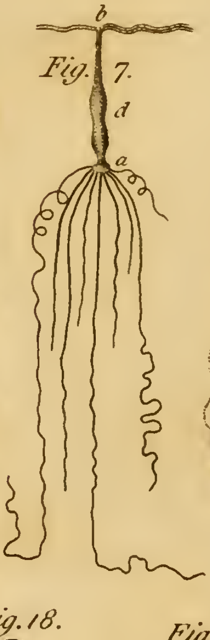

Fig. 4.

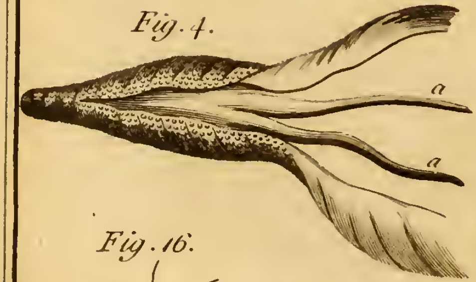

Fig. 16.

Fig. 17.

Fig. 18.

Fig. 19.

Fig. 20.

Fig. 2

T. Milne del.

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PLATE XXI

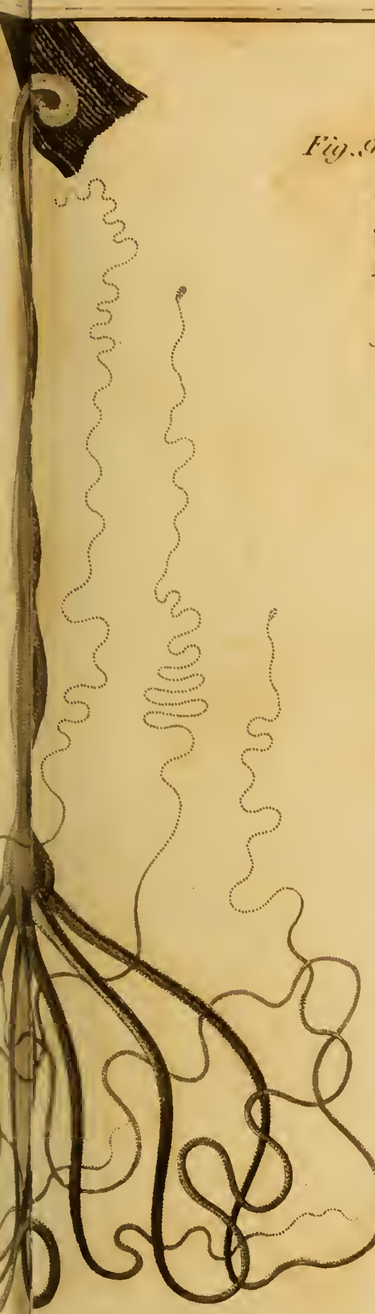

Fig. 9.

Fig. 11.

Fig. 10.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 16. *

Fig. 15.

ig. 21

Fig. 22.

Fig. 23.

Fig. 24.

ge Adams N.° 60. Fleet Street, as the Act directs. May 20.1787.

Jn. Lodge sc.

Fig. 40.

Fig. 26.

Fig. 27.

Fig. 28.

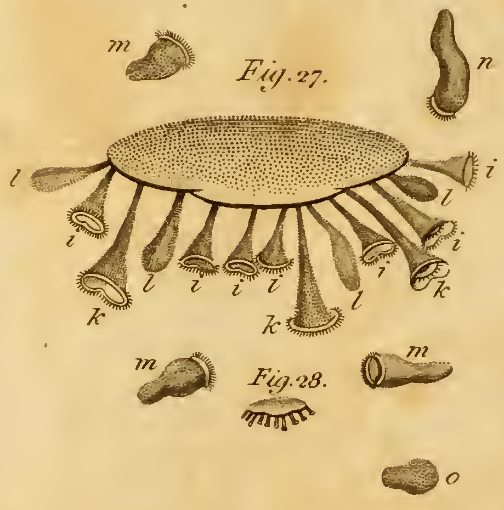

Fig. 30.

Fig. 29.

Fig. 32.

J. Milne del.

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Fig. 31.

Fig. 33.

Fig. 34.

Fig. 35.

Fig. 36.

Fig. 37.

Fig. 38.

Fig. 39.

Nº 60, Fleet Street, as the act directs. May 20. 1787.

J. Lodge sc

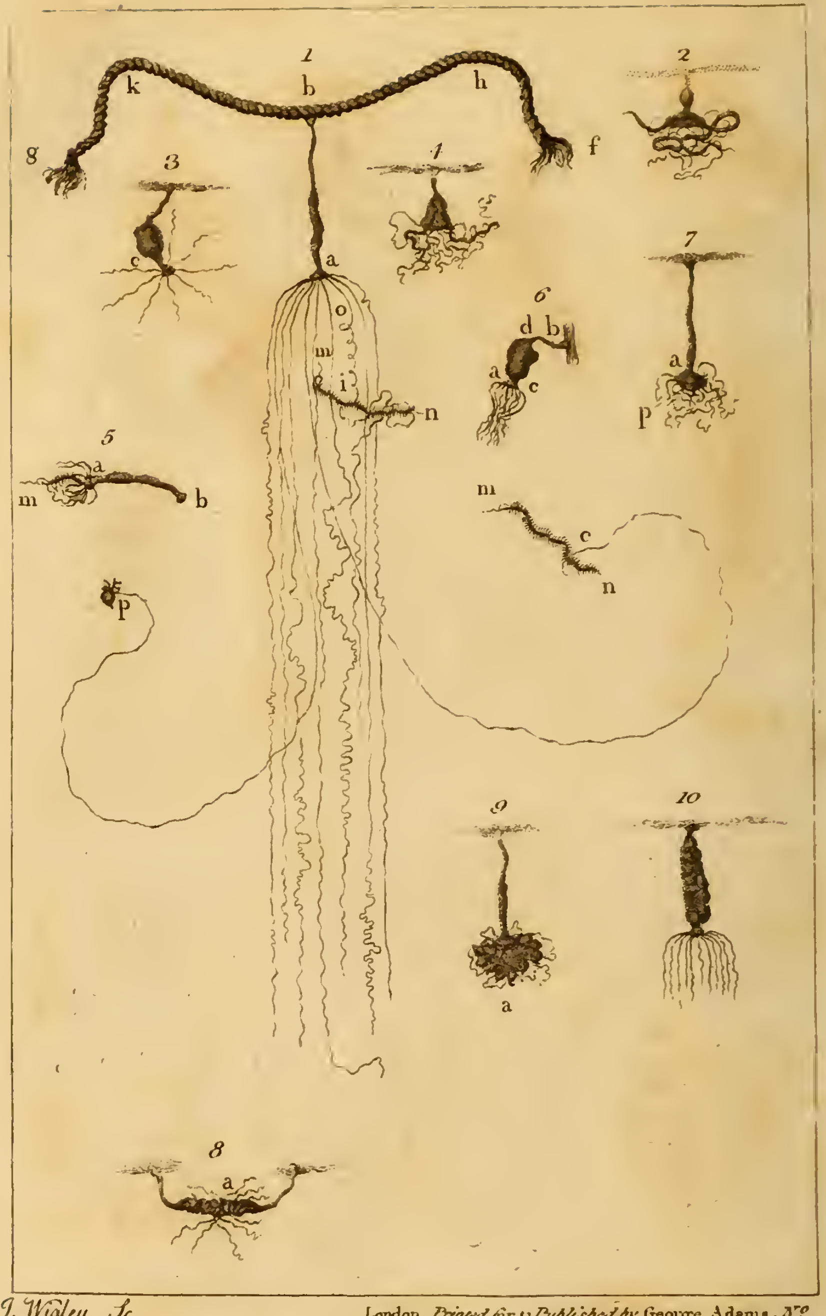
Pl. 23 A.

