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Marine biotechnologies, what are the challenges for the future ?

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Marine biotechnologies in Nice, what are the challenges for the future?

Oceans and seas comprise 70 percent of the surface of our planet and are home to over 90 percent of Earth's biosphere. The marine macro- and microorganisms are found in extremes of temperature, light, pressure and salinity. They have developed unique metabolic abilities to ensure their survival, resulting in an array of secondary metabolites with specific activities. Many of these metabolites represent high-value commercial products for the industry and their potential in terms of structure, chemistry and physiology is exploited with marine biotechnology. Marine biotechnology is a key enabling technology that supports the development of the bioeconomy with the aim of delivering new products and services.

The marine biotechnology sector is a growing emerging sector that has the potential to sustainably deliver considerable wealth and business opportunities to local economies through the development of a wide range of applications in the food industry, environment, energy, pharmaceuticals, cosmetics.

What are the measures to improve the sustainability, productivity and benefits of marine biotechnology

The huge marine biodiversity of the Mediterranean sea (MED), recognized as a hot spot in the world has the potential to sustainably deliver business opportunities through the development of numerous applications in medicine, food, biofuel, cosmetics, agrobiotech and pharma industries. But , the marine biotechnology development is far behind, mainly due to bottlenecks of fragmentation of knowledge and lack of communication between research entities, SMEs and decision-makers.

While excellent research centers in the area of Nice are supporting the development of fundamental research activities to decipher the added-value of marine resources, and while end-users are looking for the potential innovative products offered by marine resources only few SMEs start a business in Nice, by lack of support from regional political and innovation hubs.

@ Station Biologique de Roscoff (CNRS/UPMC)

Why Marine Biotechnology is a hot topic ?

Several sectors of application are concerned: pharmaceutical and well-being, cosmetics, food, agriculture, environment and maritime industry. Marine biotechnology is a hot topic because it addresses many emerging cross-cutting issues:

- **An alternative to chemical molecules** currently present in food, cosmetics or pharmaceuticals. Indeed, marine biotechnology products are a safe source of new natural molecules for consumers who demand healthy new products.

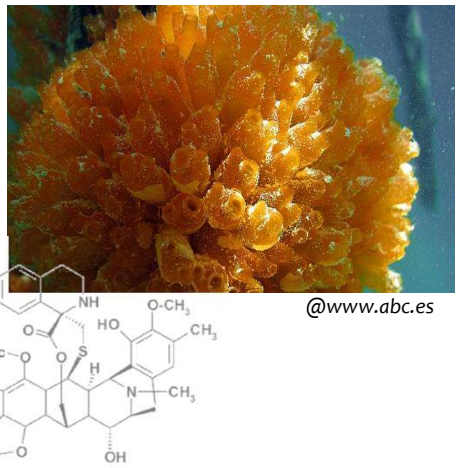
- **Health for all.** Oceans and seas are a source of new medicines and treatments. Species and marine organisms increase the chances of success in the search for new bioactive compounds.

- **Sustainable farming:** algae colloids are used in crop protection rather than in the destruction of pathogens.

- **A source of green energy:** Microalgae produce energy from biofuel.

- **Business** in perspective and a growing market: The global market for marine biotechnology products and processes is currently estimated at € 4.1 billion by 2020.

Consumers demand innovative, efficient and environmentally friendly solutions, a market that is constantly growing.



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Innovation: The health sector, which targeted marine-derived molecules as new pharmaceutical entities, continues to highlight the potential of marine-based materials in drug discovery. Trabectedin, a metabolite extracted from a marine invertebrate (pictured above), marketed under the brand Yondelis®, an approved antitumour drug in Europe, Russia and South Korea for the treatment of advanced soft tissue sarcomas. In parallel, clinical trials are under development for the treatment of breast, prostate, and children sarcoma.

