Algae Market and Value Chains

28 – 30 November 2023

EUROPEAN ALGAE BIOMASS ASSOCIATION

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SUMMARY

What are algae?

ALGAE AND TAXONOMY

Algae is a **common name** for a group of taxonomically unrelated organisms sharing a number of traits.

Algae include cyanobacteria, eukaryotic microalgae and seaweeds.

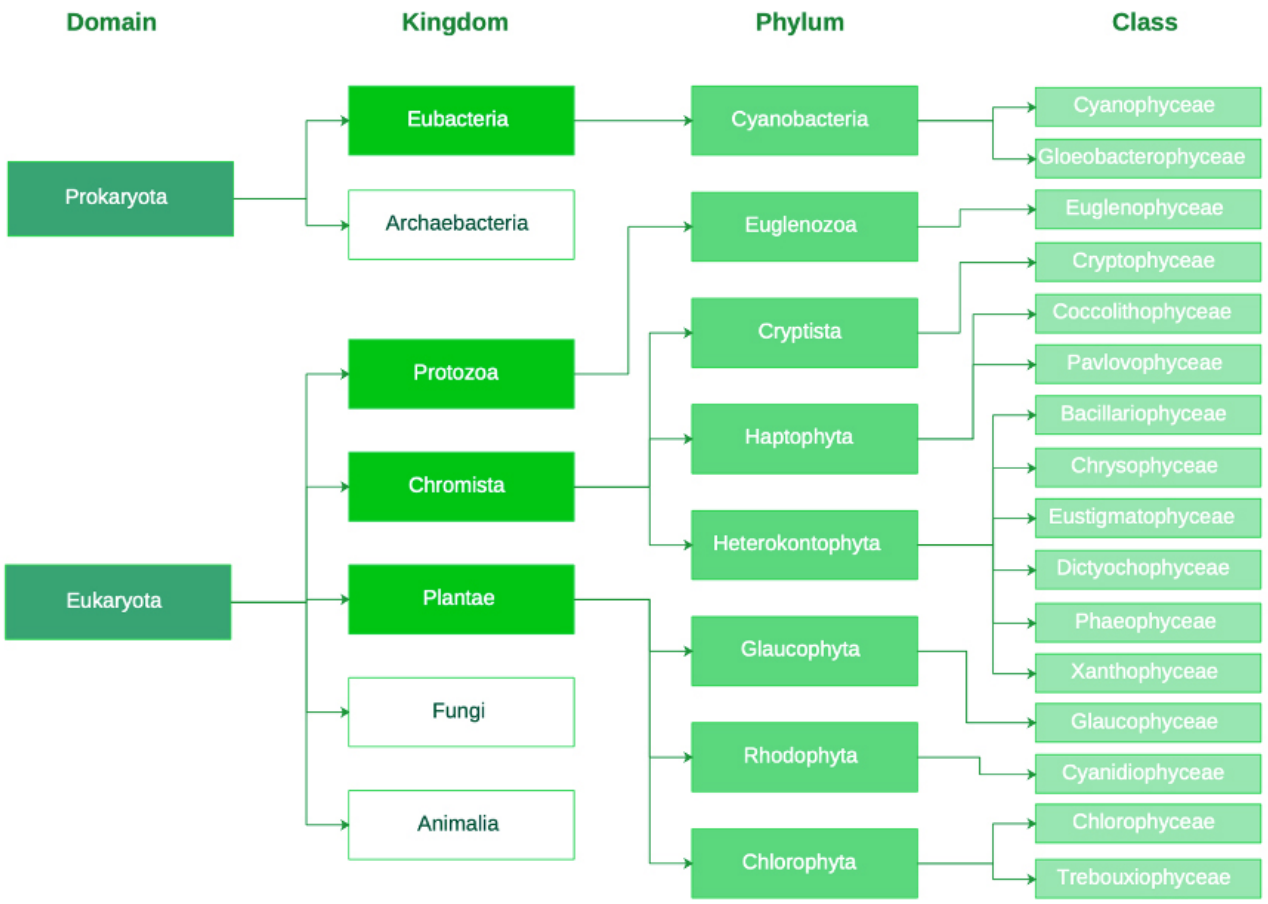
Common traits are:

- Oxygenic photosynthesis
  (use of visible light to fix CO_2 with O_2 release);
- Chlorophylls as main photosynthetic pigment;
- Lack of differentiated tissues;
- Primary producers in aquatics ecosystems.

There are exceptions because some algae can grow in the dark using simple organic compounds and some algae do not possess photosynthetic organelles so are unable to perform photosynthesis.

Alison G. Smith, Mario R. Tredici, Sammy Boussiba, Vítor Verdelho, Jean-Paul Cadoret, Matthew P. Davey, Maria Huete-Ortega, Francisco Gabriel Acien, Ulrike Schmid-Staiger, Herminia Rodriguez, John Benemann, Stefan Leu, Rodolfi, Natascia Biondi, Lisandra Meinerz (2021) **What are algae?** EABA Position Paper **www.what-are-algae.com** (2015-2019)

Adapted from:
A review of high value-added molecules production by microalgae in light of the classification Wendie Levasseur, Patrick Perré, Victor Pozzobon (2020) Biotechnology Advances, Vol. 41, July–August. https://doi.org/10.1016/j.biotechadv.2020.107545



Major microalgae phyla distribution as per seven-kingdom classification scheme inspired from (20) with classes used for various biotechnological applications| (20) Michael A. Ruggiero, Dennis P. Gordon, Thomas M. Orrell, Nicolas Bailly, Thierry Bourgoin, Richard C. Brusca, Thomas Cavalier-Smith, Michael D. Guiry, and Paul M. Kirk. **| A Higher Level Classification of All Living Organisms. *PLoS ONE*, 10(4), April 2015. ISSN 1932- 6203**.

