



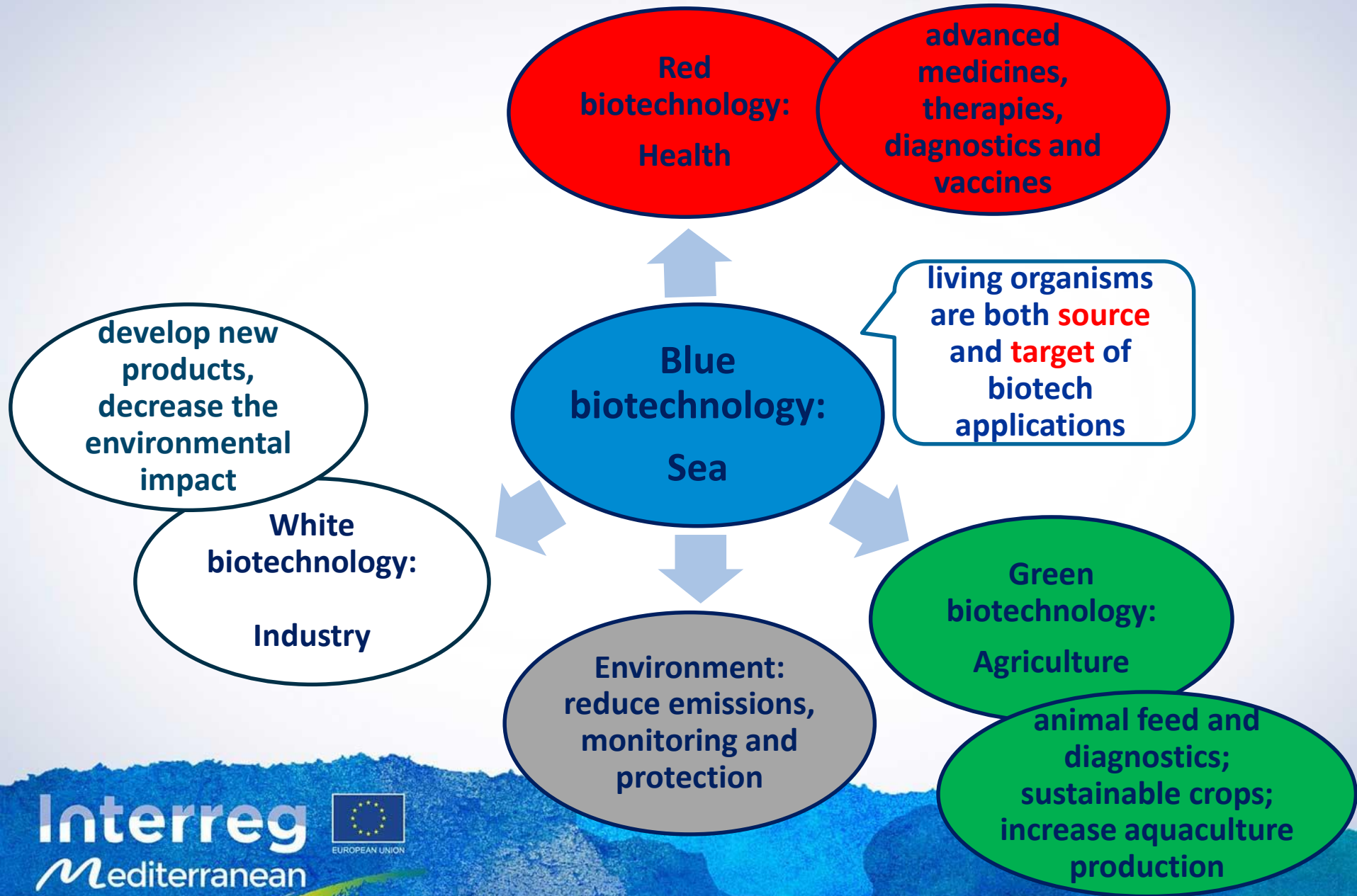
ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Blue Book: Blue Biotechnology – Innovation Potential and key enabling factors

