



Strategic growth areas: Biobased Energy and Materials, a role for Marine Biotechnology ?

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DSM: Life Sciences & Material Sciences

Life Sciences



Material Sciences



DSM: Life Sciences & Material Sciences

Life Sciences

World's leading producer of Anti-biotics, Pharma-intermediates, Vitamins and Nutritional ingredients

Involved in fighting 'Hidden hunger'

- Micronutrient (vitamin and mineral) deficiency
- 2 Billion people affected
- Working with: WFP, USAID, Sight & Life

Material Sciences

40+ years in materials experience.

World leader in performance materials for application in Electronics, Sport & leisure, Protection, Automotive, Construction, Energy

- Engineering Plastics
- Fiber Intermediates
- Resins & Functional Materials
- Dyneema®

Global presence



DSM in the news in 2012

- 08/08 DSM acquires nutrition business from [Tortuga](#), a nutritional supplements company from Brazil
- 06/12 DJSI: DSM Awarded Twice for [Sustainability](#) Leadership
- 06/05 DSM [enzymes for cellulosic ethanol](#) qualified by DONG Energy
- 05/30 Brazil's 1st Cellulosic Ethanol Plant using [DSM C5 yeast](#)
- 05/18 [DSM to acquire Ocean Nutrition Canada to expand its Nutritional Lipids growth platform](#)
- 05/03 Announced bid for acquisition Kensey Nash to strengthen DSM [biomedical business](#)
- 03/26 DSM acquires food enzymes business and key technology from [Verenium](#)
- 03/13 Start construction of [advanced bio-fuels plant](#)
- 01/23 [Joint venture POET-DSM](#) Advanced Biofuels

Mission

Our purpose is to create brighter lives for people today and generations to come.

We connect our unique competences in Life Sciences and Materials Sciences to create solutions that nourish, protect and improve performance.



