Preface

A new dawn for marine biotechnology in Europe

On 20 June 2010, scientists from across Europe specialising in the field of marine biotechnology gathered at Acquafredda, in the province of Maratea in southern Italy, to attend the European Science Foundation-COST Conference, “Marine Biotechnology: Future Challenges” (Fig. 1). With a programme designed and implemented under the coordination of the Marine Board-ESF, the conference was intentionally held in a remote location and over four full days to ensure that participants could focus fully on the topic at hand; not just by presenting their latest research, but by participating in brainstorming sessions focused on future research priorities and how to better coordinate European RTDI efforts in marine biotechnology. The papers published in this special edition of the Biotechnology Advances represent a selection of the research presented during the Conference. This edition, therefore, focuses not just on marine biotechnology, but on some of the challenge-focused research and initiatives which are driving its development in Europe.

Often referred to as “blue biotechnology”, marine biotechnology is a sub-set of the broader field of biotechnology. Marine biotechnology encompasses those efforts that involve marine resources, either as the source or the target of biotechnology applications. In many cases, this means that the living organisms which are used to develop products or services are derived from marine sources. At the same time, if terrestrial organisms are used to develop a bio-sensor, for example, which is designed for use in the marine environment, this also falls within the realm of marine biotechnology (Querellou et al., 2010).

The interest of the scientific community, and to a lesser extent of industry, in marine biotechnology has grown rapidly in the past decade, owing to a recognition of the sheer scale of opportunity presented by the seas and oceans. Consider the well-established but thought-provoking facts. Because all life originated in the sea, the diversity at higher taxonomic levels is much greater at sea than on land. There are fourteen endemic (unique) marine phyla compared with just one endemic terrestrial phylum. The recently completed Census of Marine Life estimates that there are approximately 240,000 marine species known to science, while Bouchet (2006) conservatively estimates that there may be between 1.4 and 1.6 million marine species in total. Marine organisms live throughout the water column, to an extreme depth of up to 11 km, and in ocean sediments up to a further 400 m below the seafloor. The enormous physical and chemical variability in marine environments support adapted life forms which flourish across a wide range of environmental conditions and habitats and has resulted in the highest genetic diversity on earth (Heip et al., 2009). Marine organisms produce enzymes, polymers, carbohydrates and other molecules with unique characteristics, by virtue of their species-specific adaptations to the ecosystems in which they live. Hence, the oceans represent an enormous reserve of unexplored natural resources and a vast genetic richness which marine biotechnology can harness to provide new materials of relevance to the pharmaceutical, agrochemical, food and cosmetic industries.

From an economic perspective, marine biotechnology is still an emerging sector and accounts for only a very small percentage of the overall biotechnology market. Arrieta et al. (2010) highlighted the significant growth which has recently taken place in the screening and exploitation of marine genetic resources. More than 18,000 natural products and 4900 patents have been derived from the genes of marine organisms, and the number of patents is increasing by 12% per annum. Focusing specifically on bioprospecting for drug discovery, there are currently about fifteen natural products of marine origin in various stages of clinical development, mainly targeting the treatment of cancer. However, the number of established successes in this area is still relatively low and includes ziconotide (approved since 2004 and marketed as Prialt® by Elan, Ireland) and trabectedin (approved since 2007 and marketed as Yondelis® by Pharmamar, Spain). This reflects, to some extent, a relatively low interest from industry in natural products from all sources, a problem which is particularly acute for marine derived compounds. The tide is turning, however. A 2011 global market report on marine biotechnology published by Global Industry Analysts Inc. demonstrates that, following a brief period of stagnation during the global financial crisis in 2008 and 2009, the global market for marine biotechnology returned to growth in 2010 and is forecast to reach US$4.1 billion (€2.9 billion) by 2015. The report states that the market is gaining momentum and exhibits strong prospects for growth in the future. That the USA is currently at the forefront of both research investment and the identification and development of viable commercial products and services, has not been lost on European policy makers who are keen to drive the development of this sector in the EU. European stakeholders from policy, industry and scientific sectors recognise that Europe is well placed to benefit from, and contribute to, the burgeoning field of marine biotechnology.

