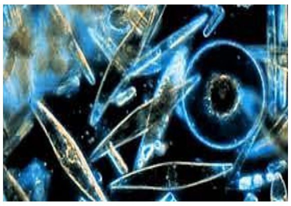
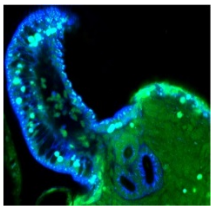
Marine Microbes: Did You Know?

What are marine microbes?

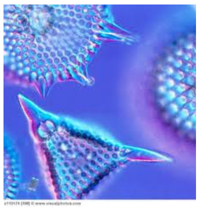
The term "marine microbe" covers a diversity of microorganisms, including microalgae, bacteria and archaea, protozoa fungi and viruses (Photo 1 to 5). These can be prokaryotes (i.e., organisms whose cells lack membrane-encased nuclei) and eukaryotes (i.e., organisms with true nuclei). These organisms are exceedingly small—only 1/8000th the volume of a human cell and spanning about 1/100th the diameter of a human hair. Up to a million of them live in just one milliliter of seawater.



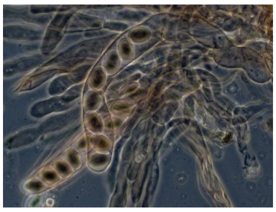
(1)Phytoplankton Diatoms (Photo NOAA)



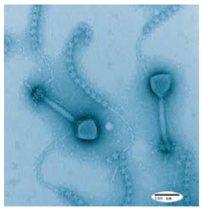
(2) Bacterium Vibrio fisheri (Photo M.McFall-Ngai)



(3) Protozoa Radiolaria (Photo Visualphoto)



(4) Ascomycete a Fungus-like Bacteria (Photo Deep Sea News)



(5) Marine Virus (Photo DOE)

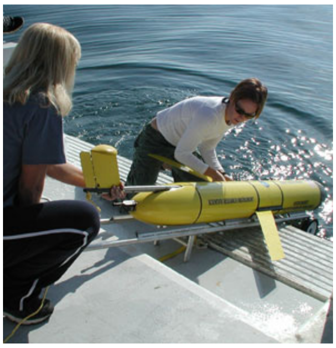
What do we know about marine microbes?

Microbes and their communities underpin the function of the biosphere and are integral to all life on Earth, yet, for the most part they constitute a hidden majority of living organisms that flourish in the sea. Nonetheless, we know that microbes are the earth's processing factories of biological, geological, and chemical (biogeochemical) interactions. Most marine microbes exist in highly organized and interactive communities that are versatile, complex, and difficult to analyze. They account for more than 98% of ocean biomass and possess as much variability as the environments they inhabit. These organisms are capable of existing in practically any environment and garnering energy from a variety of sources, ranging from solar radiation to chemosynthesis (e.g., energy generated from chemicals emerging from the subsurface of the earth). They are pervasive and play many different roles in the marine environment, from being the base of the food chain, controlling much of the flow of marine energy and nutrients, and being essential to the ocean's health. Marine microbe communities can evolve rapidly in response to environmental shifts and could be used as indicators of ocean change. In fact, marine microbes are "the canary in the coal mine" for the marine environment. In addition, they are also drivers of change in the ocean. Consequently, it is very important to acquire baseline information against which future changes could be identified.

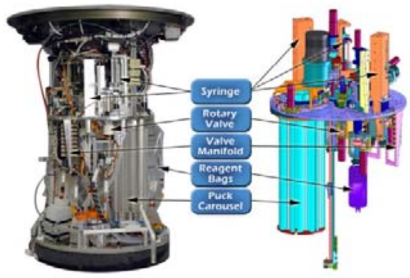
How do we study marine microbes?