Global societal trends drive DSM's markets



Ageing population

Population growth

Resources constraints

Healthcare costs

Urbanization

Energy security

Food security

Wealth

Sustainability

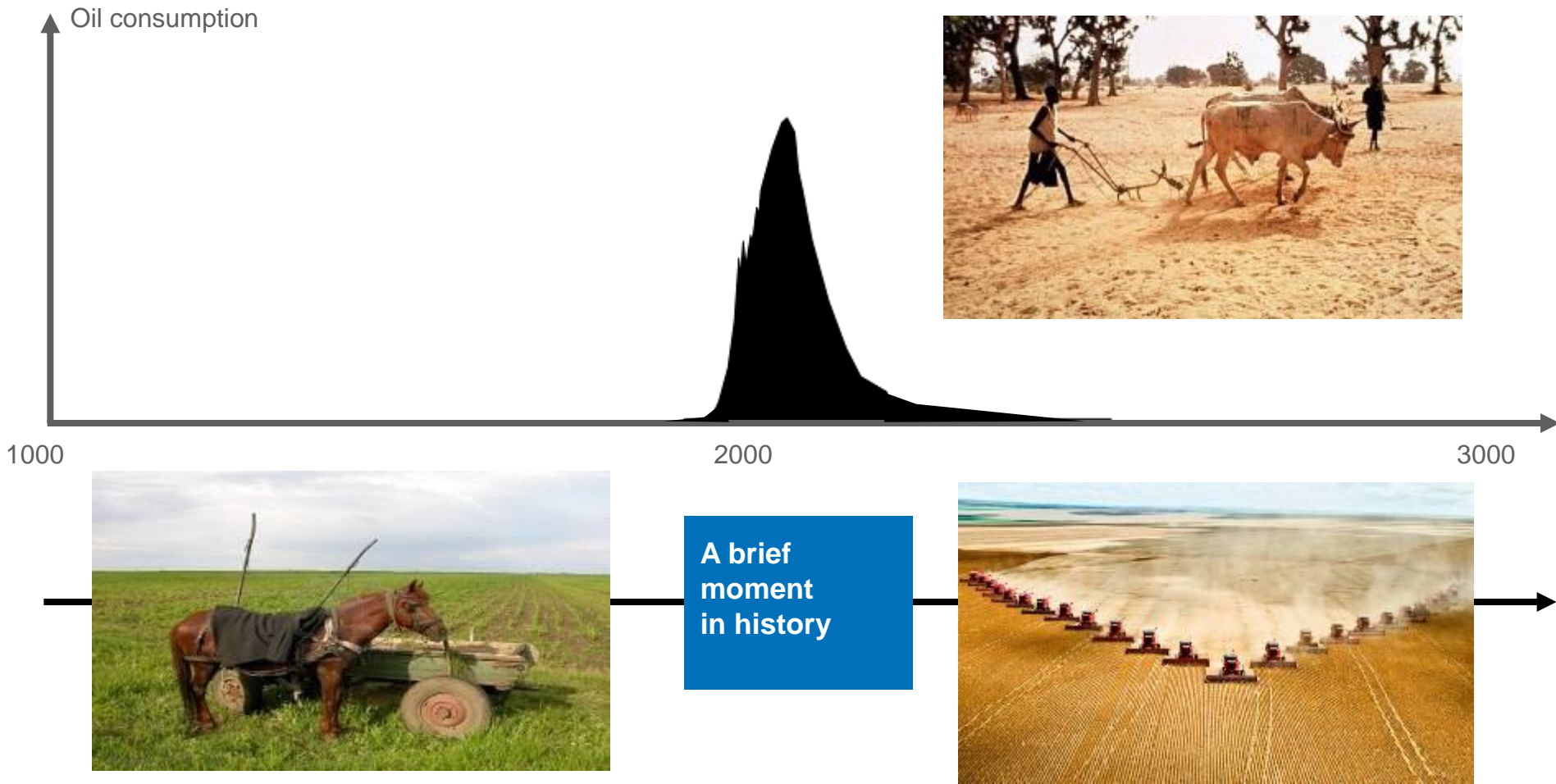
Health

Nutrition

Materials

Oil will Run Out and Biomass is Renewable

Biobased Economy - Back to the future



Key activity areas

Health

Advanced, cost-effective health and medical innovations, and healthier food and beverages, to meet the needs of a growing and ageing global population



Nutrition

World's leading producer of vitamins and nutritional ingredients meeting the growing need for more nutritious and more sustainable food and animal feed



Materials

Enabling lighter, stronger, more advanced and more sustainable performance materials



HEALTH | NUTRITION

Nutrition for all



Combating
vitamin D
deficiency

Feeding the
planet

WFP partnership



World Food
Programme



Improving nutrition. Improving lives.