1.

THE INDUSTRY STATUS

Algae production

MACROALGAE

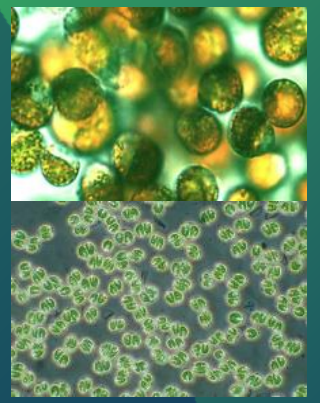
- Cultivation in the ocean
- Cultivation in ponds
- Harvesting from nature

> **Multicellular**
> **biochemical composition**

10-25% protein
30-50% carbohydrates
0.5-5% lipids
< 40 meter size

M ICR OA LGA E

- Cultivation in open systems
- Cultivation in photobioreactors
- Cultivation in fermentors



> **Unicellular**
> **biochemical composition**

30-70% protein
10-30% carbohydrates
10-50% lipids
< some rich in ω−3 fatty acids
< 1 µm = 1 meter/1000 size

René Wijffels (2019)

1.2.

THE GLOBAL ALGAE PRODUCTION

EUROPEAN ALGAE
BIOMASS ASSOCIATION

Meticulous RESEARCH
TRANSFORMING REVENUES SINCE 2010

ALGAE BIOMASS MARKET ASSESSMENT

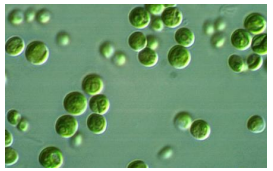
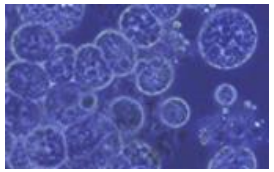
Presented by : **Vitor Verdelho ,** General Manager, EABA

in Collaboration with **Meticulous Research**

www.meticulousresearch.com

Algae biomass sub-sectors and value-chain

Global numbers from database analysis and consensus evaluation with EABA members

	BIOMASS PRODUCTION	PROCESSED BIOMASS (MOSTLY EXTRACTS)	CONSUMER PRODUCTS ****
Sunlight grown MICROALGAE (autotrophic) 	**WORLD** 150.000 ton /year DW 2.5 b€/year 25.000 jobs **EUROPE** 1.000 ton /year DW 20 M€/year 4.500 jobs	**Mostly Astaxanthin, Phycocyanin, Beta-carotene** **WORLD** 3.000 ton /year DW 1.5 b€/year > 5.000 jobs **EUROPE** 100 ton /year 50 M€/year > 500 jobs	**WORLD** from 100% to 1% but average 3% +30 b€/year **EUROPE** +200 M€/year
Fermentation grown MICROALGAE* (heterotrophic) 	**Values for 2021** **Mostly *Schizochytrium* and *Chlorella*** **WORLD** 55.000 ton /year DW 200 M€/year 500 jobs **EUROPE**** 2.000 ton /year DW 10 M€/year 70 jobs	Mostly EPA, DHA oils from *Schizochytrium* **WORLD** 30.000 ton /year DW 400 M€/year 500 jobs **EUROPE**** 20.000 ton /year 300 M€/year 400 jobs	**WORLD** from 100% to 1% but average 5% +1.7 b€/year **EUROPE** +800b€/year
MACROALGAE (Seaweeds) 	**WORLD** 1.000.000 ton /year DW 10 b€/year +300.000 jobs **EUROPE** 50.000 ton /year DW 50 M€/year 3.500 jobs	Mostly agar and carrageenans **WORLD** 100.000 ton /year DW 800 M€/year > 3.000 jobs **EUROPE**** 1.000 ton /year*** 30 M€/year > 500 jobs	**WORLD** from 100% to 1% but average 10% +3.2 b€/year **EUROPE** +120 M€/year 500 jobs

VALUES FOR 2019

(*) includes the Labyrinthulomycetes; (**) European companies, eventually not produced in Europe; (***) not including 7.000 Maerl (*Litothamnium*); (****) On average price doubes in each step in the value chain = +2 steps between Processing and Consumers.

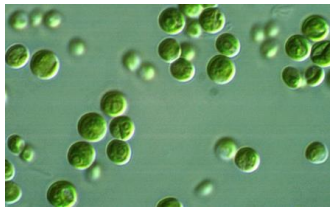
Adapted from: Araújo, R. Current Status of the Algae Production Industry in Europe: An Emerging Sector of the Blue Bioeconomy. Front. Mar. Sci., 27 January 2021 | https://doi.org/10.3389/fmars.2020.626389

DW Dry Weight / WW Wet Weight

Algae biomass production: relevance of different species

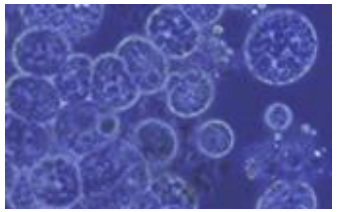
This table aims to provide the understanding about the **order of magnitude**

Sunlight grown MICROALGAE (autotrophic)