J. Wigley. Sc.

London. *Printed for & Published by* George Adams, No

60, Fleet Street. as the act directs. 20 May 1787.

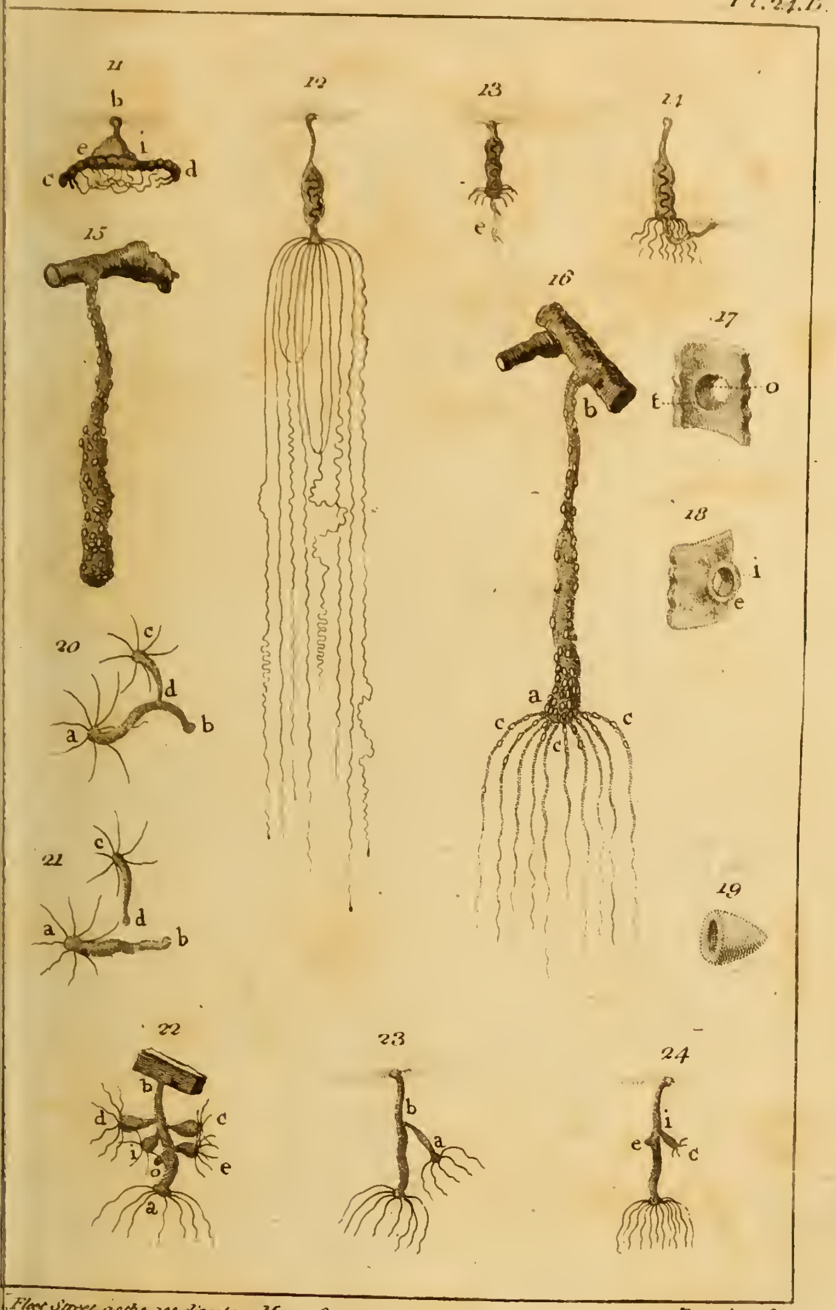
Bowles ſc.



J. Wigley. Sc.

London. *Printed for. & Published by* George Adams, No

Pl. 24. B.



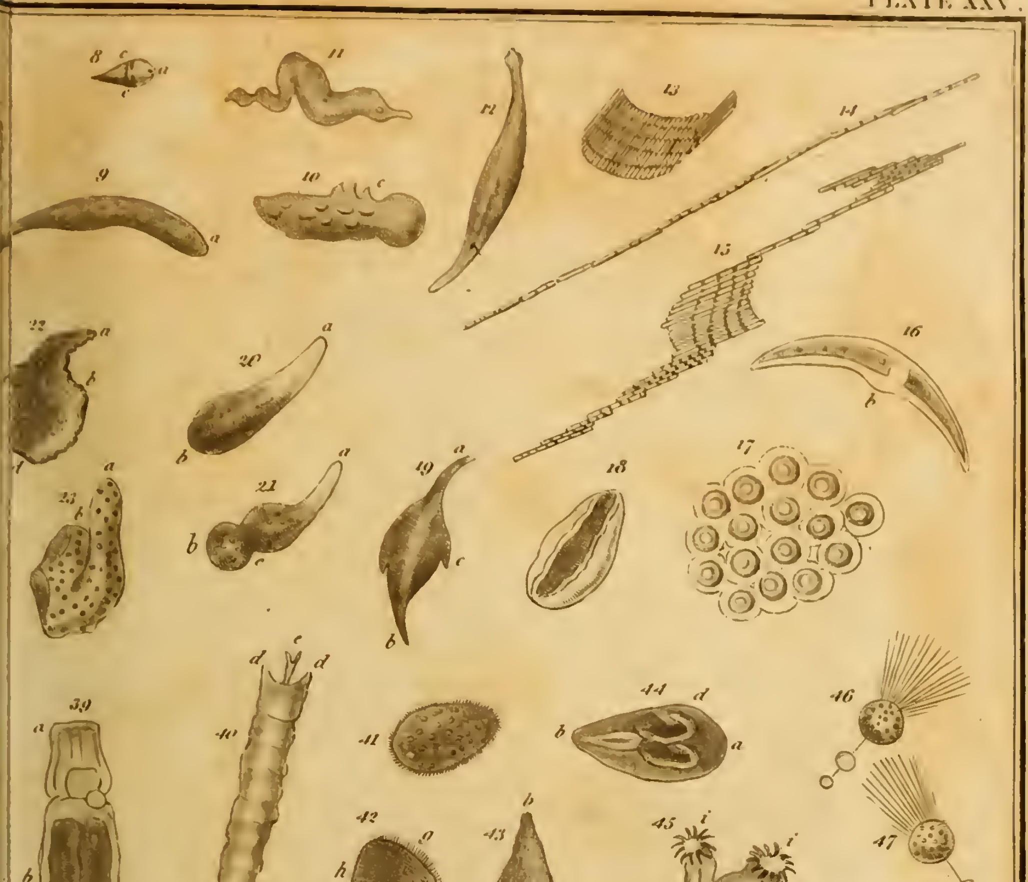
Fleet Street, as the act directs 20 May 1787.