MATERIALS

More renewable energy

Sustainable
windmill blades

Enabling
wind powered
shipping

Capturing the
power of the sun

Biogas



A need for alternative sources/feedstocks

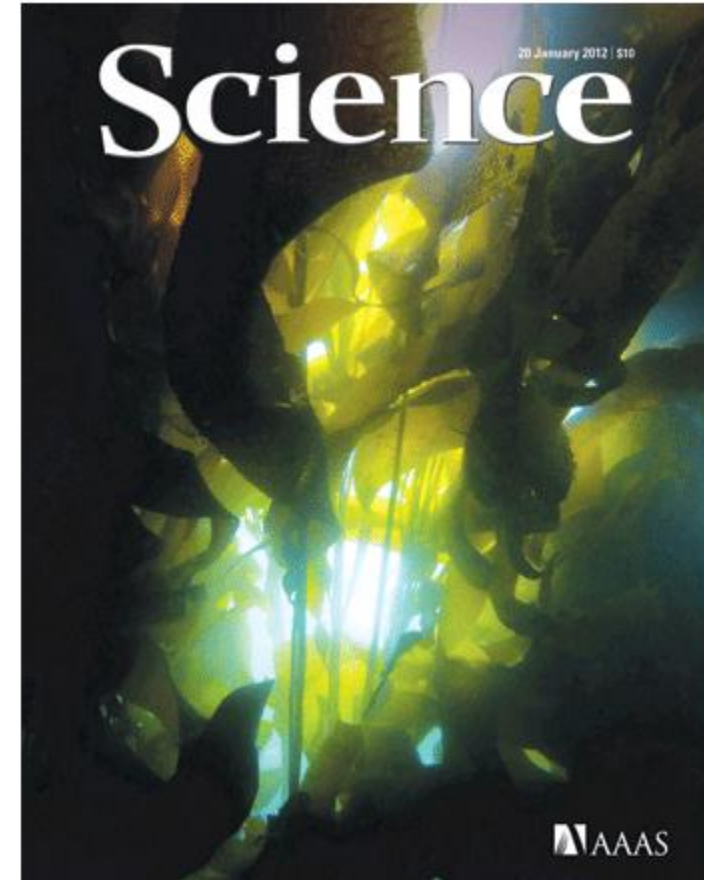


And for third generation biofuels:

Market study, Algae 2020,

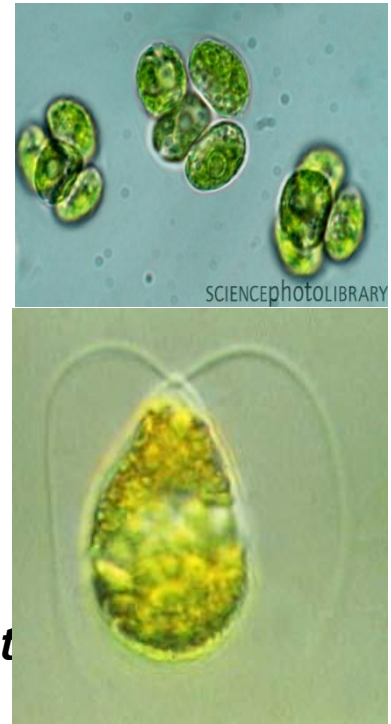
- the seaweed grows faster than terrestrial crops
- has high sugar content for conversion to advanced biofuels and ethanol
- absorbs more airborne carbon than land-based plants
- has no lignin
- requires no pretreatment for ethanol production
- can be harvested up to six times a year in warm climates.

Bio Architecture Lab efficiently converts seaweed to renewable fuels and chemicals by engineered E. coli



The Potential and Promise of Microalgae Production

- ***Microalgae productivities (g/m²/day) can be significantly higher than terrestrial crops***
 - Algae 25-35 g/m²/day vs sugar cane 3-5 g/m²/day
- ***Microalgae does not compete directly with food production***
 - Utilize saline water rather than fresh water
 - Utilize desert/non-agricultural land
- ***Microalgae can directly utilize CO₂ from industrial sources***
- ***Microalgae can exhibit higher production of lipids than traditional crops***



Current Commercial Uses of Microalgae: Human/Animal Nutrition and Health

- **Arthrospira/Spirulina (bluegreen algae) – Whole cell forms**
 - Nutritional supplements/food additive
- **Dunaliella (green algae) – Beta-carotene**
 - Nutritional supplement/food ingredient
- **Haematococcus (green algae) - Astaxanthin**
 - Nutritional supplement/animal feed ingredient
- **Schizochytrium (stramenopile) – DHA & DHA+EPA oils**
 - Nutritional supplements/food ingredient/animal feed ingredient
- **Cryptocodinium (dinoflagellate) – DHA oil**
 - Nutritional supplements/infant formula ingredient
- **Chlorella (green algae) – Tablets/cosmetic oils/veg oil repl.**
 - Nutritional supplement/food ingredient



Current Commercial Production Technology

- **Outdoor Ponds (30,000 mt/yr)**
 - Arthrospira/Spirulina (bluegreen algae)
 - Dunaliella (green algae)
 - Haematococcus (green algae)
 - Chlorella (green algae)
- **Photobioreactors (100-200 mt/yr)**
 - Haematococcus (green algae)
 - Chlorella (green algae)
- **Production costs: \$8-\$80/kg**