EUROPE	ton. DW/year **2018**	WORLD	ton. DW/year **2018**
Arthrospira (spirulina)	***130***	***Arthrospira platensis, A. maxima (spirulina)***	***> 40 000***
Chlorella vulgaris, C. pyrenoidosa, C. luteoviridis	*80*	***Chlorella***	*20 000*
Haematococcus pluvialis	*80*	***Aphanizomenon***	*2 000*
Nannochloropis oculata, N. oceanica	*70*	***Haematococcus***	*500*
Dunaliella salina	*40*	***Dunaliella***	*500*
		Nostoc	*200*
		Euglena	*200*
		Nannochloropsis	*50*

Fermentation grown MICROALGAE* (heterotrophic)



EUROPE	ton. DW/year **2020**	WORLD	ton. DW/year **2020**
Schizochytrium	VALUES UNDER EVALUATION	***Schizochytrium***	VALUES UNDER EVALUATION
Chlorella		***Chlorella***	
Galdieria		***Euglena***	
		Chlamydomonas	
		Galdieria	
	Total 2.000		Total 55.000

DW Dry Weight / WW Wet Weight

Most relevant species

Algae biomass production: relevance of different species

This table aims to provide the understanding about the **order of magnitude**

MACROALGAE
(Seaweeds)

EUROPE

ton. WW/year **2019**

WILD POPULATION CAPTURE

Laminaria (L. digitata, L. hyperborea)	**195 000**
Ascophylum nodosum	**78 500**
Lithothamnium calcareum / Phymatolithon purpureum	**50 000**
Ulva, (U. lactuca, U. Rigida)	**6 000**
Gelidium, sesquipedale, royale	**4 000**
Fucus (F. serratus, vesiculosus)	**600**
Palmaria palmata	**430**
Chondrus crispus and Mastocarpus stellatus	**400**
Himanthalia elongata	**150**
TOTAL (based on Wet Weight values)	333 919
TOTAL (based on Dry Weight values)	50 000

SEAWEED AQUACULTURE

Saccharina latissima	**510**
Undaria pinnatifida	**300**
Alaria esculenta	**400**
Gracilaria gracilis	**100**
Ulva (U. lactuca, U. Rigida)	**50**
Asparagopsis (A.taxiformis, A. Armata)	**20**
TOTAL in Wet Weight (ton. WW)	1 270
TOTAL in eq. Dry Weight (ton. DW)	202

CULTIVATION

WORLD

ton. **WW**/year **2019**

Saccharina japonnica	**11 448 300**
Eucheuma	**9 397 500**
Gracilaria	**3 454 000**
Kappaphycus, alvarezii	**1 597 000**
Undaria, pinnatifida	**2 320 000**
Porphyra	**2 872 000**
Lessonia	**300 000**
Sargassum fusiforme	**268 700**
Ascophylum	**80 000**
Macrocystis	**50 000**
Sarcothalia	**30 000**
	31 867 500

WORLD ALGAE BIOMASS PRODUCTION

SEAWEED

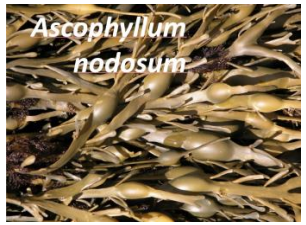
BUSINESS (1):	> 2.500
TURNOVER:	> 10 b€/year
GROWTH:	> 8%/year
PRODUCTION:	> 8.000.000 ton./year fresh bulk (10% DW)
JOBS:	> 250.000 (labor intensive, low tech cultivation)

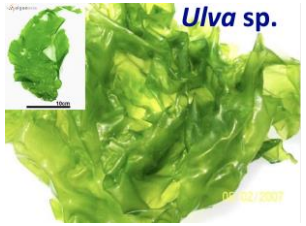
DW Dry Weight / WW Wet Weight

Most relevant species

M A CR OA LGA E

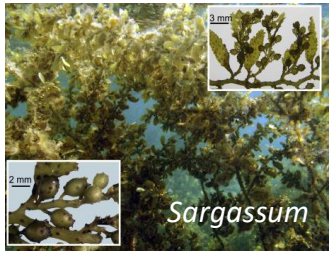
Macroalgae harvested from wild stocks in **Europe**

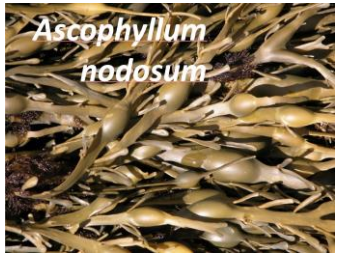




Macroalgae cultivated in **Europe**

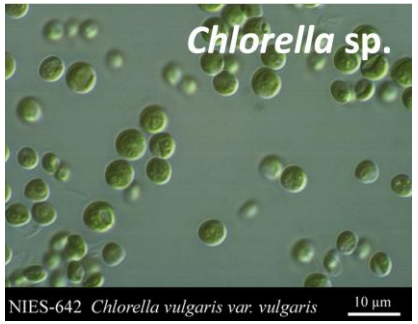
Macroalgae cultivated around the **World**