Bowles sc.

T. Milne Delin^t

London Published May 1^st 1787.

PLATE XXV.



t by Geo. Adams N°60 Fleet Street.

London Published May 1st 1787.

Plate XXVI

Geo. Adams Nº60 Fleet Street.

T. Milne del.

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60. Fleet Street. as the act directs. May 20. 1787.

J. Lodge sc.

Fig. 1.

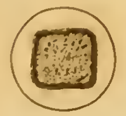
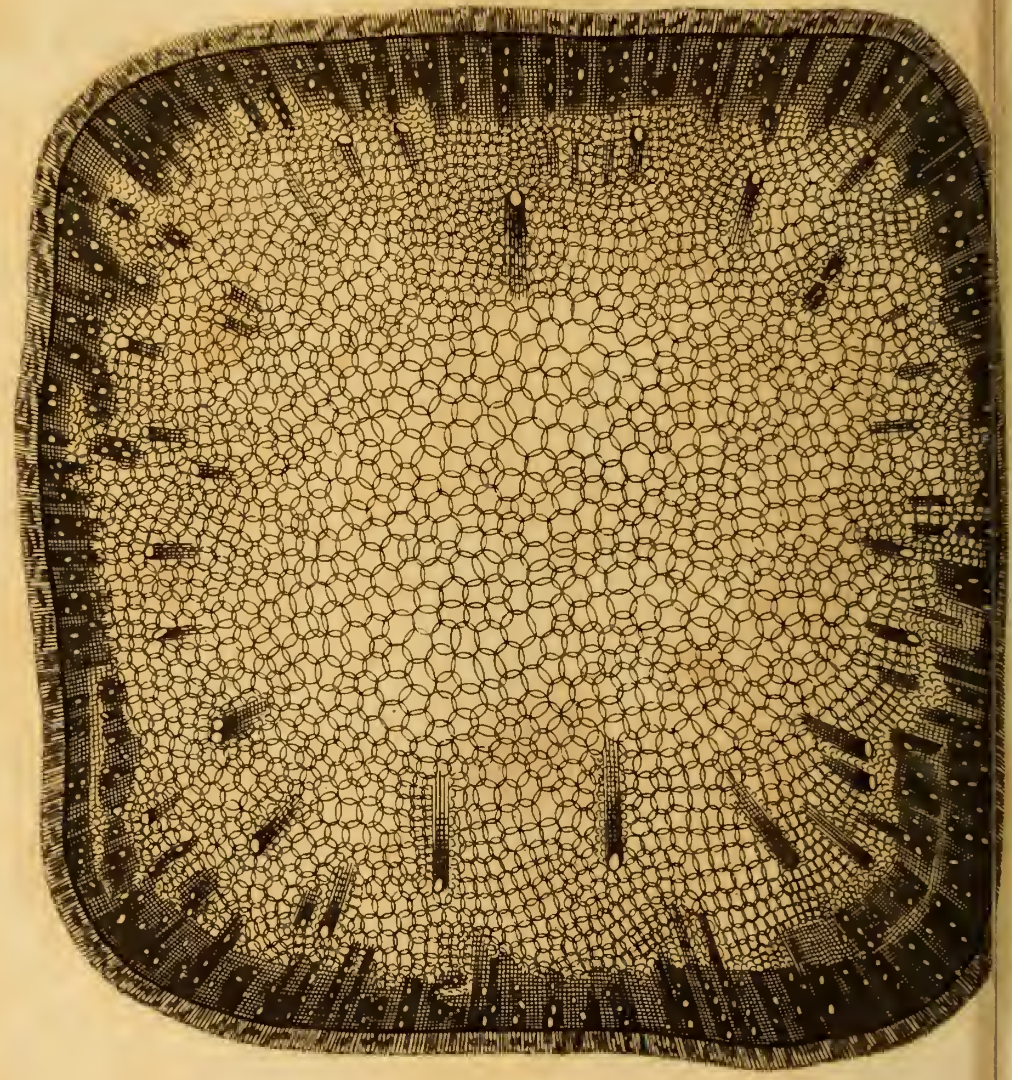


Fig. 2.



T. Milne del.

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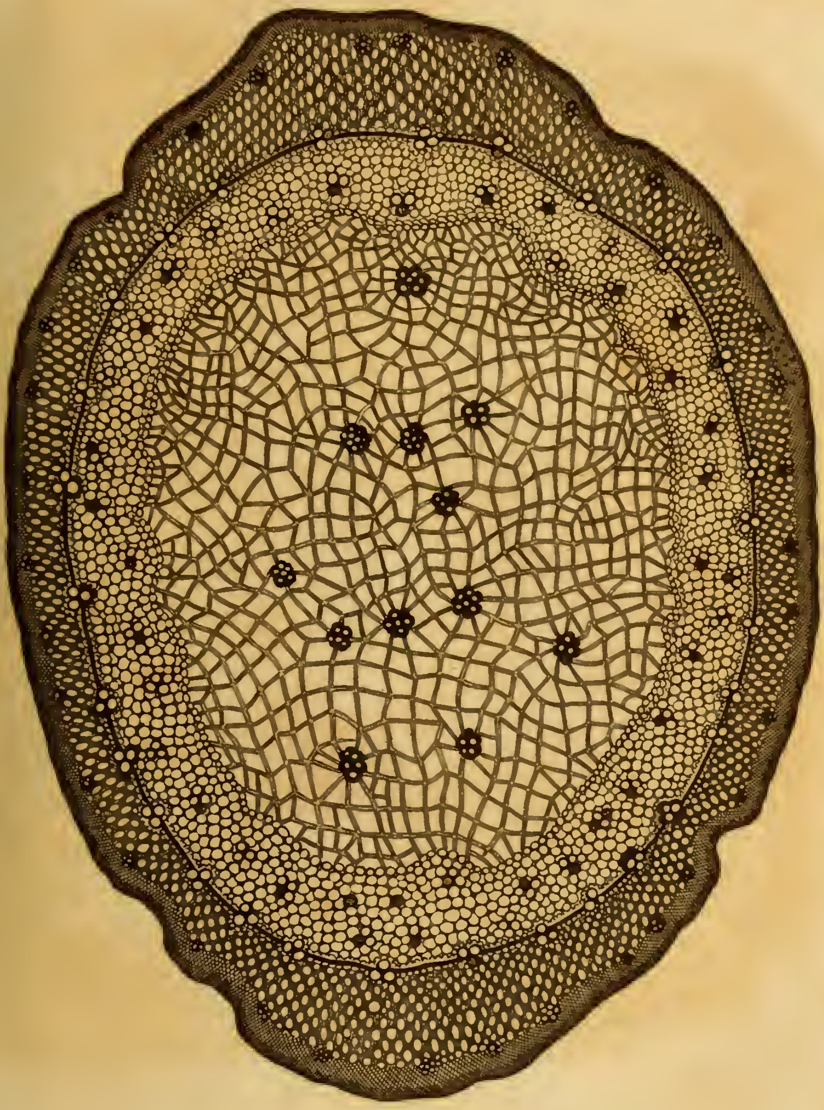
PLATE XXVIII.