Marine Biotechnology, international level

- In 2015, **the United Nations** adopted a set of goals (sustainable development goals, SDGs) to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda with 17 goals to be achieved by the year 2030. The sustainable development goals envisage a world in which every country enjoys sustained, inclusive and sustainable economic growth, environmental protection, a world in which humanity lives in harmony with nature and in which wildlife and other living species are protected. The marine Biotechnology corresponds contributes to 11 out of 17 SDGs (SDG1-3, SDG5, SDG7-9, SDG12-14, SDG17) See figure
- **The Nagoya Protocol** on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) to the Convention on Biological Diversity aims the fair and equitable sharing of benefits arising from the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity.
- **The Bioeconomy** refers to the economic sectors of bioscience and bio-technology, is valued at EUR 2 000 billion, represents more than 22 million jobs and around 9% of the workforce in the EU. Biotechnology is included in the OECD's policy agenda until 2030
- The strategy for a **sustainable bio-economy in Europe** aims to develop more innovative resource efficient and competitive society that applies to sustainable use of renewable resources for industrial purposes, while ensuring environmental protection
- The Communication of Blue Growth, adopted by the European Commission in 2011 states that the seas and the oceans have a great potential for innovation and growth to ultimately become the drivers in European economy jobs (up to 1.5 million by 2020, notably in coastal areas).
- The Blue Growth initiative is strongly linked with the **EU Marine Strategy Framework Directive** to reach a good environmental status by 2021.
- **Northern European regions** are already structured in the field of marine bio-technology: alliances and sustainable networks have been initiated in the Baltic sea, in Scotland, Norway.

11 objectives of the SDGs are directly linked to marine biotechnologies

Challenges met by marine biotechnologies

Infrastructure Challenge

There is a strong need to continue to build research and innovation capacity in the research and business sectors. This would improve science and technology research infrastructure, providing access to a range of new research support tools and facilities to strengthen marine biotechnology. Many of the tools and techniques used in marine biotechnology are widely used in other areas of science and technology. Engaging in collaborative research projects is one way of providing access to these facilities and encouraging multidisciplinary research.

Market demand

It is essential to align discovery and development activities with the needs of target markets. Linking researchers to the range of end-users is essential to stimulate innovation

Technical challenge

Access to the ocean and the deepest of its "hot spots" remains very difficult and new robotic and technical technologies are needed.

Taxonomy-

The lack of taxonomic knowledge for marine species, and the still large number of unidentified species and strains, is also a major bottleneck facing marine natural product programs.

Economic Challenge

There are several very important issues that need to be addressed by researchers or companies: (i) What are the potential applications of the industry and the market needs of that particular activity; (II) what is the target price / kg of the final bioactive; (III) what is the desired formulation and route of administration; (IV) what is the manufacturing process and how sustainable is the supply; (v) How can the product reach the value chain? A targeted strategy in this area is essential. Small and medium-sized enterprises (SMEs) have a marketing objective and, as a result, present their discovery and development programs very early. It is crucial for them to have a clearly defined strategy, otherwise the risk of failing and running out of cash quickly is high. It is important to know that the cost of technology and manufacturing processes, sometimes with poor yields, increases the cost of the market per kilogram and can make these products economically uncompetitive.

Societal Challenge

Consumers expect innovative, natural solutions that are efficient and respectful of the environment. Improving the flow of information on the benefits of marine biotechnology products to consumers in order to encourage them to purchase products that meet sustainable development criteria is necessary.

(adapted from Hurst et al., 2016)

Défis rencontrés par les biotech marines

Scientific challenges

Exploration of the potential of marine biodiversity has increased, so it is a rich source of new natural compounds. Some of these compounds are already used in food, cosmetic, agricultural, chemical and pharmaceutical products, but their diversity has not been fully characterized or used. Other possibilities exist for the use of ocean bio-resources in the markets for industrial enzymes, functional foods, cosmeceuticals, biomaterials, bio-processes and medical devices.

Since traditional medicinal knowledge associated with marine organisms is almost non-existent, the search for biologically active compounds from marine sources has been done through a random selection of organisms. But initial studies are underway to develop directed selection methods.

Environnemental challenge

The main sources of marine biomass come from species harvested from the wild and those that can be grown. Securing sustainable marine biomass presents challenges, particularly if the only source comes from wild stocks, where over-exploitation can threaten marine biodiversity as well as future supply of target species. Strategic wildlife management coupled with plans for more coherent and effective species management is essential if wild stocks remain viable sources of biomass and health and ecosystem services must be maintained.

Adapted from Hurst et al., 2016)

Production challenge

Consistency, safety and quality of biomass supply must be balanced to meet environmental challenges and sustainability requirements. The well-managed and controlled culture of marine biomass, while facing the challenges of production, provides sustainable sources of biomass.

The Mediterranean

The immense marine biodiversity of the Mediterranean offers the potential to generate sustainable business opportunities through the development of many applications. Despite these encouraging prospects, development in the Mediterranean region is difficult.