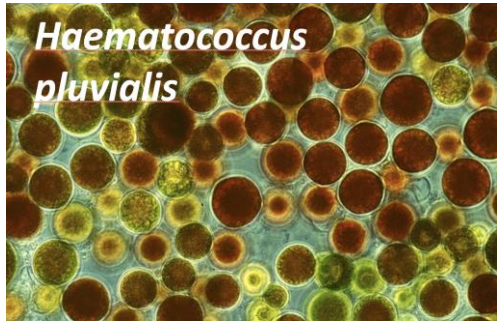


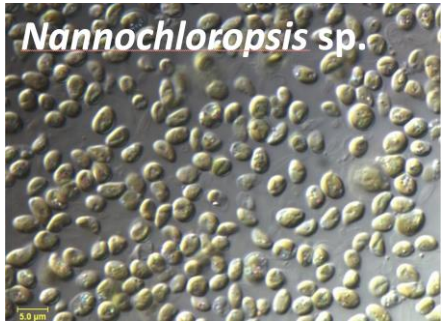


MICROALGAE

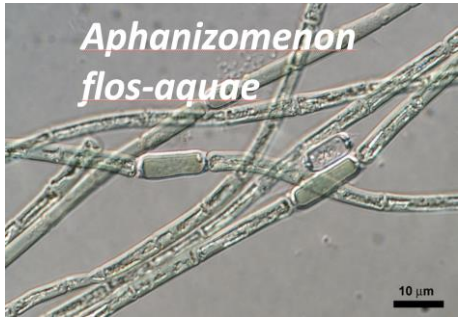
Autotrophic microalge produced in **Europe** in photobioreactors and raceways

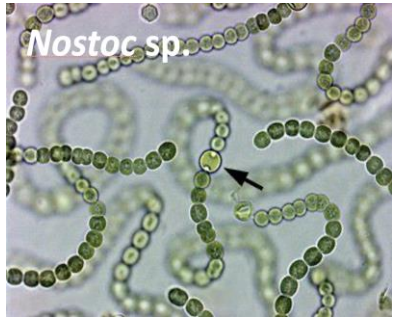


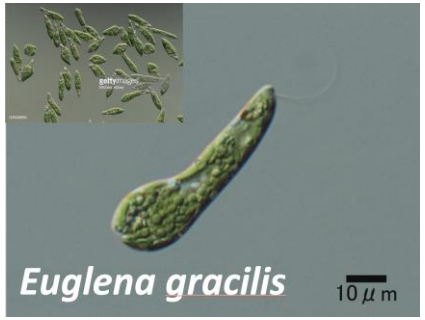


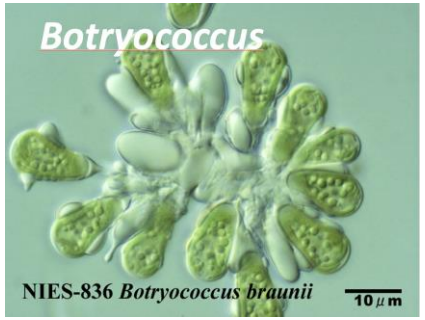


Autotrophic microalge in the world additionally to the genera poduced in **Europe**

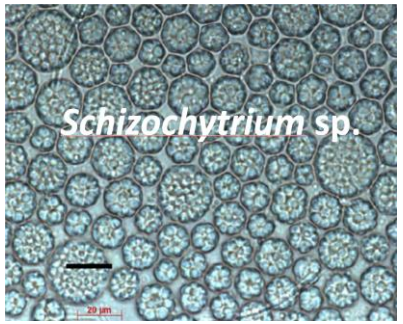


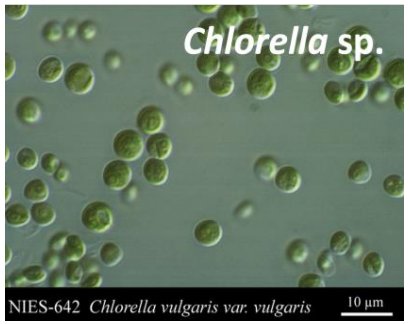


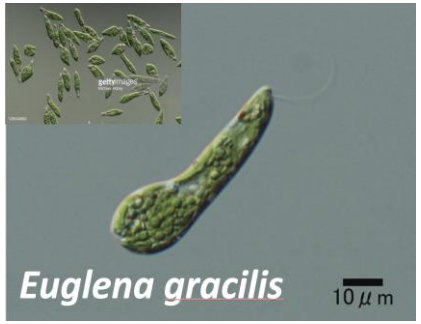


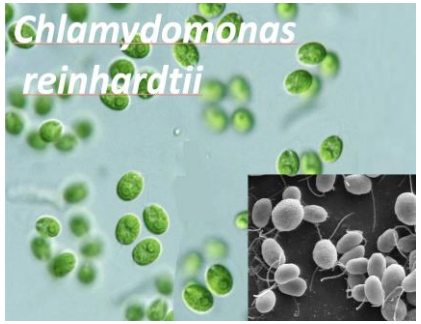


Heterotrophic microalge in **world** produced with fermentation









2.