R. Pistocchi, N. Raddadi, G. Falini

University of Bologna

The blue biotechnology sectors and subsectors



Blue Biotechnology status in the MED area

Methodology

Benchmarking

**Innovation
Potential**

GAPs and Key
Enabling
Factors

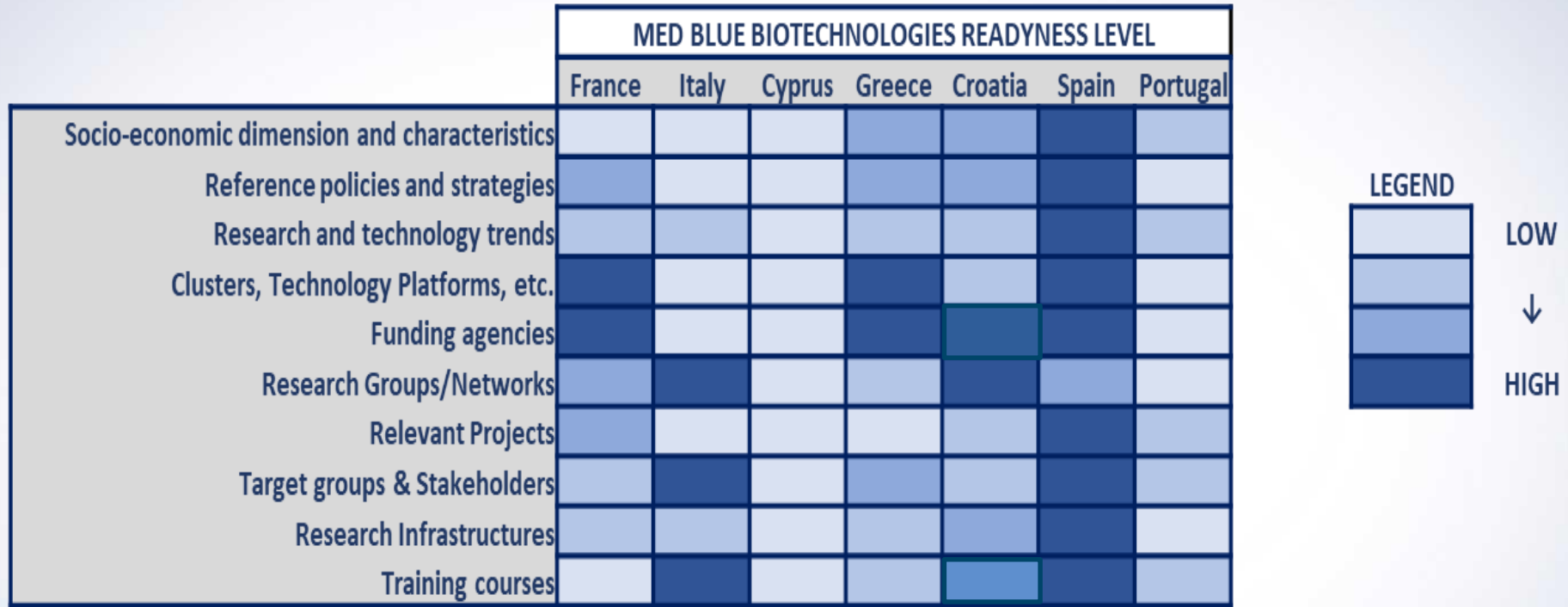
Instrument

Country/Regional Fiches



«Benchmark analysis»

Blue Biotechnology Readyness level in the MED area



In a number of answers most countries considered the BB: **in improvement...**, **under development...**, **with high potential...**, etc.

«Innovation Potentials»

- Blue biotechnology is a field with massive potential for innovation and economic growth.
- Given that Blue Biotechnology is a relatively young discipline, many innovative activities are likely to become economically viable in the medium to longer term.

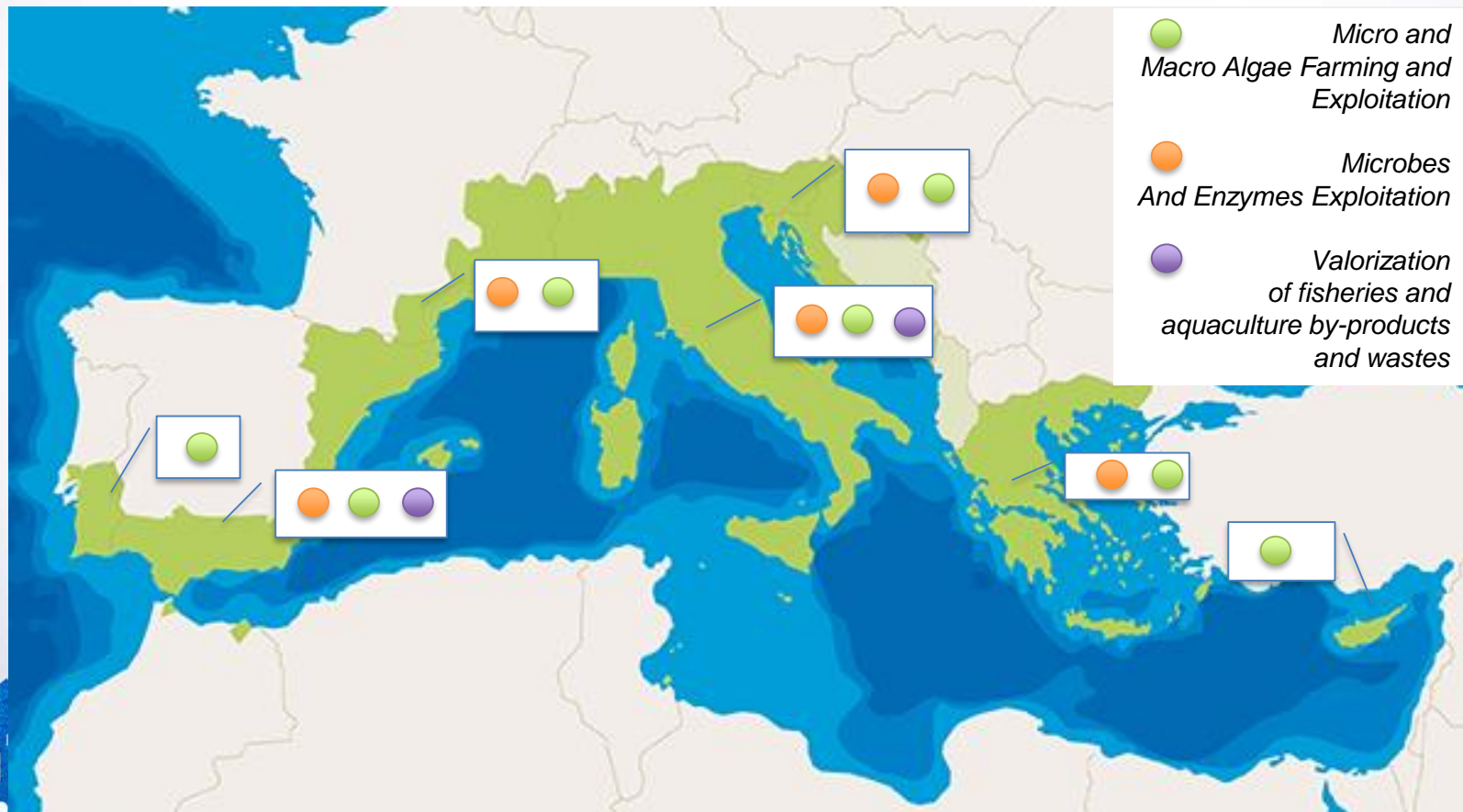
The following **three general fields** with Innovation potentials have emerged across the MED area

