

Biotechnology and natural marine resources

Marine micro-organisms (viruses, bacteria & micro-algae) represent the largest unexploited biotechnological resource on the planet. Marine biotechnology uses marine organisms at the whole, cell, or molecular level, to provide solutions, thereby benefitting society.

Biotechnology research at Plymouth Marine Laboratory (PML) focuses on:

1. Microorganisms (bacteria)

- Novel enzymes for biocatalysis
- Anti-bacterials
- Biofouling

2. Microalgae

- Natural products for healthcare
- Biofuels
- Biotransformation

3. Viruses

- Novel enzymes for biocatalysis
- Bioprocessing

This includes the biochemistry and characterization of novel products from marine organisms, particularly bacteria and micro-algae, as well as research into the role, composition and characteristics of microbial organisms and their genomes, in particular marine bacteria and viruses. PML has also pioneered new biosensors using ultra-sensitive biomarkers of toxicity.

The following are examples of techniques applied in projects at PML, for any further information please contact us or visit www.pml.ac.uk.

PML key facts:

Approx. 130 employees & 30 post-graduate students

Revenue over £8m p.a.

Multi-disciplinary teams covering Biology, Chemistry, Modelling and Molecular Science & Services.

Access to, and culturing of, unique micro-organisms

State of the art facilities, excellent IPR management

PML Applications Ltd - wholly owned trading subsidiary to provide commercial interface

Examples of recent and on-going research at PML

Giant marine viruses

A giant marine virus has been isolated and characterised by scientists at PML which infects a chalk-covered marine phytoplankton that forms huge blooms in the Atlantic Ocean. These blooms remove billions of tonnes of carbon dioxide from the atmosphere. The research discovered that this was the first example of a virus that contains genes involved in the biosynthesis of ceramide, a compound involved in cell death and frequently used in anti-aging creams.



*Left: Satellite image of an algal bloom of SW England.
Middle: These algae are coccolithophores (E. Huxleyi);
Right: The algae are infected with novel, newly discovered viruses.*

Further studies of the many novel genes uncovered by PML scientists may lead to new therapies for aging and cancer as well as helping to understand the important role that marine micro-organisms play in climate change. [*Science*, (2005), 309, 1090]

Metagenomic studies of marine microbes

Most marine bacteria have not been identified or cultured in the laboratory because they are difficult to grow. PML scientists have been using a metagenomic approach to access the genetic information in populations of marine bacteria. This involves obtaining representative DNA sequence for most of the microbes present in a given water sample.

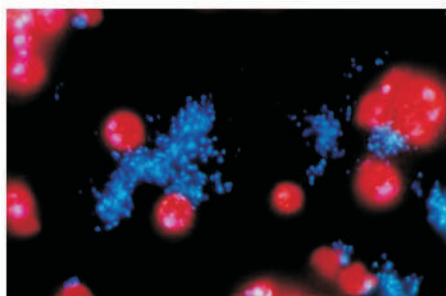
We use computer-intensive bioinformatics techniques to manage and access the enormous amount of information that is produced. A metatranscriptomics approach has then been used to determine which genes are being expressed and therefore which proteins are likely to be synthesised. From just one study of the effects of ocean acidification, we have sequenced millions of DNA fragments in which most of the genes were novel and had not been previously described. This demonstrates the incredible untapped diversity of bacterial life in the oceans.

Currently, PML scientists are investigating how these huge datasets of genomic information can be utilised in research and commercial biotechnology.

Novel approaches to the control of marine biofouling

Biofouling of ships and other marine structures is a global, multi-million pound problem. Many of the current methods of antifouling rely on toxic chemicals which cause unintended environmental harm and could therefore be banned in future.

PML scientists have discovered that a biofouling green algae actively selects surfaces for attachment. The reproductive stages (zoospores) use cues from bacterial biofilms to select a suitable surface. This process is mediated by small 'signalling molecules' produced by bacteria, in a process known as 'quorum sensing'. PML is currently investigating how zoospores detect and respond to these quorum sensing molecules and are characterising the physiological mechanisms that the zoospores use to detect the signalling process.

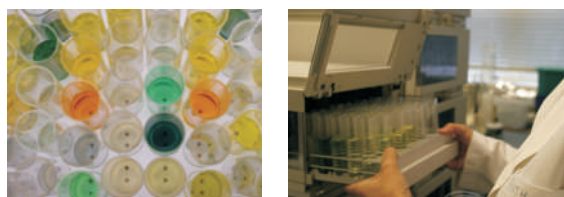


Epifluorescent image of Ulva zoospores (red) attached to a bacterial biofilm (blue). This process is controlled by quorum sensing signal molecules.

PML believes that knowledge of how algae detect and respond to chemical signals could lead to the discovery of new anti-biofouling strategies. We have isolated a number of marine bacteria that prevent zoospore settlement – biological control agents that offer great potential as a means of controlling biofouling. Currently, we are investigating the nature of the active compounds and will be engaging industrial partners in knowledge transfer to develop these novel approaches to marine biofouling.

Marine microbes as a source of novel enzymes and compounds

Marine bacteria have long been regarded as a novel source of bioactive molecules and scientists at PML have successfully isolated and characterized hundreds of novel strains with the potential for exploitation. These studies are identifying novel proteins which could improve existing industrial processes as well as providing new routes to the development of novel chemicals. A successful industrial collaboration to exploit these organisms in the search for novel enzymes for biocatalysis is currently progressing. Additionally, these bacteria are a rich source of natural products which could be invaluable in the drug discovery process within disease areas such as cancer, cardiovascular disease, ageing, obesity, and diabetes.



An array of chlorophylls and carotenoids isolated by Preparative-HPLC from a microalgal extract. These pigments form the basis of a compound library available for biotechnology screening.

Microalgae are looking good for the future

Microalgae are microscopic plants known to produce many beneficial substances with potential uses in the feed, food, cosmetics, and pharmaceutical industries. The market for health & lifestyle products developed from natural sources has grown rapidly in recent years. At PML scientists are exploiting their expertise in the biology of these organisms to produce high value extracts with proven benefits and applications to the cosmetics and skincare industry. Laboratory scale development work has been very successful and a partner organisation to distribute these products has been identified. PML scientists are actively scaling-up algal production and investigating their use in energy-related processes such as biofuels.