MARKET APPLICATIONS

Applications

Food ingredients
Healthfoods

FOOD

Premix feeds
Specialty feeds

FE E D

Nutraceuticals
Pharmaceuticals

H E A LT H

Cosmeceuticals
Thalassotherapy

COSMETICS

Biofuels
CO_2 mitigation

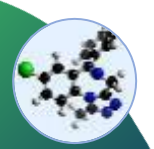
FU E LS

Biofertilizer
Soil microalgae

S OIL

N&P removal
Bioremediation

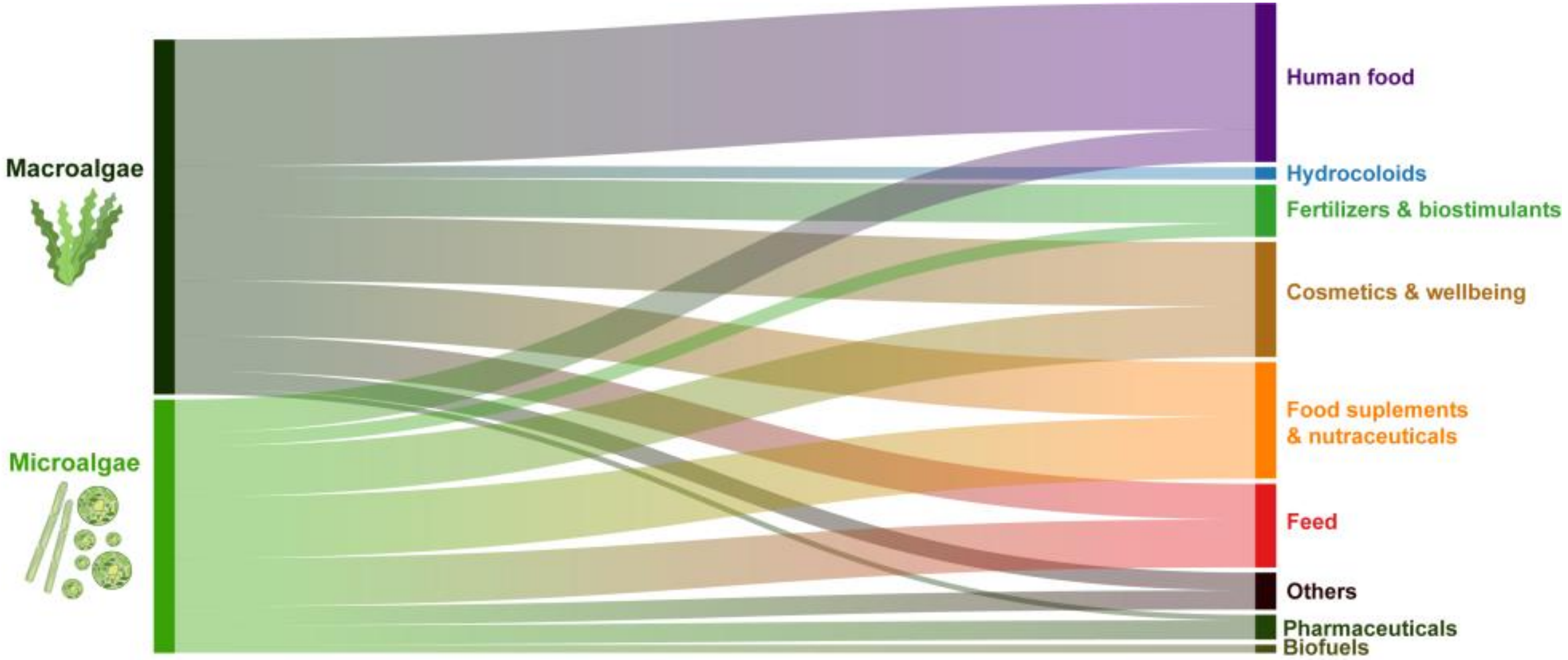
WA S T E WA T E R



Biofibers
Chemical industry

CHEMICALS

Macro and microalgae have similar applications



EABA
EUROPEAN ALGAE BIOMASS ASSOCIATION

Algae in Products today

MICROALGAE

WASTEWATER

CHEMICALS

SOIL

FEED

FOOD

COSMETIC

PHARMA

FUELS

MACROALGAE

3.

VALUE CHAINS

The product or service value depends on “value-chain” Position

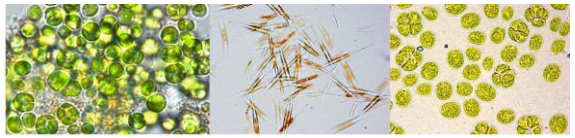
Value-chain analysis is a complex topic very often mentioned by non-experts that bring a highly confusing, misleading and unclear approach.