IPs among MISTRAL Countries and spatial distribution

1. Micro and Macro **Algae** Farming and Exploitation

2. **Microbes** and Enzymes Exploitation

3. Valorization of **fisheries and aquaculture** by-products and wastes



Sectors with high potential of innovation of Blue biotechnology areas

- Development of **new drugs, food supplements or cosmetic products** from marine (micro)organisms which concern all the organisms and also fishery waste
- Development of biotechnological solutions for the **control, protection and recovery** of contaminated marine environments which concern micro and macroalgae and microbes

Use of marine organisms: Opportunities

- High biodiversity not explored
- Sessile or slow-moving organisms ensure their protection through chemical defenses
- Compounds are released and diluted into water so they need to be highly potent

Benefits

- Natural molecules give more benefit compared to synthetic molecules
- Non-toxic biodegradable compounds with improvement of environmental health

Constraints

A **bottleneck** is the permanent availability of sufficient amounts of organisms and compounds without harming the marine environment.

Micro Algae Farming and Exploitation

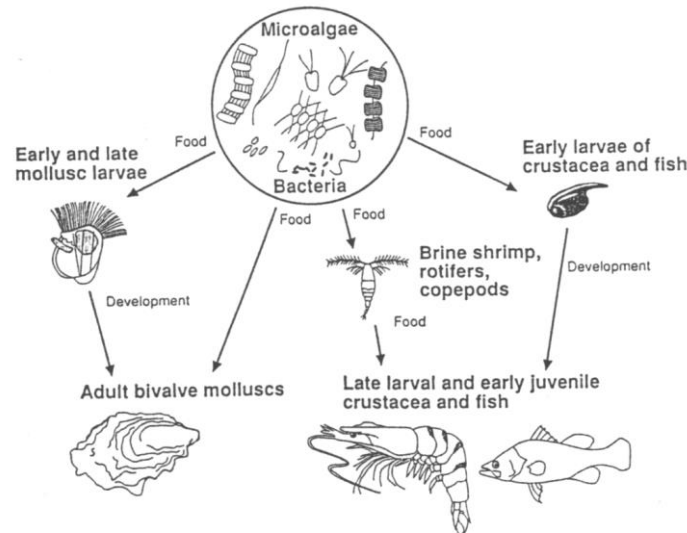
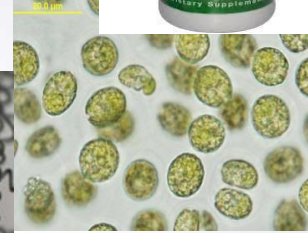
Well established commercialized applications

➤ Dried algae as nutraceuticals

Spirulina and *Chlorella* occupy most of the market

➤ Microalgae in aquaculture

Several species are used as feed for small-farmed marine organisms



MMF&E Innovation Potentials

Compounds extracted from microalgae with economical value

Pigments

Carotenoids (β -carotene, astaxanthin, lutein)

Phycobiliproteins (phycocyanin, phycoerythrin)

Fatty acids

Omega-3 (EPA, DHA)

Polysaccharides

Paramylon



➔ Few companies

Could be improved through the use of a **biorefinery concept**:
e.g. biomass utilization for more than one product or process

Macro Algae Farming and Exploitation

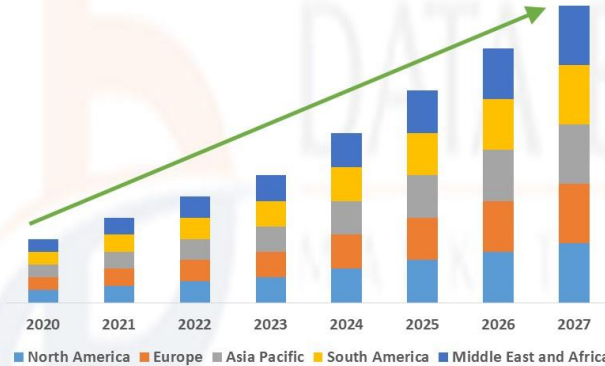
Largest applications:

- Food market and gelling agents
- Agricultural Biostimulants

There are companies in several countries and the market is increasing

Source of these compounds are several species of locally available brown algae usually collected from the field with environmental concern

Global Seaweed Extracts Biostimulant Market is Expected to Account for USD 1,808.78 million by 2027



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Global Seaweed Extracts Biostimulant Market, By Regions, 2020 to 2027