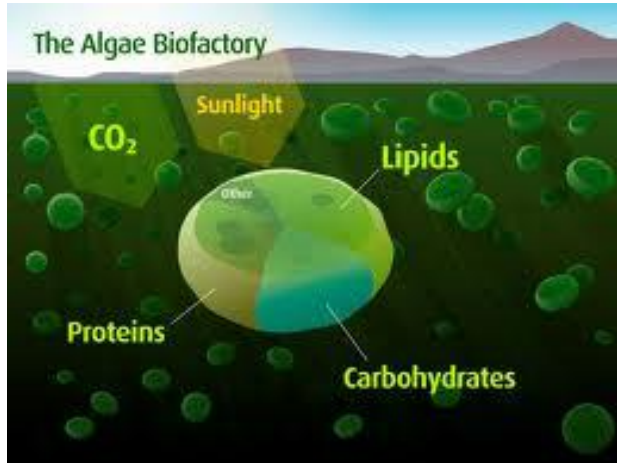


Numerous challenges ahead:

- **Need for new, higher productivity strains**
 - How to effectively isolate/screen
- **Genetic and biotech improvement of strains**
 - Growth performance, culture stability, products
 - Salinity/temp. tolerance and photosynthetic efficiency
- **Novel methods to maintain culture stability**
 - Environmental/strain improvement/system design
- **Novel methods for inducing environmental stress**
 - Triggers for product formation
- **Methods for maximizing GHG abatement potential**
- **Novel engineering designs for ponds/PBRs**
- **Opportunities for co-process integration**
- **Low cost harvesting technologies**



An integrated (micro/macro) algae biorefinery is needed



Make use of **existing competences** in the field of biotechnology in europe !

- integrate** into existing value chains
- build** on proven technology
- involve** all stakeholders
- know** your markets

DSM Bio-based Products & Services

An example to illustrate integrated sustainable biotechnology.....

DSM Bio-based Products & Services will be a leading integrated technology provider for Advanced Bio Energy and a developer and producer of Bio-based Chemicals & Polymers