Business value chain

≠

Product value chain

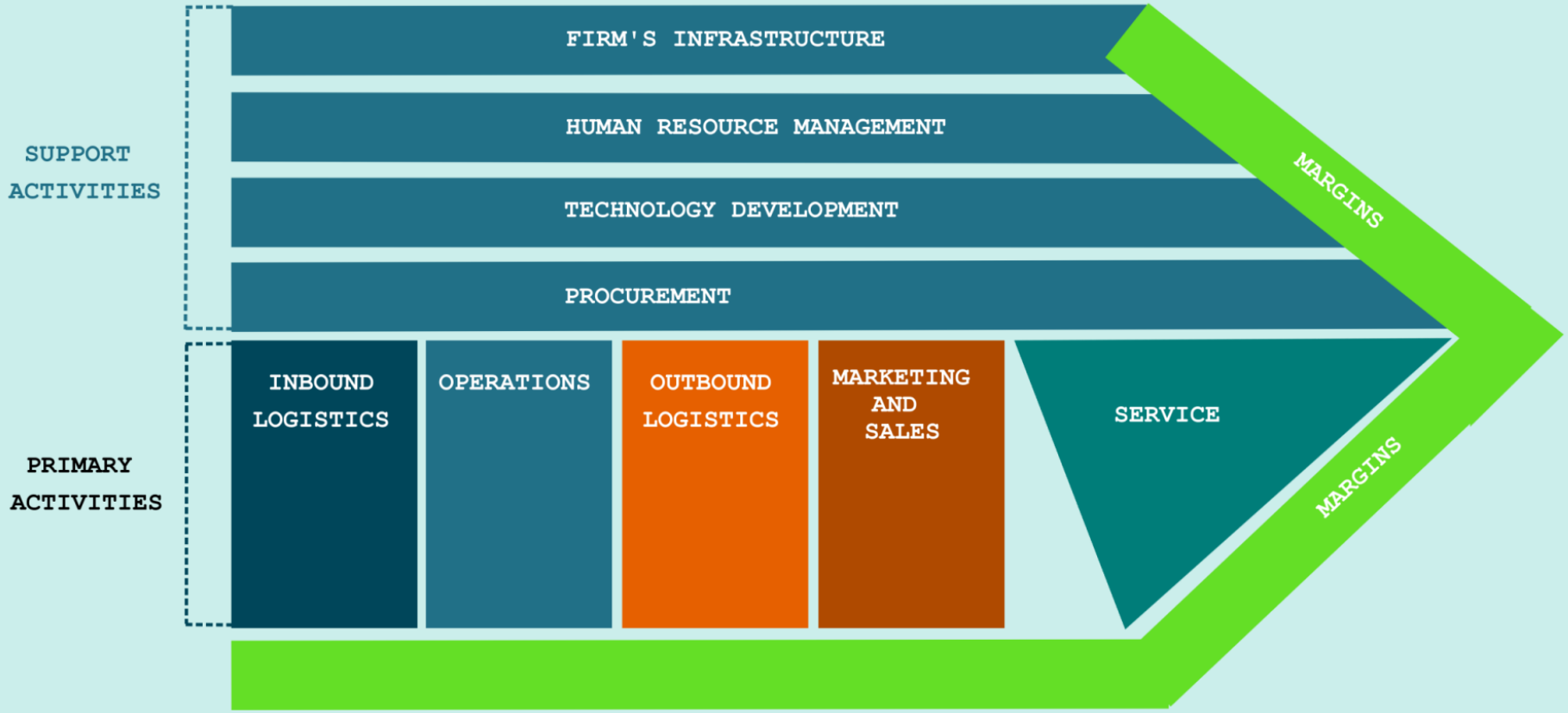
The 'value-chain' is defined in a business context as:
"the interrelated operating activities businesses perform during the process of converting raw materials into finished products".



The concept comes from business management and was first described and popularized by Michael Porter in his 1985 best-seller (Competitive Advantage: Creating and Sustaining Superior Performance).

Porter's Value Chain Model In A Nutshell

In his 1985 book Competitive Advantage, Porter explains that a value chain is a collection of processes that a company performs to create value for its consumers. As a result, he asserts that value chain analysis is directly linked to competitive advantage. Porter's Value Chain Model is a strategic management tool developed by Harvard Business School professor Michael Porter. The tool analyses a company's value chain – defined as the combination of processes that the company uses to make money.