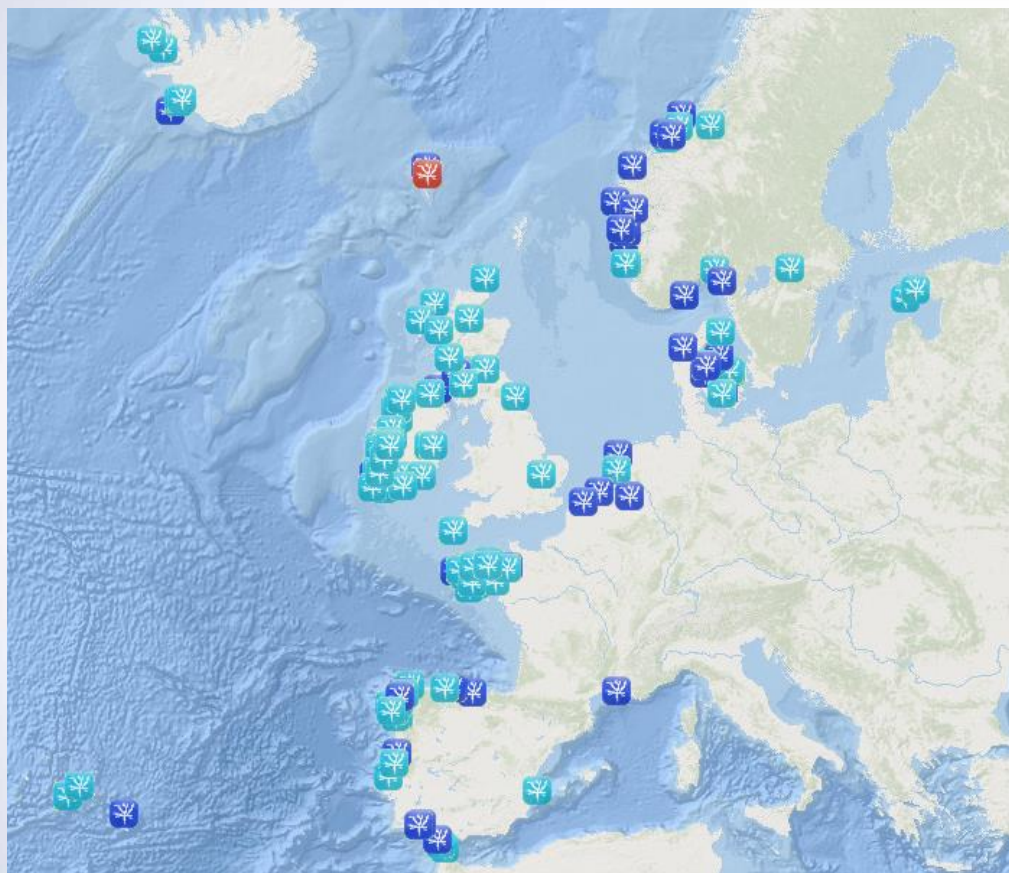


DATA BRIDGE MARKET RESEARCH






MMF&E Innovation Potentials

There is an increasing interest in macroalgae cultivation in aquaculture possibly coupled to wastewater treatments



Macroalgae production facilities

-  Aquaculture
-  Harvesting
-  Pilot

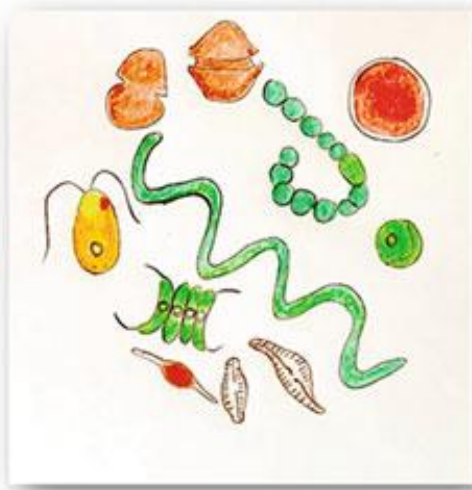
EMODnet.eu

There is a very **high potential** for both micro- and macroalgae utilization due to the presence of many **bioactive molecules** already discovered and that could be used for **pharmaceutical, nutraceutical and cosmeceutical applications**

Bioactive compounds

- Eicosapentaenoic acid (EPA)
- Docosahexaenoic acid (DHA)
- Sulphated polysaccharides
- Carotenoids
 - Astaxanthin
 - Fucoxanthin
 - β-carotene
 - Lutein
- C-phycoyanin
- Novel metabolites
 - Cyanovirin-N
 - Apratoxin A
 - Tricophycin A
 - Calothrixin A
- Dinotoxins
 - Amphidinolides
 - Karlotoxins
 - Yessotoxin

Microalgae



Chu and Fang 2019

Bioactivity

- Antibacterial
- Antiviral
- Anticancer
- Immunomodulatory
- Antiobesity
- Antidiabetic
- Anti-hyperlipidaemic
- Antioxidative



ANTITUMOR/CYTOTOXIC COMPOUNDS

- Polysaccharides
- Terpenoids
- Phenolic compounds
- Glicoproteins
- Sterols
- Carotenoids
- Alkaloids
- Sulfolipids
- Chlorophylls
- Fatty acids

BIOLOGICAL KEY TARGETS

Alves et al. 2018

ANGIOGENESIS AND METASTASIS INHIBITORS

CELL CYCLE REGULATORS

CO-ADJUVANT THERAPEUTICS

APOPTOSIS INDUCERS

OTHERS



Microbes and enzyme exploitation

Innovation potential

- Enzyme and microorganisms-based products are available for various **industrial processes** and for the **bioremediation of soils** and **wastewater** while products for the marine environment are not commercialized yet.
- Several studies have demonstrated that **natural products** isolated from marine organisms like marine invertebrates are frequently of **microbial origin**.