Fig. 1.

Fig. 3.



N° 60. Fleet Street, as the act directs. May 20. 1787.

J. Lodge sculp

Fig.4.

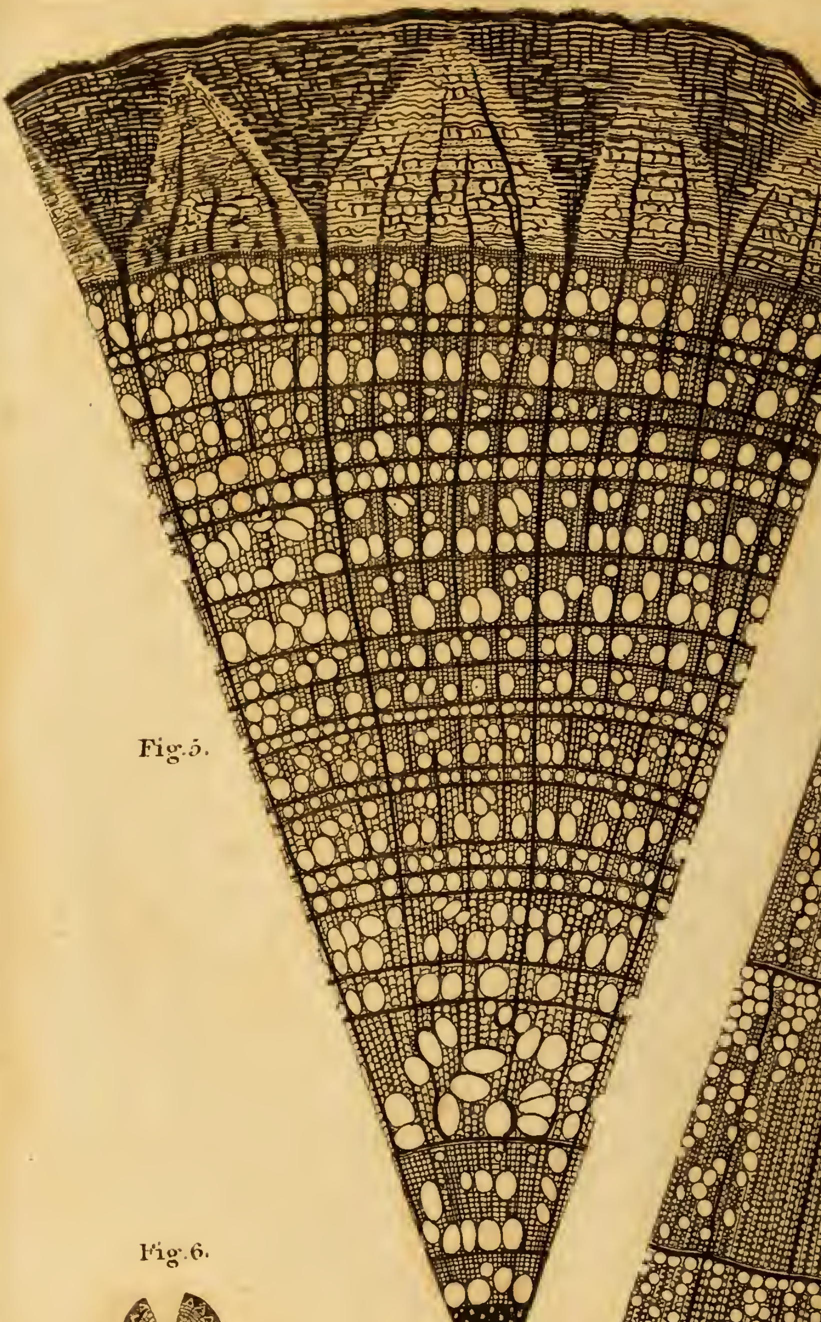


Fig.5.

Fig.6.

Fig.3.

T. Milne del.

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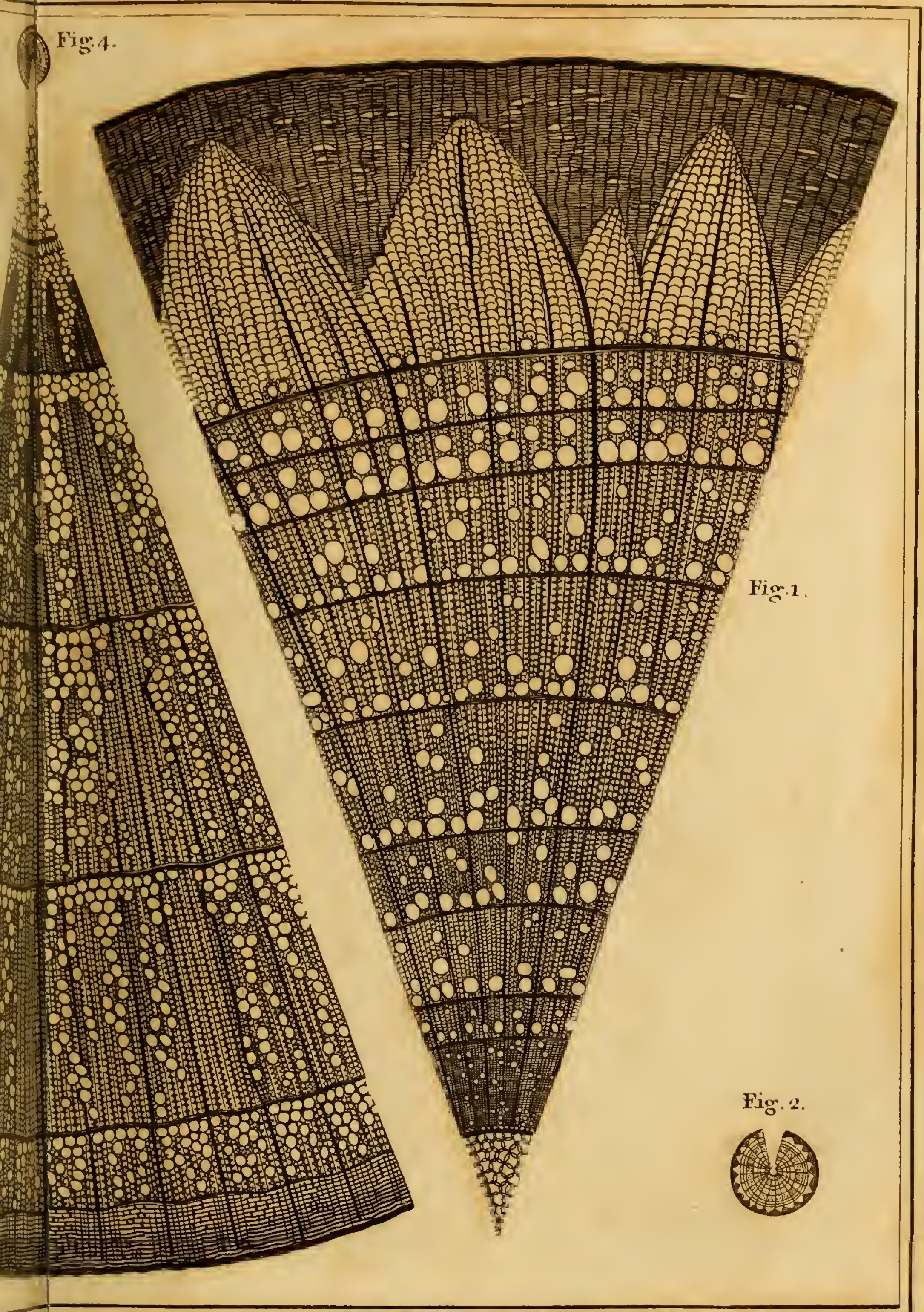
PLATE XXIX.