Social-political challenges

The Mediterranean regions host high-level research centers with internationally recognized innovation platforms, but for the most part poorly known at the regional level, and little integrated into regional innovation strategies. As a result, many emerging private players in this field do not know where to find innovative knowledge and ideas. There is a lack of coordination and communication between research centers, innovation platforms, policy makers and SMEs. As a result, the slow pace of innovation and competitiveness is commonly encountered by Mediterranean countries

Facts & Numbers

- Marine biotech revenues in Europe could reach € 1 billion within five years if market growth of 6-8% per year is maintained.
- This would result in the creation of 10,000 new jobs (Report for DG Maritime Affairs and Fisheries)
- In 2010, 4,900 patents associated with genes of marine organisms, were deposited, with a growth of 12% / year
- More than 20,000 natural products derived, marine identified. Just in 2012, 1241 new compounds were reported
- > 40,000 natural compounds of micro-organisms, fungi (NAPRALERT, Beilstein, AntiBase)
- ~ 24,000 isolated marine compounds of about 6,000 species) (MarinLit)
- ~ 170 000 compounds of marine and terrestrial organisms (Chapman & Hall Natural Products Dictionnary
- 6000 natural compounds (NAPROC-13)

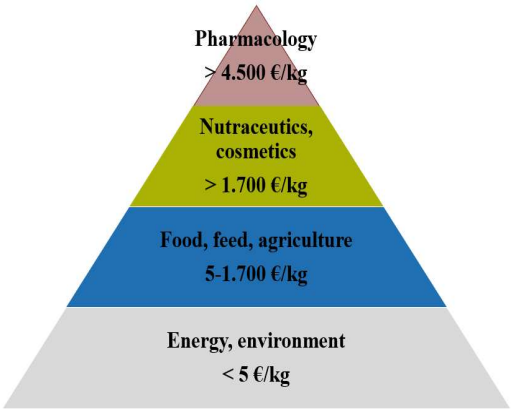
- 86.4% share of the microalgae market is held by the USA

- 10 countries file 90% of patent applications associated with marine genes and among the top ten, the top three accounts for 70%: USA, Germany, Japan (Arnaud-Haond, 2011)

Of 166 marine chemicals with anti-bacterial, anti-fungal, anti-malarial, anti-TB or antiviral activities:

45 marine derived compounds have significant effects on cardiovascular, immune and nervous system diseases and have anti-inflammatory and approximately

54 marine derived compounds act on a variety of targets with a potential contribution to several pharmacological classes



Volume/profit pyramid value for marine biotechnology domains. Martins et al. 2014

(Arnaud-Haond, 2011, Hurst D, et al. (2016), MBT ERA Net (2017), European Commission, OECD

Which RRI actions are necessary?

The RRI addresses issues of improving social benefits and economic benefits, avoiding any negative impact on the environment and helping to reduce pressure on wild stocks of biodiversity.

Today, marine biotechnology is the most promising innovation as a source of natural molecules. It offers a wide range of applications for the introduction of more natural and healthy products on the market that can benefit humans and the environment. RRI actions would improve all areas of application:

Engagement of the public and stakeholders.
Consumers need to be engaged and informed about the benefits of marine biotechnology. The seas and oceans represent a rich source of new drugs, some of which are already on the market, mainly in the field of oncology. Biotechnology helps to reduce the use of chemicals in consumer products: human and animal nutrition are improved, natural cosmetics and nutraceuticals, agricultural products. The contribution to the bioeconomy is important through the development of these innovative processes and products.

Environment

Marine Biotechnologies enable sustainable production and consumption:

It can increase the net gains from economic activities by reducing resource use, degradation and pollution throughout the life cycle through bioreactors, used for the growth of algae to produce biofuels, food and chemicals purposes. This represents an important contribution to meeting the growing need for energy supply through the production of biofuels with microalgae or the production of bioenergy from marine organisms. Marine biotechnology allows for the improvement of environmental measures such as biological indicators or sensors that contribute to the quality of coastal water, (detecting harmful algal blooms and hazards to human health). In addition, biotechnological approaches can allow the development of cost-effective and non-toxic coatings (paint, anti-fouling, etc.).

Stakeholders include consumers, businesses, policy makers, researchers, the media and economic development agencies.

Which RRI actions are necessary ?

Ethics

Fair and equitable use of marine resources is defined by the Nagoya Protocol, Convention on Biological Diversity. Other international treaties (UNCLOS), regional conventions emphasize the development of a fair and equitable sharing of benefits arising from the use of marine resources with local communities. The Nagoya Protocol preserves biodiversity for future generations.