Bioproducts from marine microorganisms (bacteria)

Carotenoids

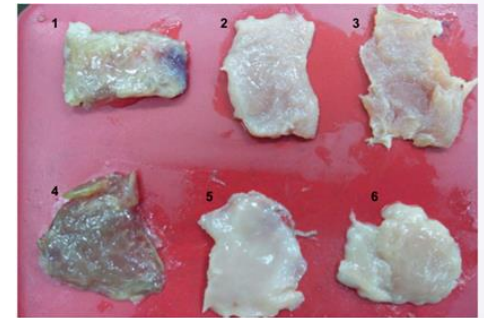
Applications: nutraceuticals (antioxidants); cosmetics (anti-aging, skin protection); food industry (natural dyes, dietary supplements, animal feed);



Antimicrobial compounds

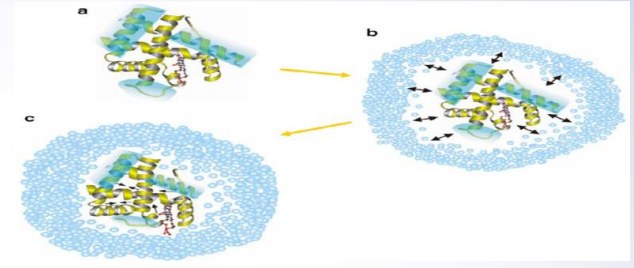
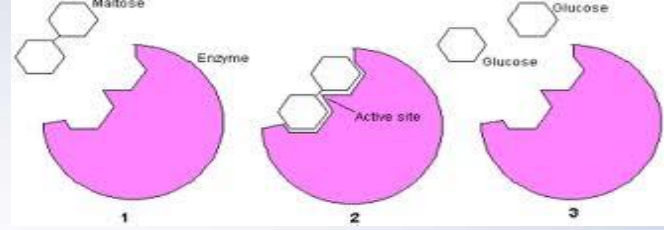
Bacteriocins: bactericidal and/or bacteriostatic against organisms often, but not always, related to the producer strain

Applications: food preservative and treatment of bacterial diseases in aquaculture



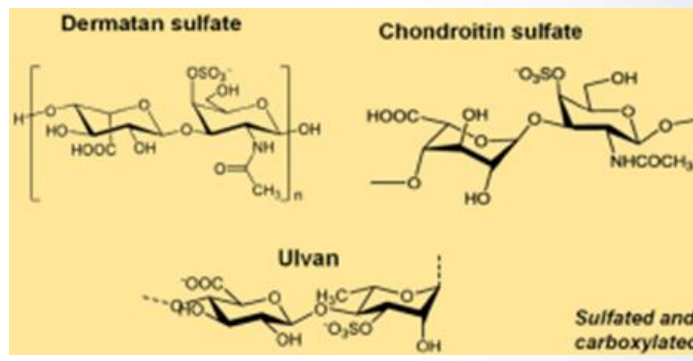
Extremozymes by extremophilic microorganisms

Two enzymes from marine thermophile microorganisms are used in PCR



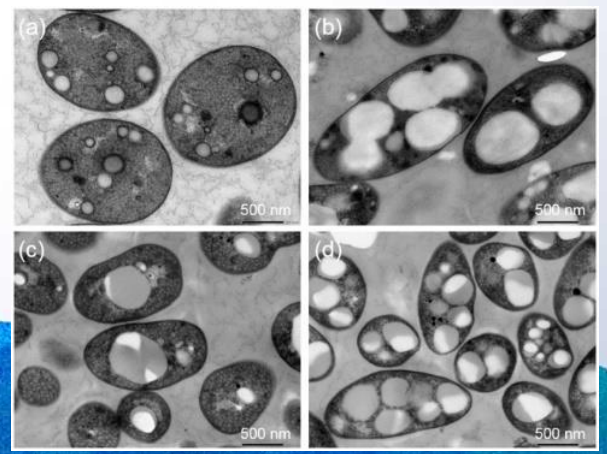
Appl Microbiol Biotechnol (2006) 72:623–634

Sulfated exopolysaccharide has potential biomedical applications: antiproliferation, anticoagulation and wound healing *in vitro*.



Have been reported from *Labrenzia* sp. isolated from sea water.

Marine Polyhydroxyalkanoates useful as bioplastics are produced by marine photosynthetic purple bacteria *Bacillus megaterium*, *Halomonas* sp.



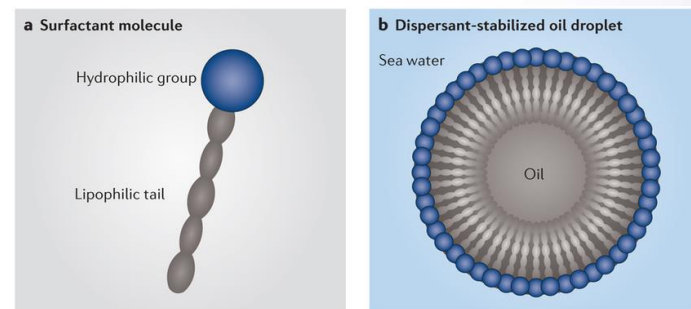
Marine biosurfactants for bioremediation of marine oil spills

Dispersants (surfactants + solvents) used to reduce the oil spilled in the water column can increase the toxicity of the sediments



Advantages of biosurfactants

- biodegradability, low toxicity, production from renewable substrates
- Activity and stability under marine environmental conditions



Raddadi et al. *Microb Cell Fact* (2017) 16:186
DOI 10.1186/s12934-017-0797-3

Microbial Cell Factories

RESEARCH

Open Access

Marinobacter sp. from marine sediments produce highly stable surface-active agents for combatting marine oil spills

Noura Raddadi , Lucia Giacomucci, Grazia Totaro and Fabio Fava



Valorization of fisheries and aquaculture by-products and wastes

Worldwide every year, some 6 million to 8 million tonnes of fishery by-products and wastes are produced.

