

RESEARCH AND OUTREACH IN MARINE BIOTECHNOLOGY: SCIENCE PROTECTING AND CREATING NEW VALUE FROM THE SEA

- More than 80 percent of Earth's living organisms are found only in aquatic ecosystems, and we know little about their biochemical characteristics. Our challenge as a nation is to discover the life-enhancing and lifesaving qualities these unique organisms possess.
- About 40 percent of coastal waters are currently unfit for swimming because of bacteria and pollutants. Our challenge is to develop the biological technologies needed to identify sources of ecological stress and develop strategies to protect and restore coastal resources.
- Understanding the dynamics of fish populations and the impact of disease is essential to manage resources. Our challenge is to develop molecular technologies that will enable scientists and managers to differentiate populations and address emerging diseases to protect fishery and ecological resources.
- Seafood-borne illness adversely affects public health and coastal economies. Our challenge is to use molecular technology to develop rapid diagnostic assays that ensure the safety of the seafood we eat and the vitality of the seafood industry.

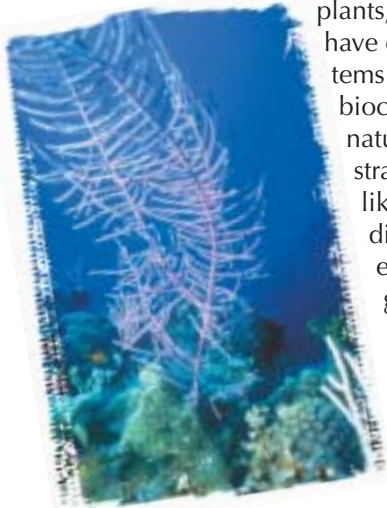


tions at extreme hot and cold temperatures. Studies of the molecular control for silicon production in marine diatoms have promising applications in the emerging field of nanofabrication. The economic potential for marine products and processes is immense.

These same technologies offer equally important opportunities in the environmental arena. The next generation of technology for monitoring biological processes, remediation of pollutants and conversion of wastes will all be linked to these new biological technologies. Current applications of molecular technology have already affected how ocean and coastal problems are managed and given us new ways to identify ecological stress in target organisms. Molecular biology has provided environmental managers, seafood processors and the aquaculture industry with an accessible toolbox that enables them to make better decisions on critical resource and economic issues.

Meeting the challenge

The biotechnology revolution has created enormous opportunities for research and economic development. The worldwide market for biotechnology-based therapeutic products alone may reach \$24 billion in 2005. While studies that extend biological technologies to the marine environment are few, they hold great promise. Marine plants, animals and microorganisms have evolved in complex ecosystems and produce many unique biochemicals. These marine natural products have demonstrated potential to treat diseases like cancer and inflammatory disorders and may prove effective against HIV. Microorganisms from extreme oceanic environments, such as thermal vents and polar regions, have provided industry with "extremozymes," which have commercial applica-



Building on a record of achievement

Sea Grant's sustained investment in marine biotechnology has placed it at the forefront of the field. Success is evident in a number of key areas:

- Pseudopterosin, an anti-inflammatory agent isolated from a marine gorgonian has a market value of \$3 million to \$4 million per year.
- Four marine natural products currently in clinical trials have a potential market value of more than \$1 billion.
- Application of the polymerase chain reaction now enables public health officials to simultaneously identify multiple microbial pathogens—including *Vibrio* and *Salmonella*—in oyster tissue in a single rapid assay.
- Contaminant-degrading microbes and metal-trapping algae are enhancing environmental remediation.
- DNA fingerprints are contributing to the management of key fisheries and identification of products.
- Molecular probes for harmful algal bloom-forming species are enabling managers to better predict potential health risks.
- Development of molecular biological tools to assess the effects of contaminants like endocrine disruptors is progressing rapidly.

Collectively, these advances provide substantive examples of the power and potential of biotechnology.

Mobilizing Sea Grant's unique resources

Sea Grant will invest in marine biotechnology to catalyze advances in marine and coastal science. If we are to reach the potential offered by these biological technologies, it is imperative that we engage current practitioners and train new researchers to take advantage of the opportunities at hand. Any effort must be coupled closely to outreach and extension activities that educate stakeholders in coastal communities nationwide.

Investing for the future

Sea Grant investments in innovative science and emerging technologies will produce strong returns. These investments will be coordinated with outreach and communication efforts designed to generate an understanding of the potential of marine biotechnology and develop links between scientists and stakeholders, including managers, industry and the public. Biotechnology provides high-paying jobs in a clean industry. The exploration of unique marine environments and new applications provide exciting educational opportunities for teachers and students alike. Our goal is to de-mystify biological technologies and the scientific process that underlies them and focus attention on the exciting new opportunities created. Key areas for investment include:

Marine Natural Products:

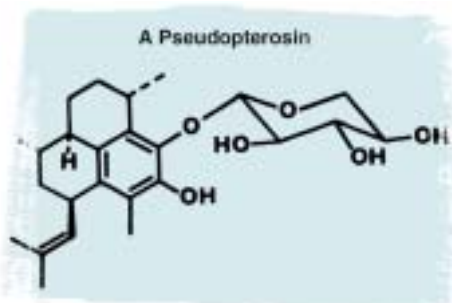
The tools of molecular and cellular biology, chemistry, pharmacology and ecology will be used to discover, evaluate and possibly synthesize innovative natural products found in marine organisms. Attention will be focused upon unique



coastal and marine environments, such as anaerobic regions of estuaries and lakes, deep-sea vents, coral reefs and arctic waters. Marshes, wetlands and even contaminant-stressed environments provide fertile grounds for novel organisms and their products. Projects will develop technologies to assure production of sufficient material for use as pharmaceuticals and in industrial applications.

Biomolecular Processes

Discovery: Research focused on the unique mechanisms used by marine organisms to generate elaborate mineralized and biomolecular structures is essential. Understanding the emerging areas of chemical signaling and signal transduction are important to enhance



our knowledge of bioluminescence, biofouling, biocorrosion, biofilm function and symbiosis. The results of such research can be used to develop antifouling and anticorrosion materials as well as create an understanding of how microbes colonize surfaces.

Marine Environmental

Biotechnology: Sensitive and accurate means of predicting impacts of stressors on marine organisms are needed to

strengthen indices of coastal ecosystem health. Sea Grant will encourage the development of novel biosensors, genome-enabled technologies (such as microarrays) and their application to real-time monitoring technologies to complement engineering and remote sensing initiatives. This research will lead to the development of effective bioremediation strategies. These will be supported by the use of molecular biology as well as innovative "green technologies" that employ biological systems engineering focused upon remediating polluted sites.

Marine Resource Management:

New tools to characterize various economically important species at the molecular-genetic level are essential for fisheries managers. Sea Grant will promote studies that identify larvae or provide fine-scale delineation of key stocks, and support applications of molecular techniques to help understand and quantify ecosystem processes.

Research will spur the identification and treatment of emerging diseases in economically important stocks and ecosystems, thus improving options available to resource managers.

Seafood Safety and

Processing: The development of molecular assays for human pathogens and aquatic organisms is vital, as is research offering new ways to identify public health issues in seafood processing. Sea Grant will help scientists and others identify clear linkages between technology development and HACCP guidelines. In addition, Sea Grant will promote the application of biological and biochemical technologies to develop value-added products and economically viable uses for wastes.



Mission

The mission of the Biotechnology Theme Team is to identify and catalyze research applying new marine biotechnologies to improve and protect human and environmental health in coastal America, and to create economic benefits nationwide by fostering the development of novel industrial processes and products.

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