Shaping our Plans: from Vision to Business

Bio-based Products & Services



- Cellulosic Bioethanol
- Biogas
- Microbial Biodiesel

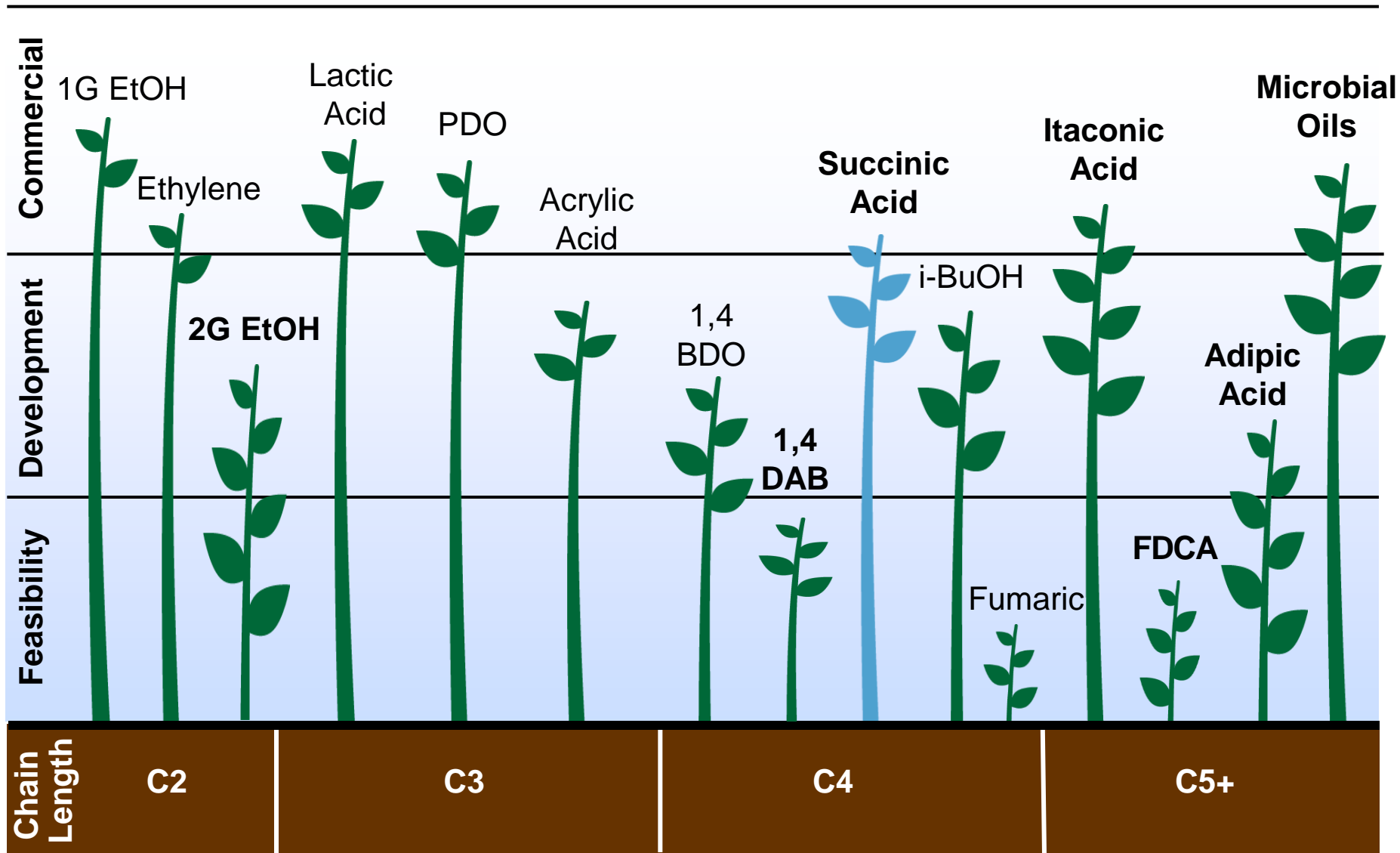
- Biosuccinium™ succinic acid
- Bio-based Adipic Acid
- Emerging Portfolio

Joint Ventures drive commercialization:



Growing a Biobased Chemicals Industry

not exhaustive / stages estimated

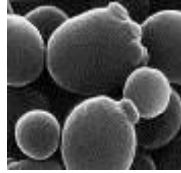


Succinic Acid - Technology Choices

- Ideal Process (economics, sustainability, product quality): yeast at low pH producing the acid
- Business model: production partnership, amenable to licensing model

Bacterial Processes Versus Yeast

Process Technology as a Starting Point:
low pH (yeast) process has significant advantages



Yeast



Bacteria

| | | Yeast | Bacteria |
|------------------|----------------------------------------|-------|----------|
| Fermentation | Production at pH 3 | ● | ● |
| | Robustness / phage infection | ● | ● |
| Recovery | Product purity | ● | ● |
| | No waste salts | ● | ● |
| | Simple purification | ● | ● |
| Carbon footprint | Compared to petrochemical | ● | ● |
| Economics | COGs at regular large scale production | ● | ● |

Providing our customers:

- consistent high quality product
- best sustainability performance
- best economics
- Strong alternative for petrobased building blocks