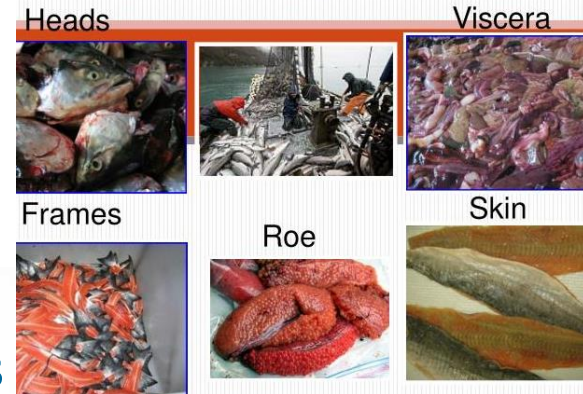


Benefits:

- Utilization of discards can limit environmental impacts of fishing activities



Fish Processing Byproducts



Fishery by-products and wastes harbour useful chemicals:

Organic fraction
(proteins, lipids, enzymes)

Inorganic fraction
(carbonates)

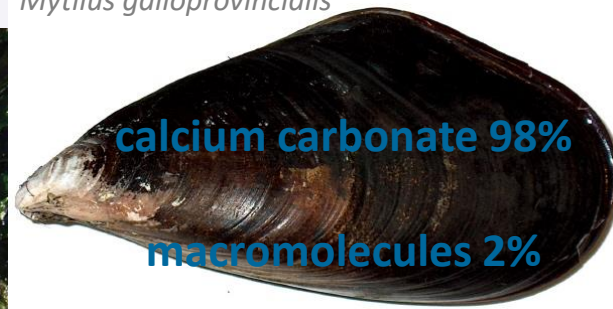


Valorized through chemical and/or biotechnological process for the
production of compounds and materials for different industrial sectors

Shells from aquaculture: a valuable biomaterial



Mytilus galloprovincialis



Cassostrea gigas



Healthcare

Applications

Chitin derivatives: cosmetics,

Protein fraction: bioactive peptides, food ingredients;

Lipid fraction: long-chain polyunsaturated fatty acids;

Biogenic calcium carbonate: drug delivery system;

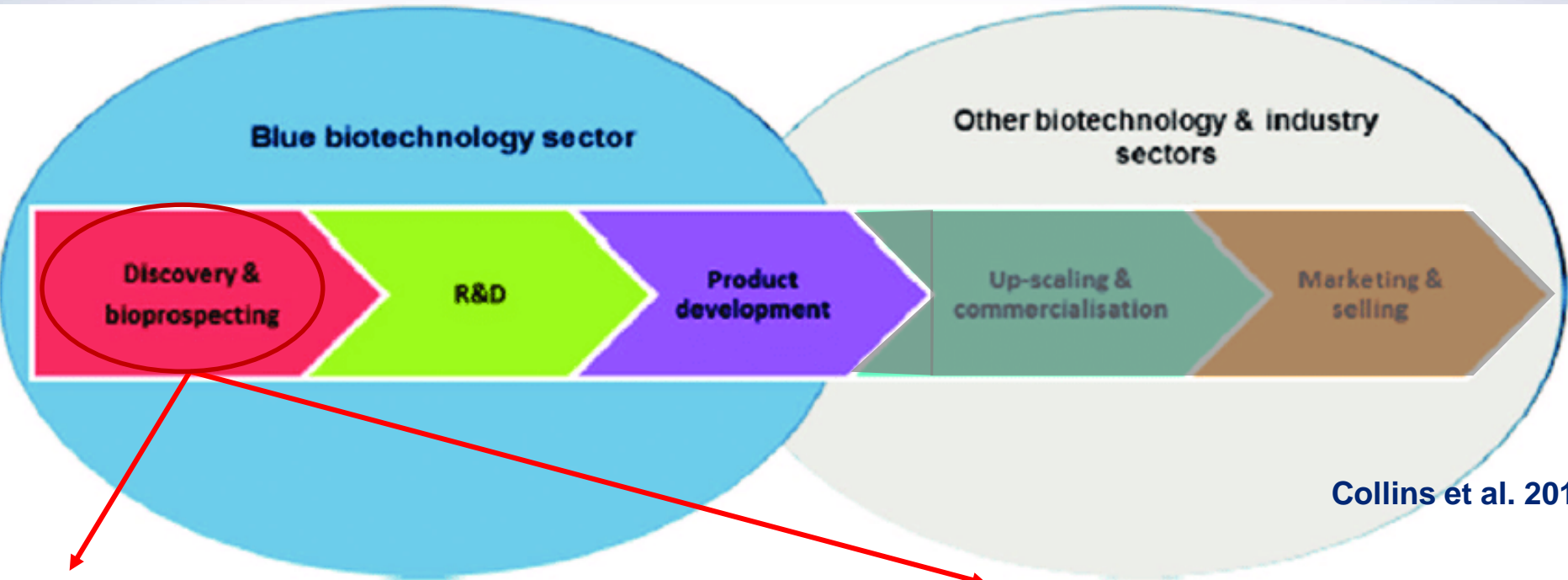
Livestock

Grounded mollusc shells are used as buffer in acidic soils and feed additive.