Representing over 50% of the territory of the European Union, the marine waters under European jurisdiction (including four seas and two oceans) stretch from the Arctic through the North Sea, Baltic, Atlantic, Mediterranean and Black Sea. European jurisdiction also includes the waters surrounding Europe’s ultra-peripheral regions, many of which are located in tropical latitudes. The European landmass has a coastline of 74,000 km (equivalent to eight times that of the USA and four times that of Russia). Hence, Europe is a truly maritime continent, with access to an enormous range of marine habitats from coastal lagoons, to inshore waters to shelf seas and deep ocean. It was recognised some time ago, however, that nationally focused and uncoordinated initiatives being delivered at the level of EU Member and Associated States are insufficient to provide Europe

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with the economies of scale in human capacity, research funding, and research infrastructures it needs to compete with the United States and other burgeoning global powerhouses. Hence, for over a decade now, a constituency of European scientists and policy makers has been calling for enhanced efforts and better coordination between European nations and institutions to exploit the massive potential opportunities presented by marine biotechnology.

In 2001, the Marine Board-ESF published its first marine biotechnology position paper, "A European Strategy for Marine Biotechnology" (Halvorson et al., 2001). This called for a European initiative on marine biotechnology to mobilise the scattered human capital and strategically refocus the extensive but dispersed infrastructure into concerted action. A year later, in 2002, the US National Academy of Sciences published the report, "Marine Biotechnology in the Twenty-first Century: Problems, Promise, and Products" (National Research Council, 1999). This report made broadly similar recommendations to the Marine Board position paper and stressed the need to develop advanced techniques for the detection and screening of potentially valuable marine natural products and biomaterials.

Since that time, various European initiatives have further advocated marine biotechnology as a sector with considerable potential but in need of a coordinated European approach, and some notable progress has been made. A European Commission Collaborative Working Group on Marine Biotechnology (CWG-MB), and an EU–US Task Force on Biotechnology have highlighted the potential of the sector and provided clear recommendations to support its development in Europe. With the adoption of its Integrated Maritime Policy (Oct 2007), the EU has also made huge strides towards ensuring an integrated, multi-sectoral and multidisciplinary approach to dealing with challenges and opportunities presented by the coasts, seas and oceans. At the same time, the European Commission has been working with Member and Associated States towards development of a "European Research Area" (ERA), which aims to reduce fragmentation and duplication of research efforts and to better integrate the scientific communities and the research infrastructures they need. Through support for several pan-European integrated projects under its Knowledge-Based Bio-Economy (KBBE) initiative, the EU Framework Programme (the EU’s primary funding programme for science and technology) has also been responsive to the emergence of marine biotechnology. Recent efforts to improve transnational coordination of, and access to, research vessels, marine stations and laboratories, sample repositories, culture collections and data holdings indicate a recognition that action is needed to fully exploit the vast but fragmented research infrastructure available for marine science in Europe.

Considering the important scientific and policy developments since 2000, the Marine Board-ESF initiated in 2009 a new set of activities to stimulate European marine biotechnology research. The 2010 ESF-COST High Level Conference was one of these activities, but most important, perhaps, was the work of the Marine Board expert working group on marine biotechnology, which was convened with a mission to (i) provide a strategic assessment of the current scientific

Fig. 1. Participants at the ESF-COST Conference, “Marine Biotechnology: Future Challenges”, 20–25 June 2010, Acquafrredda di Maratea, Italy. ©Marine Board-ESF.

Fig. 2. Cover of the Marine Board Position Paper 15 Marine Biotechnology: a new Vision and Strategy for Europe.


understanding of marine biotechnology relevant to European Union and Member State policies; (ii) identify priorities for further research in this field; (iii) analyse the socio-economic context in which marine biotechnology is evolving; and (iv) formulate recommendations for future policies and critical RTDI support mechanisms.

The work of the expert working group culminated in the publication of a new and updated Marine Board position paper, “Marine Biotechnology: A New Vision and Strategy for Europe”, which was published in October 2010 (Fig. 2). The Position Paper presents a vision for European marine biotechnology whereby:

By 2020, an organised, integrated and globally competitive European marine biotechnology sector will apply, in a sustainable and ethical manner, advanced tools to provide a significant contribution towards addressing key societal challenges in the areas of food and energy security, development of novel drugs and treatments for human and animal health, industrial materials and processes and the sustainable use and management of the seas and oceans.