https://fourweekmba.com/porters-value-chain-model/

Value depends on formulation

Product Value Chain

Increasingly Market Driven

- ALGAE (LOW PROCESSING)
- ALGAE BIOMASS
- BIOREFINERY CONCEPT

there are only 3 product types common to micro and macroalgae

1

Paste (*)
- Aquaculture
- Fertilizers

2

Dried (**)
- Food & Feed
- Aquaculture
- Ceuticals
- Fertilizers

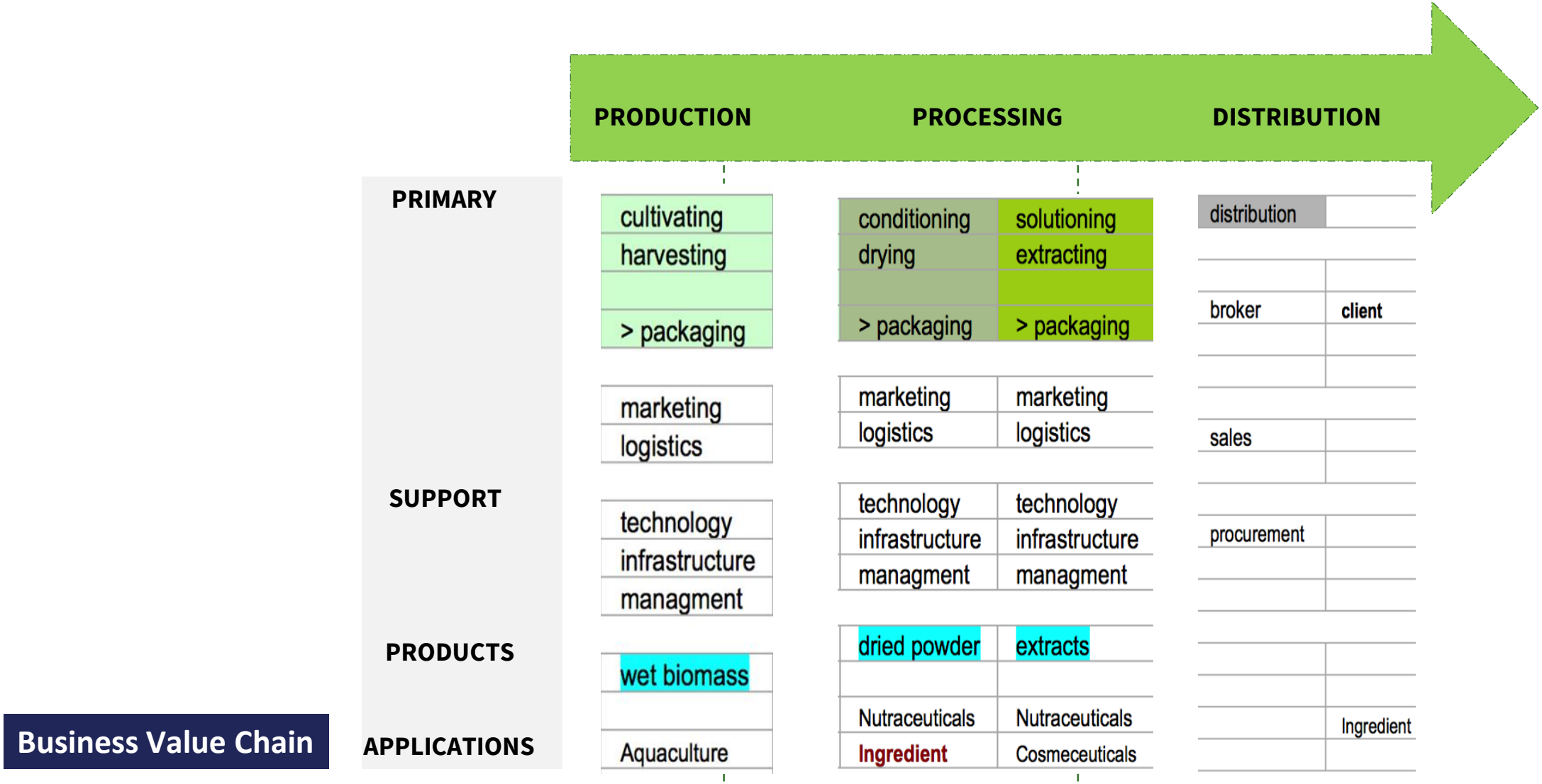
3

Extracts
- Ceuticals
- Fertilizers

(*) paste **microalge** algae can be in liquid for, live, also frozen; **seaweed** can be fresh and fermented
(**) dried include solar dried, spay-dried, drum-dried or freeze-dried

Value-chain for microalgae biomass

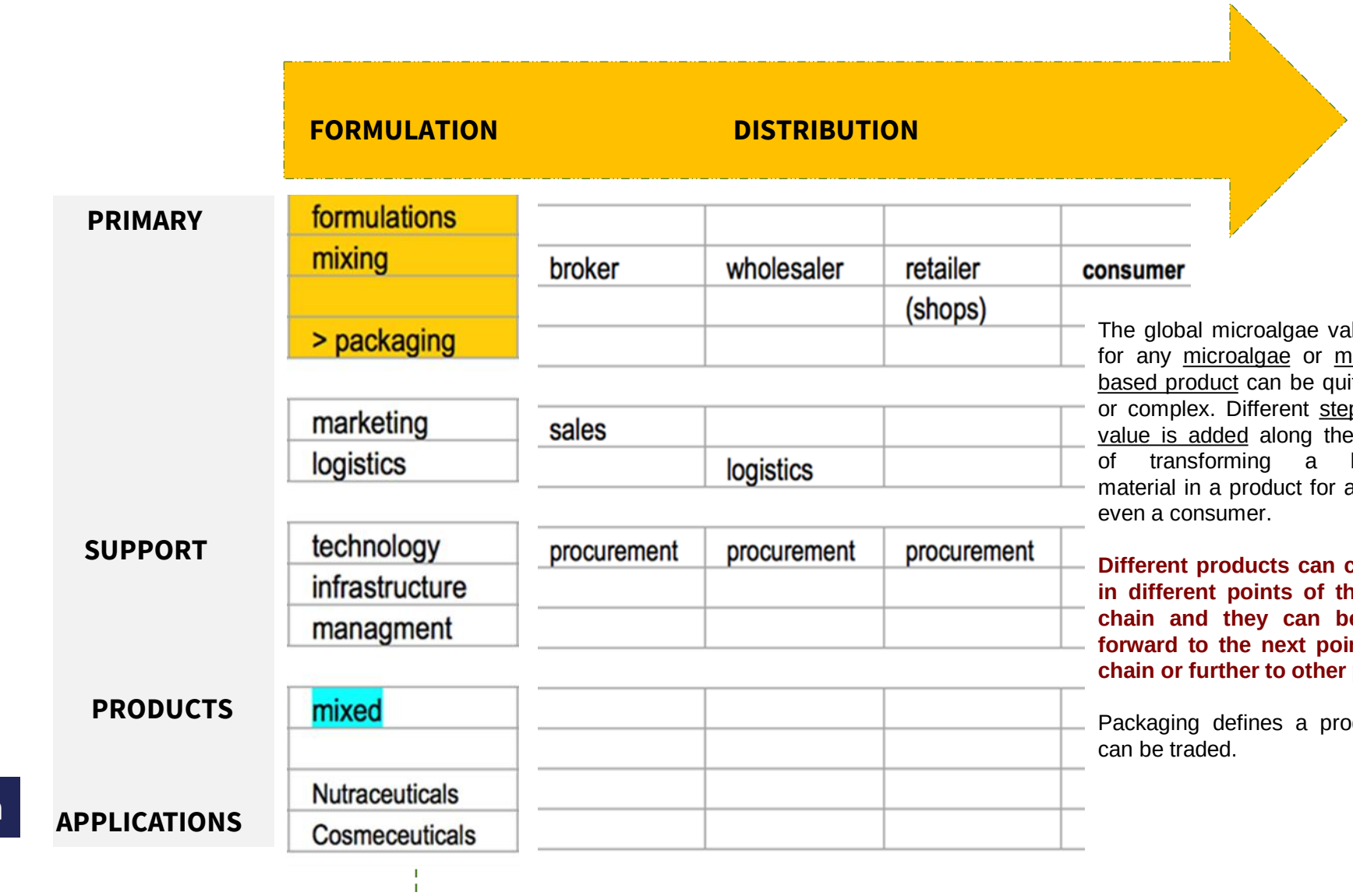
Product Value Chain



Business Value Chain

Value-chain for microalgae based products

Product Value Chain



The global microalgae value chain for any microalgae or microalgae based product can be quite simple or complex. Different steps where value is added along the process of transforming a biological material in a product for a client or even a consumer.