Industrial Processes and manufacturing: biopolymer production

«GAPs and Enabling Factors»

Some GAPs and EFs are common to the exploitation of all the marine resources and concern all the value chain

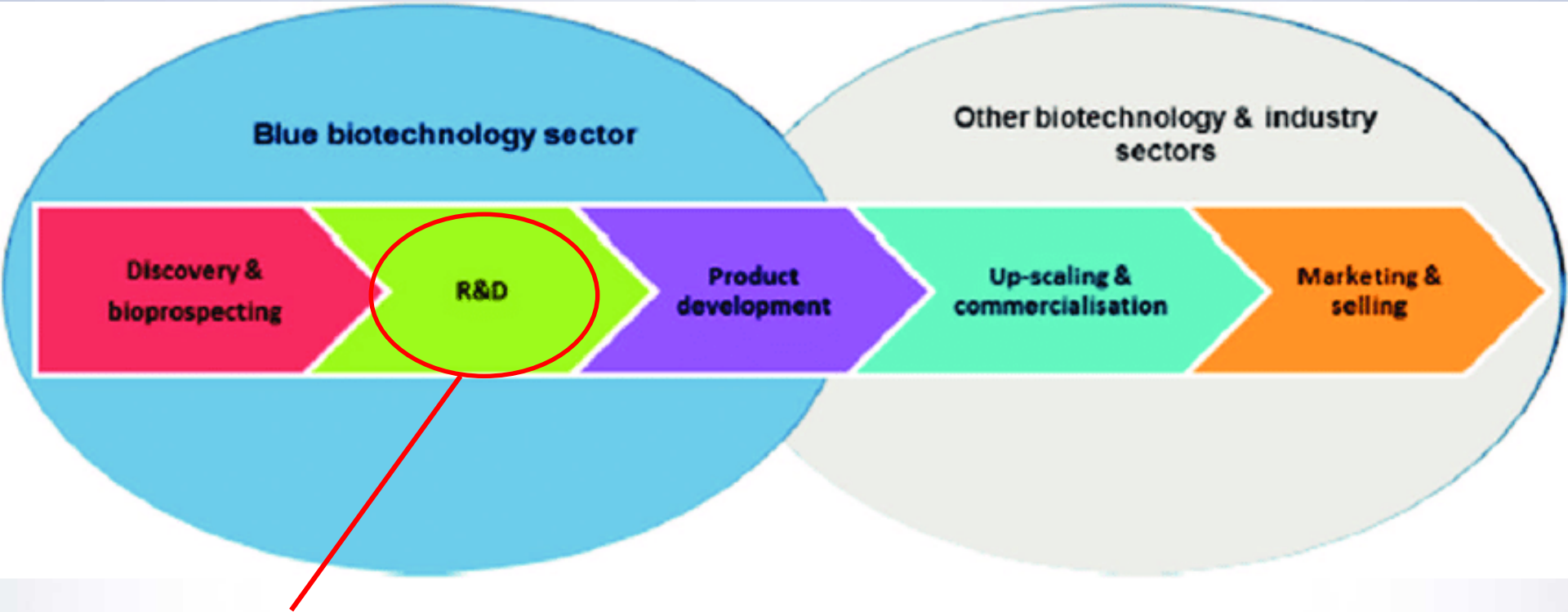


Discovery of new species is necessary and **bioprospecting** is actually looking at extremophilic organisms

Needs: improvement of genetic and biologic knowledge about marine biodiversity

Research Topic
Bioprospecting and Biotechnology of Extremophiles

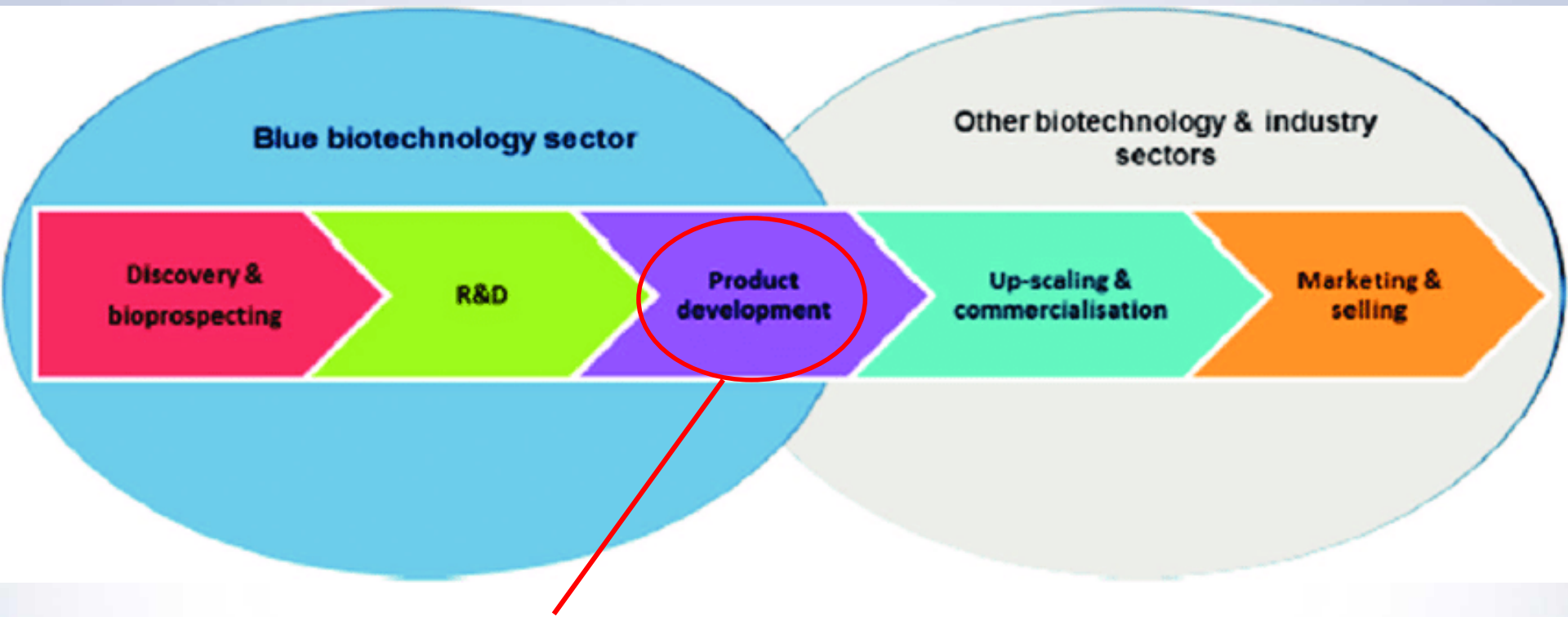
Submission closed.