The paper calls for a collaborative industry–academia approach and uses the “Grand Challenges” as the basis for a logical analysis of the current and possible future development of marine biotechnology, set against its capacity to deliver products and processes to address high-level societal needs and opportunities in the areas of food, energy, environmental health, human health and well-being, and industrial products and processes. The paper also sets out a coherent strategy for the development of marine biotechnology in Europe, built around the following high-level recommendations:

1. Create a strong identity and communication strategy to raise the profile and awareness of European Marine Biotechnology research;
2. Stimulate the development of research strategies and programmes for Marine Biotechnology research and align these at the National, Regional and Pan-European level;
3. Significantly improve technology transfer pathways, strengthen the basis for proactive, mutually beneficial interaction and collaboration between academic research and industry and secure access and fair and equitable benefit sharing of marine genetic resources;
4. Improve training and education to support marine biotechnology in Europe.

Aside from identifying key research priorities, the strategy and core recommendations come with a set of concrete and achievable actions and an implementation roadmap designed to support and develop European marine biotechnology research, enhance the European biotechnology and bioscience industries, and provide a considerable contribution to the Knowledge Based Bio-Economy (KBBE). The ambitious vision for European marine biotechnology set out in the Marine Board position paper can be achieved, but only with the active support and involvement of a diverse range of stakeholders.

Today, humankind is facing complex and difficult challenges that will shape our common future. Issues that top the agenda include a sustainable supply of food and energy, climate change, environmental degradation, human health and ageing populations. The recent global economic downturn has made these issues even more pressing. Marine biotechnology can and should make a significant contribution towards meeting these impending challenges and in providing significant economic opportunities. In doing so, it can also contribute to the development of greener, smarter economies, central components of the new “Europe 2020” Strategy, the EU’s knowledge-based growth strategy for the next decade.

The range of research presented at the “Marine Biotechnology: Future Challenges” conference and published in this special edition, illustrates just some of the challenges being tackled by European scientists across a broad spectrum of marine biotechnology research. Kleinegris et al., for example, report on the prospects of using two-phase systems for microalgal production which could reduce costs and increase the commercial viability. In another article, Stengel et al. demonstrate the extent of natural variability in the content and composition of pigments across a range of intertidal macroalgal species, driven by spatial and temporal variability in environmental conditions. Such variability is one of the major issues causing the relatively low interest from industry in sourcing bioactive components from marine natural products. Other reviews such as those from Imhoff et al. and Schumacher et al. illustrate the enormous potential of marine bioactive compounds for the development of, for example, antibiotics or anticaner drugs and highlight some of the main challenges of the associated research in the coming years.

The presented research and review articles in this issue illustrate how the development of marine biotechnology opportunities will continue to rely on efforts from basic research for knowledge and understanding, through proof of concept to pre-commercialization and demonstration. A broad and integrated knowledge platform, pan-European research collaboration in strategic areas, and the capacity to pick up and utilise innovative research findings through better industry–academia collaboration are critical elements for future success. The discussions at the ESF-COST conference showed clearly that the science community increasingly recognises that it must work proactively with those who can drive and deliver a supportive policy environment and with industry which is best placed to deliver economic benefits from research findings. As the European Union plans its next round of science, technology and innovation funding (the Horizon 2020 Programme will replace the Framework 7 Programme from 2014), the next two years will be critical for planning the way forward in its marine biotechnology sector. Proactive, coherent and strategic action now can not only significantly advance European marine biotechnology research in its own right, but, in turn, contribute strongly to knowledge-based economic growth, and to addressing some of the most critical societal challenges of our time.

Acknowledgements

The Marine Board of the European Science Foundation provides a pan-European platform for its 33 member organisations (both research performing and funding organisations) from 20 European countries to develop common priorities, to advance marine research, and to bridge the gap between science and policy in order to meet future challenges and opportunities (www.esf.org/marineboard).

We thank the European Science Foundation and the COST Office which provided financial support for the Marine Board-ESF-COST Conference Marine Biotechnology: Future Challenges, the conference organising committee for their hard work and support, and the members of the Marine Board Working Group on Marine Biotechnology for their efforts and expert contributions in developing the Marine Board Position Paper 15, Marine Biotechnology: a new Vision and Strategy for Europe.

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