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MICRO B3

Microbial Biodiversity, Bioinformatics, Biotechnology

| 2012 |

Understanding the world from a marine microbial perspective

The emergence of new marine knowledge based on the genomic revolution is leading to a better understanding of the biggest ecosystem on Earth. There is massive potential for biotechnological innovation without overharvesting the marine environment. The Micro B3 project aims to bring about major developments in the field of environmental bioinformatics to support these novel technologies

BIOTECHNOLOGY BASED ON genomic, proteomic and metabolomic information (collectively called 'Omics), from marine organisms has wide-ranging applications, most significantly in agriculture, the food industry, medicine and pharmaceuticals. In spite of this, 'blue biotechnology' is new territory for most companies. Globally, only 1 per cent of all biotechnology companies make use of marine ecosystem knowledge.

By improving the infrastructure for the huge amount of data on marine ecosystems, the ability of researchers to take a holistic approach to data can be improved, especially through combining 'Omics with environmental, biological and biochemical knowledge. A new research discipline called Environmental Bioinformatics is emerging, with Micro B3's task to ensure this is developed and implemented internationally.

The €9 million Ocean of Tomorrow Project Micro B3 is led by Dr Frank Oliver Glöckner, Professor of Bioinformatics at Jacobs University in Bremen. It forms teams of experts in bioinformatics, computer science, biology, ecology, oceanography, bioprospecting, biotechnology, ethics and law. The group includes a large number of partners who own considerable amounts of data on marine microbial diversity and the marine environment.

Micro B3 builds on output from two earlier developments in related fields: Since 2005 the megx.net system has been providing scientists with access to integrated environmental and meta-genomic data to be used in marine microbial ecology. It is used to generate hypotheses to discover new functional genes by integrating meta-genomic and ribosomal data with curated metadata and primary environmental data. Megx.net was supplemented through the EU NEST Metafunctions project which ran from 2005-08 and achieved final proof-of-concept as well as providing further data mining tools.

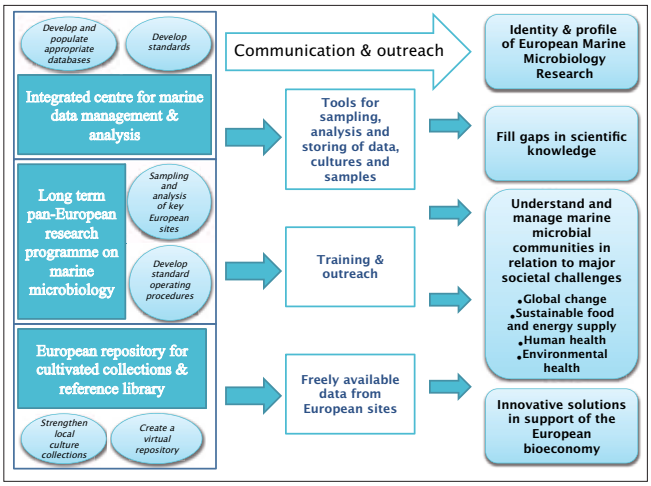

FIGURE 1. Schematic overview of main recommendations and their expected impacts in relation to addressing the key societal and scientific challenges (ESF Position Paper 17: *Marine Microbial Diversity and its Role in Ecosystem Function and Environmental Change*, May 2012).

Starting in 2004, main drivers for large-scale collaboration across Europe were two Networks of Excellence: 'Marine Genomics Europe' and 'Marine Biodiversity and Ecosystems Functioning'. Micro B3 builds on all these projects, its research and training is conducted in close contact with two large research infrastructure initiatives: the European Marine Biological Resource Centre (EMBRC) and the European Life Sciences Infrastructure For Biological Information (ELIXIR).

Micro B3 will provide researchers with new analytical approaches to marine ecological genomics, which will be integrated, standardised and extended to other applications within the project. The consortium's main aims are to bring together the existing bodies of expertise in ecosystems biology, the processing and interpretation of data, modelling and prediction and the development of intellectual property agreements to facilitate the exploration of potential commercial applications.

"Micro B3 aims to develop an innovative, transparent and user friendly open-access system, which will allow for seamless processing, integration, visualisation and accessibility of the huge amount of data collected in ongoing sample campaigns and long-term observations," states Glöckner. "We also plan to offer analytical and feedback tools on our platform. This is unique in terms

of integrating genetic and ecological information and will generate collective knowledge. This will in turn offer new perspectives for the modelling and exploration of marine microbial communities."

OCEAN SAMPLING DAY

A key boost to the work will be provided by the Ocean Sampling Day (OSD), scheduled to take place on 21 June 2014. This will involve all partners in the project and will be open to any other interested labs across Europe and beyond. It will bring together a large group of marine researchers to undertake a detailed snapshot of microbes across the world's oceans on a single day.