Research & Development activities in most countries are performed mainly by universities, research institutes and spin-offs;

Needs:

- Interdisciplinary cooperation, establishment of collaborations between companies and R&D institutions, intersectorial training
- Demonstrations of the whole value chain



Product Development: includes the development of sustainable production strategies

Problems linked to cultivation

Microbes

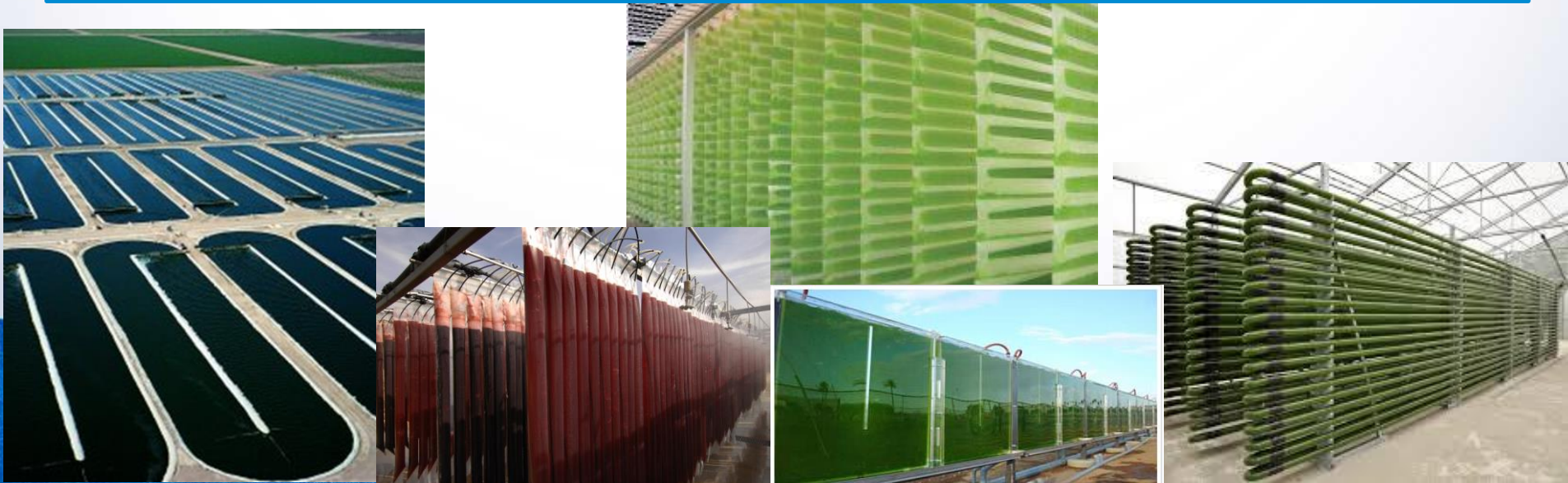
microorganisms in a symbiotic associations usually cannot be cultivated alone and only a part of their biosynthetic genes is transcribed

Algae

- cultivation systems fit for very few algal species
- cultivation scale up is difficult, the production is unstable, the culture medium is submitted to external incursions: predator animals, diseases

Needs:

- improvement of technologies and reduction of costs
- improvement of downstream processes



«Enabling factors»

healthcare and
pharmaceutical

agriculture,
livestock, food
processing

industrial
processes and
manufacturing

The market for

- natural nutraceutical/cosmetic products
- a new generation of food products
- microbial enzymes and enzyme-based formulations

is ready and it has an increasing trend and there is a good acceptability of natural products

In addition:

the BB sector has economic relevance and could have positive impact on a number of different sectors

Needs: Development of **dedicated policies** e.g. on microalgae cultivation, quality standards of algal biomass, exploitation of wastes, generation of an integrated fishery waste management scheme, restrictions about Novel Foods, etc.

THANK FOR YOUR ATTENTION!

Interreg
Mediterranean