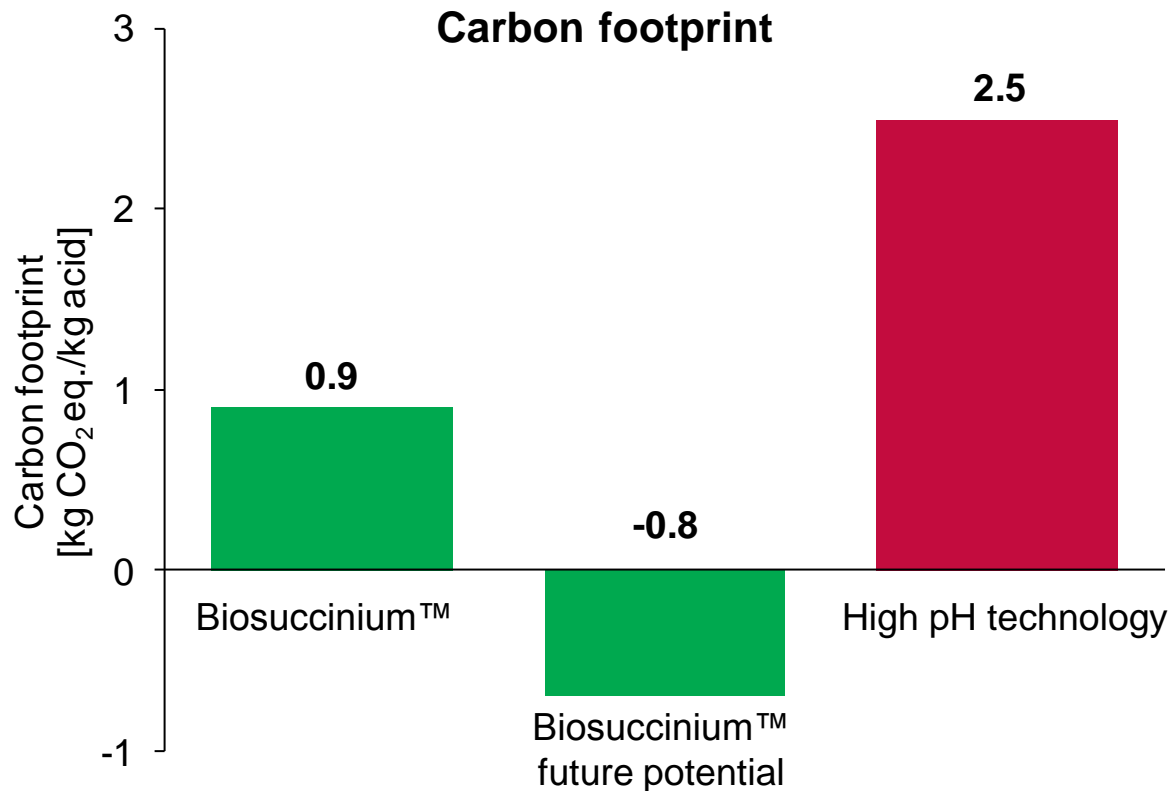
Reverdia: Reliable Biosuccinium™ Supply

Building on the Innovative Strengths
and Experience of Our Parents



Biosuccinium™ - Best-in-class Carbon Footprint

Low pH Biosuccinium™ process outperforms competing bacterial processes



Executed by Copernicus Institute
Data pending publication

Biosuccinium™ Key Applications

Packaging



- PBS
 - Food packaging
 - Cutlery and utensils
 - Disposable cups and lids
 - Shopping bags

Industrial



- PU foams
 - Insulation
- TPU
 - Building and construction
 - Mining equipment
- Plasticizers
- Pigments
- Resins
 - Coatings
 - Composites

Sports and Footwear



- TPU and PU
 - Footwear
 - Outdoor garment
- Spandex / Elastane
 - Apparel
- PBS
 - Packaging
 - Buttons
 - Plastic parts