Doubtful scientific practices or other practices such as plagiarism, fraud, infringement of intellectual property are banned from research.

Governance

Sustainable and regulated use of the oceans as a resource is a key feature of a sustainable future. Marine biotechnology is one way to achieve sustainable use of resources. Partnerships between sectors (government and private) and between countries / regions are needed to secure investments in important sectors such as sustainable energy and environmentally sound technologies. Marine bio-technology can provide the means to produce an alternative food source, thereby helping to reduce the degradation of our oceans and the biodiversity caused by overfishing and overexploitation of natural resources.

Educational system

A M.Sc. in marine biotechnology in "Science, Conservation and Management of Marine Resources" (MARES program) has been created to prepare students to pursue research, develop conservation projects locally or internationally, enter in the private sector, or become an entrepreneur by developing the countless marine resources that they will help to protect.

Gender equality

women entrepreneurs are a powerful economic resource and the potential of women's entrepreneurship has only recently begun to materialize. By promoting and supporting entrepreneurship around marine biotechnologies for women, we can contribute to gender equality at the highest levels of management, thereby contributing to job creation, economic decision-making and the empowerment of women. business diversification. UNESCO also recognizes the mainstreaming of gender in marine sciences, promoting the equal representation of men and women in the marine science community as a whole

Open access: The fundamental scientific discoveries, to acquire knowledge are generally public.

Site web, projets et articles

- Présentation: Barbier M. 2017 (http://bit.ly/2EK9to3)
- OECD, 2013 (http://bit.ly/2AOouzO)
- European Commission (http://bit.ly/2CZnZeb) (http://bit.ly/2FooJF7) (http://bit.ly/2CZx1J5)
- ERA Net Marine Biotech (http://bit.ly/2AOzL66), Hurst D, et al. (2016). (http://bit.ly/2foRsog)
- ESF marine Board, position paper 15 (http://bit.ly/2r4b7Pk)
- The Commowealth 2016, (http://bit.ly/2DojQGN)
- Méditerannée: CIESM: M. Barbier (2014) The CIESM Charter on Access and benefit sharing (http://bit.ly/2moOtwc); Barbier et Briand F. 2014 (http://bit.ly/2CX4AL3); L. Giuliano & M. Barbier, 2014 (http://bit.ly/2AMPK4t); M. Barbier and H. Milo, CIESM Marine Policy series 2012, (1): 25-30Giuliano, M. Barbier. 2012 (http://www.ciesm.org/CIESM2011.pdf) L. Giuliano, M. Barbier & F. Briand, (2010 (http://bit.ly/2mi5OpT);.
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- European Projects:

Mar3Bio (www.marinebiotech.eu/mar3bio); MacroFuel (www.macrofuelfood.com/); CSA in Marine Biotechnology (www.marinebiotech.eu/); Euromarine (www.euromarinenetwork.eu/); MicroB3 (www.microb3.eu/); PharmaSea (www.pharma-sea.eu/); Bluegenics (www.bluegenics.eu/); MaCuMBA (www.macumbaproject.eu); MarPipe : (www.marpipe.eu); BLUEandGREEN: (/cordis.europa.eu/result/rcn/203656_en.html); MAMBA: (mamba.bangor.ac.uk/); GoJelly(www.esf.org/our-services/project-management/ec-contracts/gojelly/); BLUEMED: (www.bluemed-initiative.eu)

- Projets en PACA: Purple Sun (project.inria.fr/anrpurplesun/); Fullspectrul (http://bit.ly/2Ev4wPC); biocarburants: http://bit.ly/2Eut8YO
- Pôle de compétitivité: Pôle Mer (http://bit.ly/2D1PrsL), Trimatec (http://bit.ly/2mfsJCf)
- PMEs/start'up française le long de la Méditerranée: Nice/Monaco: Coraliotech (http://bit.ly/2Evh2yI), Inalve Conception (http://bit.ly/2iFkpuo), Naturis causa, Languedoc Roussillon: Greensea (http://greensea.fr/), microphyte (http://www.microphyt.eu/)

- Presse: La France en pointe sur les biotechnologies marines (http://bit.ly/2mp3puf), La farine de microalgues, la solution protéinée d'inalve (http://bit.ly/2FrwIV5),
- Youtube: et toi tu veux faire quoi (http://bit.ly/2EF6flw), Euraxes (http://bit.ly/2AXDQ7X), Université de Nantes (http://bit.ly/2muVnzl)

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