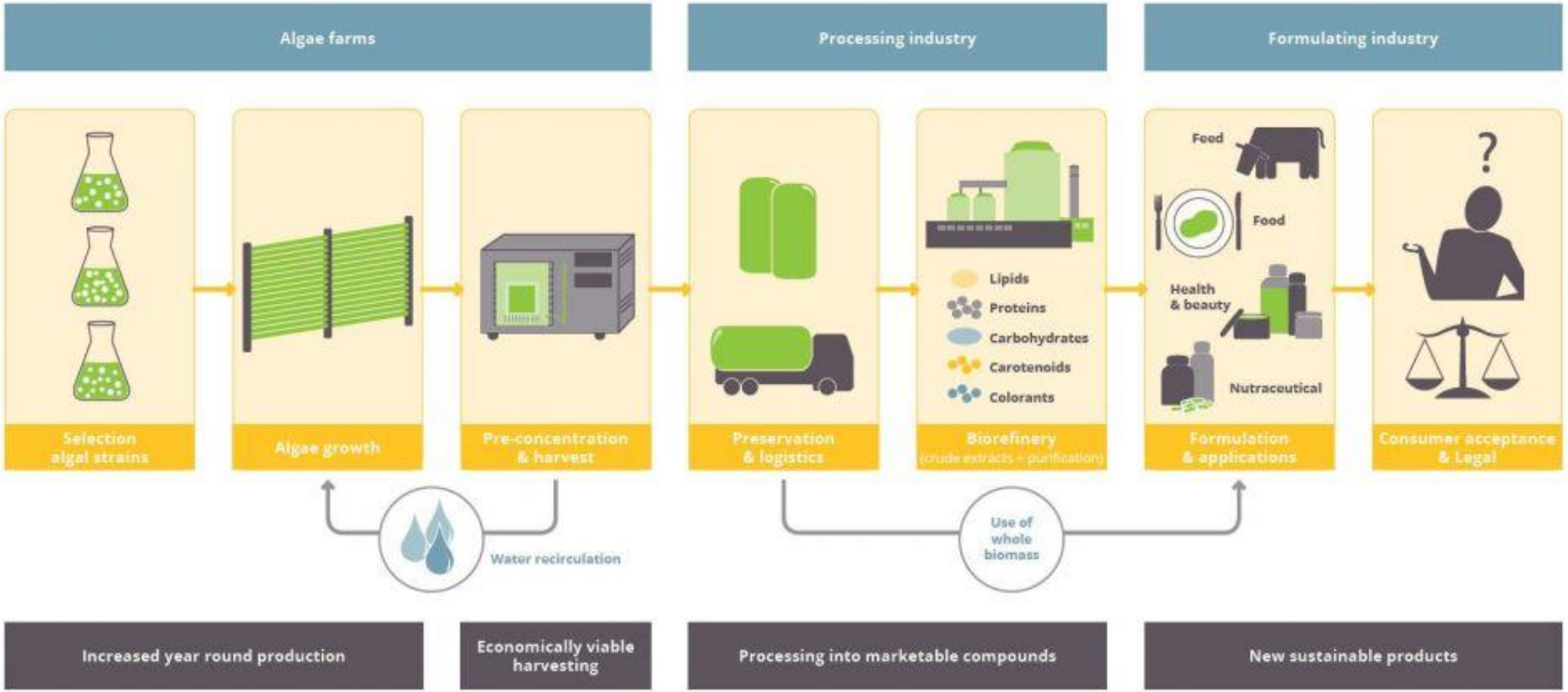
Different products can come-out in different points of the value-chain and they can be traded forward to the next point of the chain or further to other point.

Packaging defines a product that can be traded.

Business Value Chain

IDEA

Implementation and development of economic viable algae-based value chains



https://vito.be/nl/idea-implementation-and-development-economic-viable-algae-based-value-chains

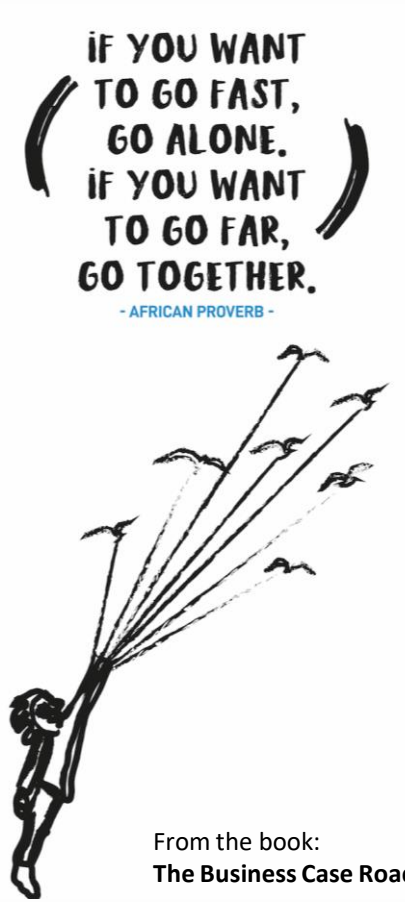
There is the **Product Value Chain**

> From the pond to the paste, dried or extract

There is the **Business Value Chain**

> From the biomass to final products with a wide range of applications

Thank You!



From the book:
The Business Case Roadmap

Vítor Verdelho Vieira

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