Non-wovens and Fibers



- PBS
 - Diapers
 - Hygiene products
 - Fishing lines and nets

Automotive



- PU foams
 - Seats
- TPU
 - Interior and sealing
- PBS
 - Interior

Agricultural

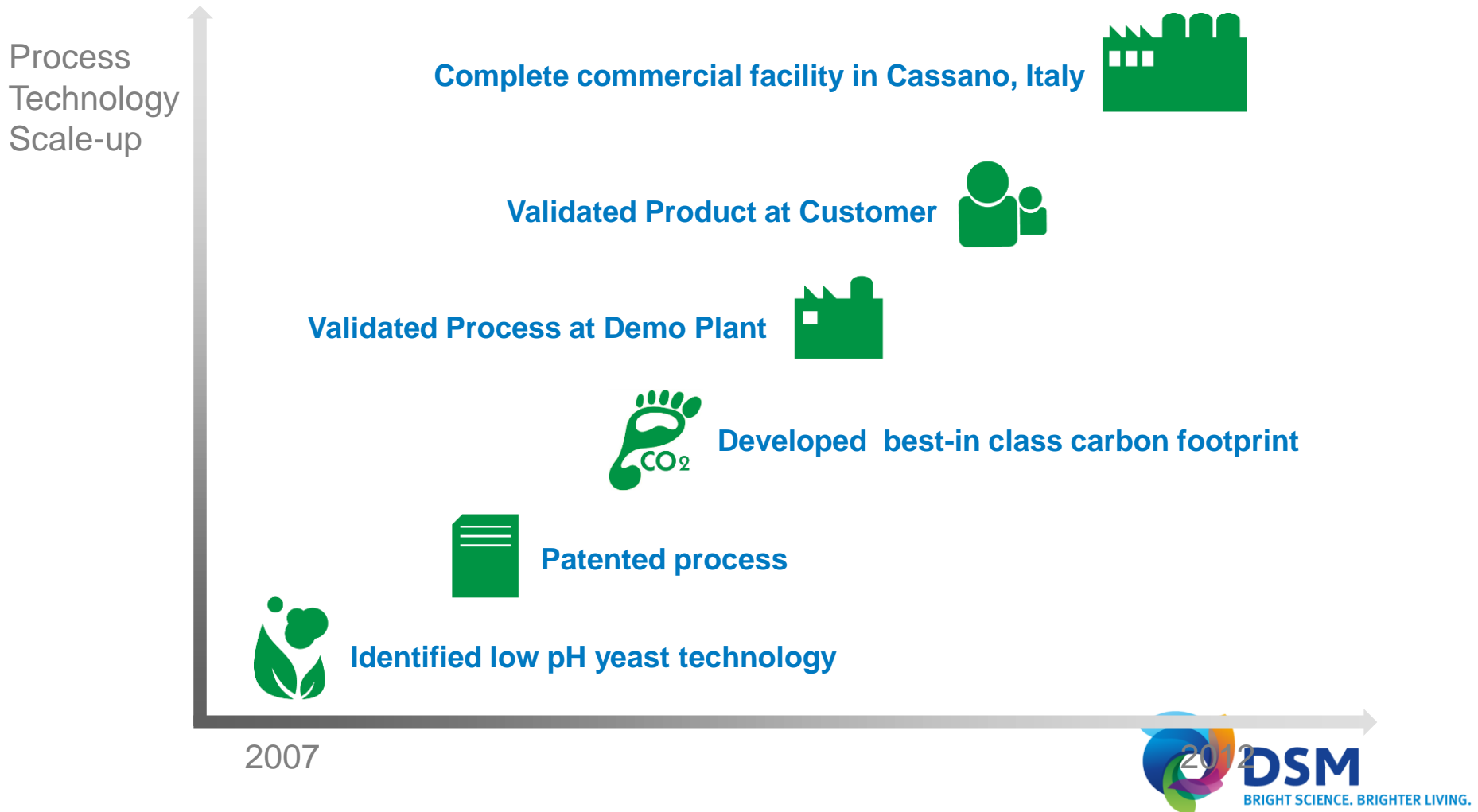


- PBS
 - Mulch films
 - Plant pots

TPU = thermoplastic polyurethane; PU = polyurethanes;
 PBS = polybutylene succinate: new biopolymer; Spandex / Elastane = elastic fibers