OSD will take place at various sites, with pilots conducted 2012-13 to establish standardised sampling techniques. All analyses will adhere to the Minimum information checklists (MIxS) standard for describing molecular samples as outlined by the Genomic Standards Consortium.

The event is a key element of Micro B3 as it will generate a massive amount of useful marine microbial data to be included in the project's integrated MB3-Information System, providing other members of the team with information to generate hypotheses for more cost- and time-efficient biotechnological testing and applications.

INTELLECTUAL PROPERTY – WHO OWNS MARINE MICROBES?

One of Micro B3's main tasks will be to develop an innovative set of model arrangements that foster facilitated access to pre-competitive research materials, software, data and published research results, as Glöckner highlights: "We promote appropriate IP management and open access strategies for downstream applications".

Since Micro B3 is likely to bring about the discovery of new biotechnological applications for marine microbial data, there are complex issues of intellectual property involved, particularly given that much of the data gathered originates in exclusive economic zones or areas of ocean completely beyond any national jurisdiction. Micro B3 has a strong focus on open access and on involving all interested stakeholders in a non-exclusive way, with a view to future applications of marine diversity research.

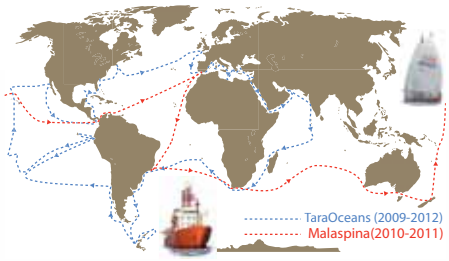

FIGURE 2. Overview of the Tara Oceans and Malaspina circumnavigation cruises © by B Garriz, E Broglio and JM Gasol.

THE MAJOR OBJECTIVE of the Micro B3 project is to cross borders by creating a new inter- and multidisciplinary culture in marine RTD. Detailed goals include:

- Providing access to state-of-the-art facilities and expertise to high quality sequence- and environmental data for a broad range of marine environments, combined with
  - **i.** Oceanographic databases, earth observation and monitoring data
  - **ii.** Data management, development of standards for describing all sampling, and data processing elements
- Bringing together expertise in
  - **i.** The development of innovative bioinformatics approaches for data processing, analysis and integration
  - **ii**. Ecosystems biology for better interpretation of data and to empower modelling approaches enhancing predictive capacities for the marine ecosystem
  - **iii**. Discovering enzymatic functions and bioactive compounds for biotransformation and biocatalysis
  - **iv**. Developing IP agreements for pre-competitive microbial research materials, for data and for the exploitation of high potential commercial applications
- Providing training and outreach activities to support knowledge and technology transfer as well as capacity building around Europe

The approach taken by Micro B3 is based on the Nagoya Protocol, which recognises that biological diversity is a 'common concern of humankind' and links to the broader goals of conservation and sustainable use of resources. The team aims to produce model contracts and good practice standards specifically tailored to the marine field.

Training for young scientists, including a summer school for the OSD as well as a range of workshops in biodiversity, bioinformatics and biotechnology, are planned together with highly accessible outreach activities (web portal, films, media materials) by Dr Johanna Wesnigk from the company EMPA. Related IP issues will be delivered by Dr Tom Dedeurwaerdere, Research Director of the Biodiversity Governance Unit of the Centre for the Philosophy of Law and his team.

Micro B3 is a hugely ambitious project sure to have implications on an international scale as it develops over the next four years. Glöckner and his partners are set to revolutionise Europe's capacity for bioinformatics and marine microbial data integration, to the benefit of a variety of disciplines in bioscience, technology, computing and law.

INTELLIGENCE

MICRO B3

MICROBIAL BIODIVERSITY, BIOINFORMATICS, BIOTECHNOLOGY

OBJECTIVES

To develop new bioinformatic approaches to analyse, integrate and visualise marine molecular and environmental data jointly. From the outset, this will be done in close collaboration with field scientists providing ecosystems expertise as well as their small and large-scale datasets.

PARTNERS

MPIMM, Germany • **UOXF**, UK • **HCMR**, Greece • **AWI**, Germany • **CNRS**, France • **CSIC**, Spain • **SZN**, Italy • **MBA**, UK • **VIB**, Belgium • **TUBITAK**, Turkey • **MARIS**, the Netherlands • **ICES**, Denmark • **VLIZ**, Belgium • **IFREMER**, France • **EMBL-EBI**, UK • **CEA - Genoscope**, France • **UniHB**, Germany • **UGRO**, The Netherlands • **BIOMERIT**, Ireland • **BANGOR**, UK • **IAMC**, Italy • **UCL**, Belgium • **CIESM**, Monaco • **IUCN**, Switzerland • **EMPA**, Germany • **MATIS**, Iceland • **BIO-ILIBERIS**, Spain • **INTERWORKS**, FYROM • **RIBOCON**, Germany • **Bio-Prodict**, The Netherlands • **PharmaMar**, Spain

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FRANK OLIVER GLÖCKNER is Head of Microbial Genomics and Bioinformatics Research Group at the Max Planck Institute for Marine Microbiology in Bremen, Germany and Professor of Bioinformatics at Jacobs University Bremen. His group develops enabling technologies to transform the wealth of sequence- and metadata from the environment into biological knowledge. Techniques are whole genome and metagenome analysis, sequence classification, phylogenetic inference as well as software and database development for integrated data analysis.