J. Lodge sc.

ished by Georg Adams N°. 60. Fleet Street, as the Act directs. May 20 1787.


Fig. 3.
Fig. 2.
Fig. 1.
Fig. 4.

PLATE XXX

London Printed for & Publiſhd by Geo.s Adams No. 60 Fleet Street May 20th 1787.

Fig. 2.

Fig. 1.

T. Milne del

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Fig. 3.

Fig. 4.

80. Fleet Street. as the act directs. May 20. 1787.

Jn. Lodge sc.

Fig. 1.

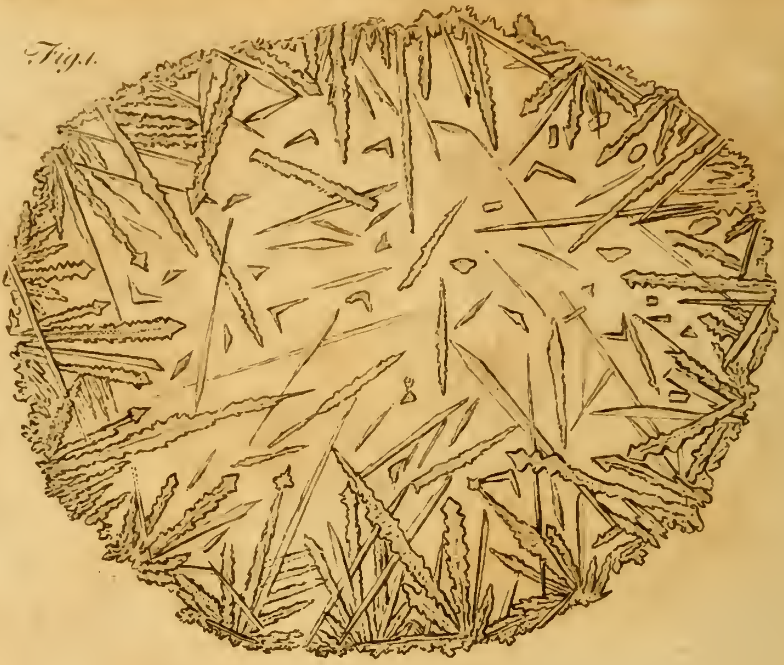

Fig. 3.

PLATE XXXII.

Fig. 2.

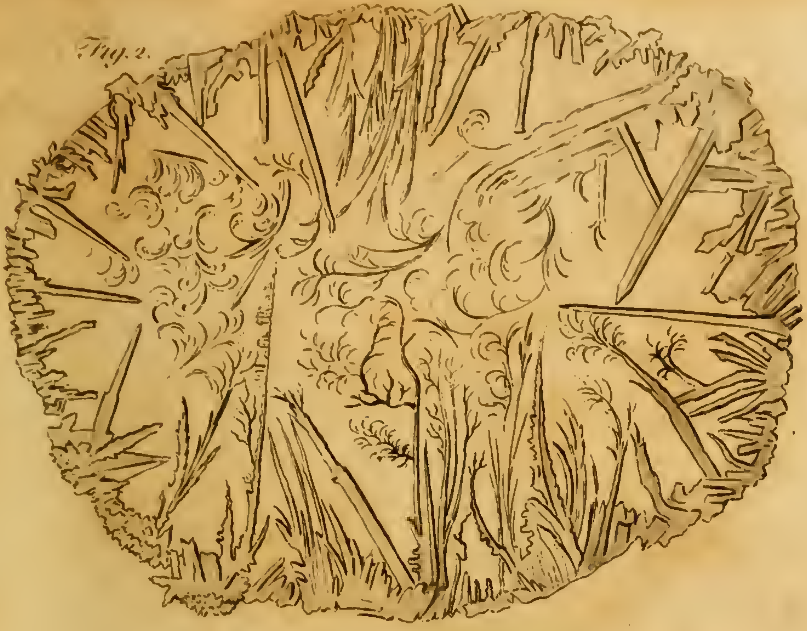

Fig. 4.

A

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OF

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OPTICAL INSTRUMENTS.	£.	s.	d.
Best double-jointed standard gold spectacles, with pebbles, and fish-skin gold-mounted case	16	16	0
Ditto single-jointed, with ditto case	10	10	0
Best double-jointed silver ditto, with pebbles	1	16	0
Ditto, ditto, with glasses	1	1	0
Best single-jointed, with pebbles	1	8	0
Ditto, with glasses	0	13	0
Best double-jointed steel ditto, with glasses	0	9	0
An improved sort of ditto for ladies	0	10	6
Second best double-jointed steel spectacles, with spring case	0	7	6
Common ditto	0	4	6
Best single-jointed steel spectacles	0	4	6
Second best ditto	0	2	6
Common ditto	0	1	6
Tortoishell spectacles, silver-jointed, with pointed, and other shaped sides, peculiar for their lightness and uninterruption of dressed hair, in morocco leather cases	0	10	6
Ditto, double-jointed frames	0	15	0
Spectacles for eyes that have been couched	0	7	6
Ditto with green glasses for very weak and inflamed eyes, according to the frames, from 6s. to	1	1	0
Ditto for the same purpose, with new contrived portable shades to screen the eyes from candle, or other light	0	15	0
Nose spectacles in silver	0	7	6
Ditto in tortoishell and silver	0	4	0
Ditto in horn and steel	0	1	6
Spectacle cases in very great variety, from 2d. each to	10	10	0
Concave glasses for short-sighted persons, in horn cases	0	1	6
Ditto in tortoishell, pearl, silver, &c. from 2s. 6d. to	2	2	0
Ditto in new-contrived frames for gentlemen when shooting	0	16	0
Reading and burning glasses, in various mountings, from 1s. to	1	16	0
Convex glasses for watch-makers, engravers, &c. from 1s. to	0	10	6
Gogglers, to guard the eyes from the dust or wind	0	3	0
New green-light shades for the eyes	0	6	6