Consistent, Superior, Unique Low pH Yeast Production Technology

Same process used throughout scale-up with only quality improvements



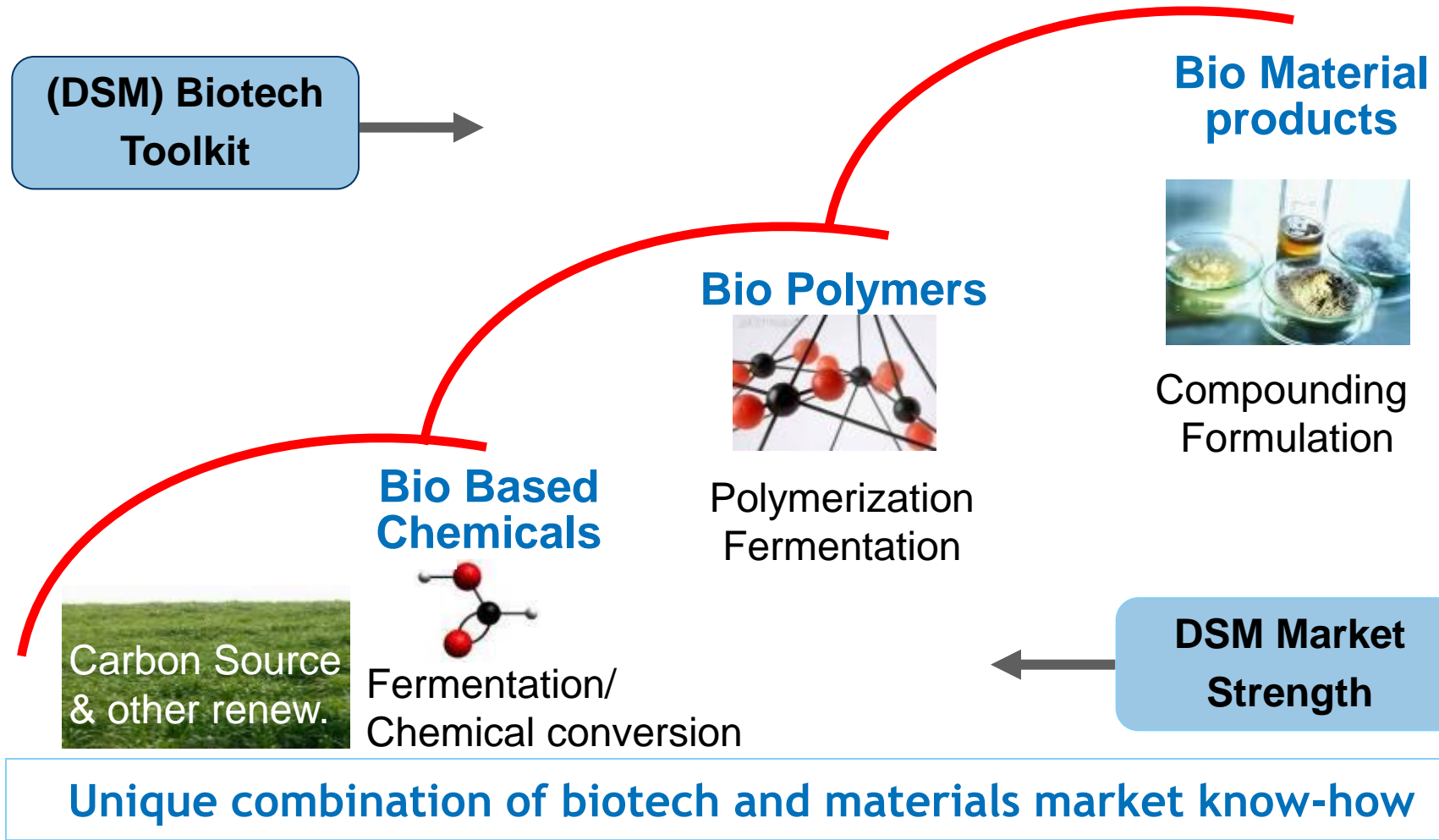
Reverdia Commercial Plant

Cassano Spinola, Italy

On schedule to be operational by end of Q3 2012



The Bio Materials Value Chain is emerging



Conclusion:

- DSM is a game changer: Biobased Economy is here to stay.
- Potential for new algae-based (nutritional) technologies is great
- **Patience** is necessary as challenges are large
- Game-changing technologies will take time to develop - **this is not the internet!**
- Near term future: high value products (carotenoids, pigments, PUFA's), long term future: commodities (biodiesel, proteins for feed)
- Successful integration of biology and engineering techniques will be one of the major keys to success



BRIGHT SCIENCE. BRIGHTER LIVING.™