Tackling the secrets of marine genomics

Dr Frank Oliver Glöckner, Coordinator of the large Ocean of Tomorrow project Micro B3 on marine microbial biodiversity, bioinformatics and biotechnology, outlines the research efforts on an integrated information system including new tools for 'Omics analysis, to be used by researchers worldwide

To begin, can you outline the context from which the Micro B3 project emerged?

With technological advances in the fields of sequencing technology, oceanography and lab automation, marine scientists are now starting projects they only dreamed of 10 years ago. However, the deluge of data produced is beyond the skill set of many marine scientists and very little data management infrastructure exists at the moment. Our project aims to facilitate the whole process from sampling and data acquisition to analysis, leading to better understanding of marine ecosystems and biotechnological applications.

What are the specific objectives of the project?

The overarching objective is to cross borders by creating a new inter- and multidisciplinary culture in marine RTD. We aim to achieve this by providing access to, and by integrating genomic, oceanographic and Earth observation databases into, one Micro B3 Information System (MB3-IS), based on global standards for sampling and data processing.

We are building capacity across Europe including training on intellectual property rights, knowledge and technology transfer. Our Ocean Sampling Day planned for 2014, will be a major dissemination event to measure marine microbial diversity and test our bioinformatic and environmental MB3-IS in practice.

What is the role of bioinformatics in bridging the current gaps in microbial data analysis? How do you plan to integrate and visualise this data?

Novel techniques and infrastructures for Environmental Bioinformatics are urgently needed to turn data into sensible and useful information and finally into biological knowledge. The marine bioinformaticians' work ranges from data and quality management (cleaning, standardisation) of the raw data to processing and annotating via data-mining and large-scale georeferenced data integration – and statistics and ecosystem modelling tasks.

How is Micro B3 integrating global marine data with research on microbial biodiversity and function? What partner institutions are making this possible?

Our main partners are the Centre National de la Recherche Scientifique (CNRS) and Consejo Superior de Investigaciones Científicas (CSIC) for the TaraOceans and Malaspina cruises. Other partners are several European long-term ecological research sites (LTER) from the UK, France, Greece and Germany, the owners of datasets from coastal stations, and finally a five-partner SeaDataNet team (see p46) for linking us to the oceanographic community.

By what means does Micro B3 analyse the genetic makeup of marine microbiology? Have your efforts uncovered any novel characteristics that may be of benefit to commercial applications?

With Marine Genomics we mine data, not resources. Using next-generation sequencing technologies this can be achieved quickly and efficiently. Strong arguments for using marine resources are the high bio- and chemical diversity in the sea, where many bio-active substances are in use in the fight for survival. However, sufficient quantities are difficult to obtain, expensive to extract, and any long-term harvesting of commercially useful amounts is neither sustainable nor guaranteed over time. Mining of genomic data is therefore an efficient and environmentally friendly alternative.

Could you explain what Ocean Sampling Day is and how preparations for this are progressing?

The Ocean Sampling Day (OSD) is a highly concerted effort that will be conducted in parallel on the summer solstice (21 June) in 2014 at numerous marine stations. It will use best practices developed, discussed within Micro B3 and tested during pilot OSDs in 2012 and 2013, and further refined during a summer school shortly before. It will be based on ongoing efforts of the Genomic Standards Consortium and thus ensure a high level of consistency across sites and maximum usefulness for stakeholders.

Intense regional and Europe-wide PR work will accompany this event. An open call to select the best additional sites is envisaged in 2013/14.

How have European frameworks evolved over the years to consider the importance of marine microbes? In order to fully integrate Micro B3, what additional policy is needed?

Several small and large projects have been funded by the European Commission on national and international levels. Micro B3 is in many respects a pilot project to build appropriate capacities in bioinformatics, but also in data mining for biotechnology and modelling, as well as Intellectual Property Management (IPR). To address the latter, a group of international experts and biotech companies such as PharmaMar are integrated in Micro B3.

To conclude, can you briefly highlight your hopes for the future success of Micro B3?

In cooperation with ESF and European research infrastructure initiatives we are achieving a better understanding of the needs and wishes across disciplines. I am convinced that success of future environmental and life sciences will strongly depend on the abilities of individual researchers to work across disciplines, ranging from classical marine knowledge to bioinformatics, oceanography, biotechnology and intellectual property management. Micro B3 will develop a mutual understanding between field and computer scientists, lawyers, industrial researchers and product developers.

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