	£.	s.	d.
Opera glasses, in great variety of mountings, from 4s. 6d. to	2	12	6
Ditto, on an improved construction of glasses, plain mounting	1	1	0
Refracting Telescopes of various lengths, from 6s. to	1	16	0
Ditto to use at sea by night, from 1l. 11s. 6d. to	2	12	6
Achromatic stick telescopes of various lengths from 18s. to	4	0	0
The new-improved ditto, with three sliding brass tubes, by which an instantaneous view of the object is obtainted, and shuts up very short for the pocket, of one foot in length, in a case	1	11	6
Second best two-drawers, ditto	1	1	0
Twenty inch best three-drawers, ditto	2	12	6
Ditto second best two-drawers	1	10	0
Two feet best three-drawers, ditto	4	4	0
Ditto second best, ditto	3	3	0
Three feet, best four-drawer ditto	6	6	0
Second best ditto	4	4	0
The preceding telescopes, fitted up elegantly with silver or plated tubes, from 2l. 2s. to	21	0	0
Astronomical eye-pieces and portable brass stands for the above, from 10s. 6d. to	2	12	6
The new-improved 2½ feet achromatic refractor, on a brass stand, mahogany tube, with two sets of eye-glasses, one magnifying about forty times for terrestrial objects, and the other about seventy-five times for astronomical purposes, packed in a mahogany box	9	9	0
Ditto, ditto, the tube all brass, with three eye-pieces	11	1	6
The 3½ feet ditto, ditto, mahogany tube	17	6	6
Ditto, ditto, brass tube	19	8	6
Ditto all in brass, with rack-work motions, &c.	24	3	0
Achromatic perspective glasses for the pocket, in brass, &c. tubes, with a change of eye-glasses, from 12s. to	3	3	0
New-improved ditto, answering the purpose of an opera-glass, with a compass, and helioscope for viewing the sun, from 1l. 3s. to	2	2	0
New-improved achromatic pocket telescope, which, by a small apparatus within its tubes, is readily converted into a compound microscope	3	13	6
An improved portable seven-inch achromatic telescope in brass, with a stand that packs up into the tube of the telescope, adapted for astronomical uses	3	13	6
Reflecting Telescopes, fitted up either upon the *Gregorian*, *Newtonian*, or *Herschelian* principles, with improved wood, or metal stands, and other apparatus for making celestial observations in the most commodious and accurate manner—The general prices are as follow:			
— Fifteen feet in length, the large metal fifteen inches in diameter, from 250l. to	500	0	0
— Twelve feet in length, fourteen inch metal	200	0	0
— Ten feet in length, twelve inch metal	150	0	0
— Eight feet in length, eleven inch metal	140	0	0
— Six feet in length, nine inch metal	100	0	0
— Four feet long, in brass tubes, with portable brass or mahogany framed stands, from 40l. to	100	0	0

Those reflectors that are constructed upon the principles of Newton *or* Herschel *are about twice the above lengths in the tubes. The reflectors upon the usual Gregorian construction are made with the vertical motion upon a new principle, so as to render them more firm and steady while in use, than any reflectors mounted in the old manner.*

	£.	s.	d.
A four feet seven inch aperture Gregorian reflector, with the vertical motion upon a new invented principle, as well as apparatus to render the tube more steady in observation; according to the additional apparatus of small speculums, eye-pieces, micrometers, &c. from 70l. to	100	0	0
Three feet long, mounted on a brass stand, common mounting	23	2	0
Ditto with rack work motions, improved mounting, and metals	36	15	0
Two feet long, without rack-work, and with four magnifying powers, improved, 13l. 13s. to	14	14	0
Ditto improved, with rack-work motions	22	1	0
Eighteen inch on a plain stand	8	8	0
Twelve inch ditto	5	5	0
Telescopes of both the above kinds fitted up with equatorial, &c. motions, micrometers, adjusting, compensating, &c. apparatus, for the most accurate astronomical purposes.			
Common MICROSCOPES, from 2s. 6d. to	1	1	0
Wilson's single pocket microscopes, from 18s. to	2	12	6
Compound microscopes improved, from 2l. 12s. 6d. to	5	5	0
New improved universal ditto	6	6	0
Ditto with the most complete apparatus	10	10	0
Solar microscopes in brass, improved, from 4l. 14s. 6d. to	6	6	0
The new opake and transparent solar microscopes, with improved apparatus, from 10l. 10s. to	16	16	0
Ditto of a larger size, with additional megalascopic apparatus, from 14l. 14s. to	19	19	0
Ditto, and best compound ditto, packed together in one mahogany box	21	0	0
The LUCERNAL MICROSCOPE, as improved by W. JONES, exhibiting images of opake and transparent objects by night or day, in a manner singularly pleasing, brilliant and distinct, with upwards of 100 objects, proper apparatus, patent lamp, &c.	16	16	0
Ditto combined with a solar, compound, &c. apparatus, forming the most perfect collection of microscopical apparatus	35	14	0
A portable optical apparatus, consisting of a scioptic ball and socket, a solar microscope, Wilson's microscope, a pocket compound microscope, a pocket telescope, and solar telescope, in mahogany and brass	3	13	6
Pocket microscopes for opake objects, from 16s. to	2	12	6
Botannic microscopes for flowers, &c. from 5s. to	1	11	6
A new universal pocket ditto, adapted to all sorts of objects	1	6	0
Cloth microscopes, from 2s. 6d. to	0	10	6
Magic lanthorns, from 1l. 4s. to	1	8	0
Sliders for ditto in great variety of subjects, each	0	3	6
A new set of moveable painted sliders, shewing the fundamental principles of astronomy, with the real and appa-			

	£.	s.	d.
rent motions and positions of the planets, stars, &c. &c. accompanied by a proper improved lanthorn, complete . .	13	13	0
Small magic lanthorns, with twelve sliders complete, at 7s. 6d. 10s. 6d. 12s. and	1	0	0
Ditto with twelve sliders of best English paintings	2	2	0
Optical diagonal machines for viewing prints, from 1l. to	1	11	6
Perspective views in great variety for ditto, each	0	1	6
Scioptic balls and sockets from 10s. 6d. to	1	11	6
An artificial eye in brass, to exemplify the nature of vision	1	11	6

For a description of this instrument, as well as of spectacles, reading-glasses, &c. see the late Mr. G. ADAMS's Essay on Vision, *8vo. price 3s. now sold by* W. *and* S. JONES.

Camera obscuras for the pocket, from 9s. to	1	16	0
A new invented folding ditto, very portable	2	2	0
Large ditto, shutting up like a book, or neat portable chest, the objects represented on paper, from 4l. 14s. 6d. to . .	8	18	6
Concave and convex glass mirrors, in plain black frames, four, five, six, and seven inches diameter, each 9s. 12s. 14s. and	0	18	0
Eight inches diameter ditto	1	1	0
Nine inches ditto	1	7	0
Ten inches ditto	1	12	0
Twelve inches ditto	2	5	0
Fifteen inches ditto	3	13	6
Eighteen inches ditto	6	6	0
Twenty-one inches ditto	11	11	0
Twenty-four inches ditto	16	16	0
Concave mirrors, ground cylindrically, possessing several curious properties in the deformation of objects, according to the size, from 1l. 1s. to	5	5	0
Concave metal burning mirrors, superior to the glass ones, from 3l. 13s. 6d. to	21	0	0
Glass prisms, plain, or mounted on stands, from 7s. 6d. to	1	11	6
A curious set of optical models, where the rays of light are represented by silken strings, and illustrating the principles of vision, telescopes, prisms, &c. packed in five cases	6	16	6

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THEODOLITES of the common construction, and of the best workmanship, from 4l. 4s. to	31	10	0
A portable theodolite, with a telescope, level, and vertical arch	7	7	0
Ditto larger, with parallel plates, &c. divided to two minutes	12	12	0
Ditto with rack-work motions, divisions to a minute	22	1	0
A new-improved theodolite, with two telescopes, and contrivances for every accurate adjustment	36	15	0
A new very portable theodolite, by rack-work, measuring angles with equal accuracy as those of the common large sort, is at the same time applicable for taking altitudes, and is truly adapted for the purpose of levelling	8	8	0
A 4-inch further improved ditto, by which the vertical and horizontal angles are shewn at the same time, with portable staves, &c.	10	10	0

	£.	s.	d
Circumferentors, much used in wood lands, from 2l. 2s. to	4	4	0
An improved ditto, contrived to answer the purposes of a common theodolite, level, altitude instrument, &c.	4	14	6
Surveying crosses or squares, on a staff, from 12s. to	1	11	6
A brass cylindrical ditto, with a staff	0	18	0
Ditto with compass, agate capped needle, &c.	1	11	6
Improved ditto, with rack-work and pinion, and moveable divided limb, making a very portable cross-staff, compass, and theodolite in one instrument	2	18	0
Levels of the latest improvements, from 2l. 2s. to	12	12	0
Station staves, with sliding vanes, for levelling	2	12	6
Plane tables, with index, sights, &c. complete, from 3l. 13s. 6d. to	5	5	0
Pentagraphs, by which any person unskilled in drawing may copy plans, surveys, profiles, drawings, &c. in any proportion to the original, from 1l. 16s. to	6	16	6
Perambulators or measuring wheels, from 6l. 6s. to	10	10	0
Gunter's measuring chain, according to strength, from 5s. to	0	11	0
——— navigation scale, from 2s. to	0	4	0
——— ditto improved by Donn, with book of directions	0	5	0
——— ditto improved by Robertson, with brass adjusting screws, &c. being the completest scale of the kind	1	10	0
——— sectors of various lengths, from 2s. to	1	11	6
A new pocket ten inch box sliding rule for solving all sorts of problems in trigonometry, &c. from 2s. 6d. to	0	4	0
Measuring tapes, one, two, three, and four poles, 5s. 7s. 6d. 9s.	0	10	6
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Miner's compasses, for working in subterraneous grounds, from 10s. 6d. to	1	11	6
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Parallel rulers of different constructions, from 2s. to	2	12	6
Protractors for laying down angles, from 2s. to	1	1	0
Ditto, with a nonius and moveable limb	2	2	0
Ditto, ditto, with teeth and pinion	4	10	0
Sets of protracting and plotting scales; instruments for dividing lines or transferring divisions on paper. An instrument for describing circles from four to six inches radius,			

	£.	s.	d.
or to the utmost conceivable distance—Gunners callipers—Gunners levels or perpendiculars—Shot gauges—Shell ditto—Gunners quadrants, with a plummet or level, or adjusting screw, &c. and all other instruments for military purposes.			
Hadley's Quadrants, mahogany, the divisions on wood	1	11	6
Ditto mahogany with ivory arch and nonius, double observation	2	2	0
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Ditto, ebony and brass, best glasses, engine divided, &c. ..	3	0	0
Ebony and brass mounted best sextants, from ~~4l. 4s.~~ to ..	8	18	6
Metal ditto, all brass, framed on a principle the least liable to be warped or strained, with adjusting screws, telescopes, and other auxiliary apparatus, the most proper for taking distances accurately, to determine the longitude at sea, &c.	12	12	0
Ditto, second best	8	8	0
A new small 3-inch pocket box sextant to take angles to a minute, from 2l. 2s. to	3	3	0
Artificial horizons, by parallel glasses and quicksilver, to take double altitudes by	1	16	0
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Ditto seven inches	0	16	0
Ditto eight inches, into two minutes	1	4	0
Ditto ten inches, ditto	1	16	0
Ditto twelve inches, ditto	2	10	0
Ditto fifteen inches, into every minute, thirty-two points of the compass, &c.	4	14	6
Ditto eighteen inches, ditto, ditto, with equation table, &c.	8	8	0
Ditto 2 feet diameter, ditto, ditto	15	15	0
A new universal ditto and equatorial, making a very portable angular instrument, from 8l. 8s. to	31	10	0
Universal ring dials, from 7s. 6d. to	10	10	0

For a general description and representation of the instruments used in surveying, levelling, and other branches of practical geometry, see the late Mr. G. Adams's Geometrical and Graphical Essays, *an improved edition by* W. Jones, *in two vols. 8vo. 1797, with thirty-five folio copper-plates. Price 14s.*

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A portable Transit Instrument, with a cast iron stand, to ascertain the rate of chronometers, the longitude, &c. the axis is twelve inches in length, and the telescope about twenty inches, packed in a case	12	12	0
Ditto, with a brass framed stand, and other additions	20	0	0
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The new Circular Instruments and Equatorials, from 63l. to	180	0	0
Planetariums, shewing the phænomena of the Ptolemaic and Copernican systems, from 7l. 7s. to	50	0	0

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Manual orreries of the common construction from 2l. 12s. 6d to	6	6	0
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Tellurian and planetarium together, making the *New Portable Orrery*, packed in a neat mahogany box, according to the sizes, from 2l. 12s. 6d. to	5	5	0
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Other planetariums and orreries in great variety, the motions by wheel-work, exemplifying all the motions and phænomena of all the planets, the Georgium Sidus included, from 40l. to	1000	0	0
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Twelve inch ditto, improved by Ferguson, with all the new discoveries of Capt. Cooke, &c. with the new hour circles, which supersede all the intended advantages of cumbersome wires, and other appendages, in other globes, mounted in neat mahogany claw-feet frames	5	5	0
Ditto, in common coloured wood frames	3	3	0
Additional price of a compass, and fitting to both globes.	0	5	0
A pair of red leather covers for the globes	0	9	6
Globes, nine inches diameter, with the new discoveries	2	2	0
Ditto, three inches ditto, in claw-feet, mahogany frames	1	10	0
Ditto, three inches single, one in a case for the pocket	0	9	0
Geographical planispheres, to solve problems, mounted as a hand fire-screen	0	7	6
A brass armillary sphere, three inches diameter	3	3	0
A six inch ditto	6	6	0
A nine inch ditto	9	9	0
A twelve inch ditto	12	12	0
Larger ditto, with planetarium, from 21l. to	105	0	0

For a general description of orreries and other astronomical instruments, see the late Mr. G. Adams's Astronomical Essays, *8vo. with sixteen plates; price* 10s. 6*d.. now sold by* W. *and* S. Jones.

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A single-barrel Air Pump, with receiver	2	12	6
Improved ditto, exhausting more accurately	5	15	6
A small double-barrel air pump, with gage plate	5	5	0
A middle size ditto	6	16	6
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Air pumps of the largest sort, exhausting more accurately, from the constructions of the different inventors..			
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The principal Apparatus for the Air Pump as follow:

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Guinea and feather apparatus, demonstrating the resistance of the air, with one, two, or three falls, from 18s. to ..	1	11	6
A set of wind-mills, for the same demonstration	1	11	6
The brass hemispheres, shewing the air's external pressure, from 14s. to	1	10	0
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Improved constructions of this bell, from 1l. 1s. to	3	3	0
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A copper air-pipe for experiments on infected air	0	17	0
A flat plate, collar of leathers, with sliding wire, for placing on receivers	0	12	0
An apparatus for firing gun-powder in vacuo	0	18	0
A copper bottle, beam and stand, for accurately weighing of air	2	12	6
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Fruit stand	0	3	6
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With a great variety of receivers, and other apparatus, described by various authors.			
Exhausting and condensing syringes, from 10s. 6d. to ..	1	11	6
Exhausting syringes, with sets of cupping glasses, breast glasses, and scarificator, complete	4	14	6
Air fountains of copper, with various jets, from 3l. 13. 6d. to	7	7	0
ELECTRICAL MACHINES, with conductors and jars, from 2l. 12s. 6d. to	10	10	0
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Electrical machines and complete apparatus, for medical purposes, packed in boxes, the cylinder from seven to ten inches diameter, from 6l. 6s. to	12	12	0
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Apparatus for Electrical Machines as follow:

Electrical batteries of combined jars, from 2l. 12s. 6d. to	10	10	0
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An useful and illustrative apparatus, compounded of the luminous conductor, exhausted flask, two jars, exhausted syringe, insulated stand, and wires with balls, &c. complete	3	0	0
Luminous conductors, from 12s. to	1	5	0
Exhausted flasks, called Aurora Borealis	0	6	6
A thunder house, demonstrating the use of conductors	0	6	0
A powder house, for the same purpose	0	16	0
An obelisk or pyramid for ditto	0	10	6
A set of plain bells, three to a set	0	7	6
A new set of musical ditto, containing the gamut	1	10	0
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Spiral tubes, to illuminate by the spark, from 4s. 6d. to	0	10	6
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A double jar for explaining the Franklinian theory	0	15	0
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An artificial spider	0	1	6
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Balls of wood, bone, &c. each from 6d. to	0	2	6
A curious collection of working models, to be set in motion by the electrical fluid, consisting of a corn mill and a three-barrelled water-pump, worked by one crank only: an orrery, shewing the diurnal motion of the earth, age and phases of the moon, &c. and astronomical clock, shewing the aspects of the sun and moon, age, phases, &c. all delicately made of card paper, cork, and wire only, packed in a deal case	2	12	6
Kinnersley's electrical air thermometer	1	1	0
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Ditto, as improved by Saussure	1	1	0
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An electrophorus, from 10s. 6d. to	3	3	0
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A new medical ditto, for communicating shocks in the most convenient and qualified manner	0	7	6
A pair of directors, glass handles, wood points, &c.	0	7	6

	£.	*s.*	*d.*
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Electrical insulated stools and chairs, from 9s. to	5	5	0
A new perpetual inflammable air lamp, lighted by the electrophorus, a curious and useful apparatus	4	4	0
A variety of other apparatus, too numerous to be inserted here, which as well as the machines, are mounted from the most approved, eligible methods, so as to render them in action both powerful and permanent.			

For a complete description of electrical apparatus, see the late Mr. G. ADAMS's Essay on Electricity, *8vo. six plates; price 6s. now sold by* W. *and* S. JONES.

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Six's new thermometers, for shewing the extremes of heat and cold, in the absence of the observer, from 1l. 11s. 6d. to	2	12	6
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Barometers, thermometers, and hygrometers, all in one neat mahogany frame, from 4l. 4s. to	6	6	0
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A rain gauge, with float and tin vessel	0	18	0
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Ditto, in the shape of a horse-shoe, the strongest form, from 1s. 6d. to	1	1	0
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Dipping needles, variation, and other compasses, in great variety.			
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The mechanical powers, for illustrating and demonstrating the laws of motion, gravity, &c. a set neatly made in brass, consisting of the balance, the pullies, the different kinds of levers, the inclined plane, the wheel and axle, the screw, a compound engine, a compound lever, a double cone to move up an inclined plane, friction wheels, weights, wedges, &c. complete	25	4	0
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A whirling table, for explaining and demonstrating the laws of the planet's motion, the demonstrations of the doctrine of the tides, and other properties of gravity and centrifugal force, from 7l. 7s. to	16	16	0
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The sensitive fishes, that have the property of swimming to a piece of bread placed at the end of a stick; and, when the other end is presented, of retreating and going back, sensible, as it were, of no substance for them to eat	0	6	6
The sagacious swan, that with a machine makes three kinds			

	£.	s.	d.
of amusements—1st. the swan will point out the secrets of the cards; 2d. it will point answers to 16 humorous enigmas; and 3d. disclose any particular hour that was thought of, such as going to bed or rising; packed in a case	1	18	0
A box containing four numbers and four letters, the order of which may be discovered, if ever so secretly placed, by means of a curious magic perspective	0	10	6
Ditto with five numbers, no perspective, but another very similar box, made in neat mahogany boxes, and more difficult to discover the reason of	1	18	0
A curious magic oracle, unfolding answers to any proposed questions secretly taken out of a bag	0	16	0
A magic painter, exhibiting a copy of any one of eight different paintings secretly chosen	0	10	6
A communicative mirror, shewing portraits of any one of four secretly chosen; an elegant and curious instrument	2	12	6
A box containing five pieces of different metals, which may any way be secretly placed, and their situation be told by the magical perspective	1	8	0
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