Marine microbes have been studied for many years, using basic microscopy. However, much of this microbial life remains unknown because it is difficult to culture in a test tube or to observe in nature. Technology has rapidly evolved in recent years, due to what is often referred to as the "-omic revolution", with collective information from genomics, proteonomics, transcriptomics, metabolomics and metagenomics. Some of the more recent tools/techniques developed to study marine microbes include: the *in vivo* pigment spectrometer "Brevebuster" (Figure 6), the "Flow Cytobot" used for *in situ* flow cytometry, the "Nucleic Acid Sequence Base Amplification" (NASBA) for genetic detection, the "Autonomous Microbial Genosensor" and the "Environmental Sample Processor (ESP)"(Figure 7)-- both used to detect a wide range of organisms--, the Cytometric Sorting or "Multiple Displacement Amplification (MDA)," used for single cell or whole genome amplification, Meta-transcriptomics that capture gene expression patterns in microbial communities, and satellite imagery that can be used for harmful algal bloom remote detection.

"Microbes comprise 98 percent of the biomass of the world's oceans, supply more than half the world's oxygen, are the major processors of the world's greenhouse gases and have the potential to mitigate the effects of climate change. They are the cause of diseases that are suspected to be spreading due to global warming, yet paradoxically compounds they produce are potential cancer cures and solutions for combating human disease. Scientists are only just beginning to understand the important environmental roles that microbes play in marine systems - from feeding ecosystems to consuming waste and sequestering carbon." (*Australian Institute of Marine Science website*)



(6) Brevebuster (Photo NOAA)



(7) Environmental Sample Processor (Photo NOAA)

What is the role of marine microbes in the ocean?

As we learn about the diversity of microorganisms and their associated biogeochemical processes, our view of the world's ocean ecosystems is being transformed, and the relevance of microbes to ocean resiliency and marine resource management is becoming undeniable. Yet, the sheer number of microorganisms as well as their vast diversity and different functions has led to the realization that we only poorly understand the biogeochemical processes that exist on our planet. We need to advance the understanding of how emerging diseases are responding to global changes (warming, acidification, coastal urbanization, pollution, etc), and how microbial processes should be integrated into our biogeochemical and ecosystem health forecasts.

Biogeochemical processes: Biogeochemical processes control the cycling of biologically important elements, such as carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur as well as other elements of lesser importance, such as sodium, potassium, magnesium, calcium and chlorine. Microbe metabolisms are diverse, (e.g., autotrophic or heterotrophic) and can modulate these biogeochemical processes that are the foundation for primary production and the formation of new organic matter but we still know very little about their exact function. We do know, however, that marine microbes play a role in the incorporation and use of metals such as iron and copper in these major biogeochemical cycles and perform a critical function in the various ecological processes that determine the Earth's habitability.

Ecosystem health and diseases: Marine microorganisms are essential players in the health of marine ecosystems. They can have a positive influence on ecosystems' health. For example, in coral reefs, microscopic coral-specific algae live in symbiosis with the coral polyps and provide them with photosynthetic energy used by the colony for its biological functions. Over the past decades, increases in microbial abundance as well as changes in community structure and function have occurred in response to increased environmental stress mostly related to climate change and eutrophication. "Microbialization of the ocean" is the term used to describe this phenomenon. In addition, microbialization is often associated with changes in the pathogenicity of microbes leading to increases in disease occurrence of marine organisms and changes in ecosystem function and services.

Benefit from marine microbes: Marine biotechnology developments have led to the discovery of valuable natural products extracted from marine microbes that can benefit human health. Although, a large number of bioactive substances have been identified, the first drugs from the ocean were only recently approved. For example, the harmful algae *Karenia brevis* produces Brevetoxin, a very potent toxin that could aid in stroke recovery. Other potentially useful chemicals extracted from the same microalgae include Brevenal, for treating cystic fibrosis, as well as COPD and Escortin that has the potential to transform cancer treatment by escorting anti-cancer drugs directly into cancerous cells. Realization of the importance of microbes in marine biotechnology has stimulated efforts for the sustainable exploration of marine microbe resources.

Why does NOAA care about marine microbes?

Ecosystem-based management is a main focus of the National Oceanic and Atmospheric Administration (NOAA) activities. Since marine microbes are the base of the food web and the main players in ecosystem functioning and services, it is essential for NOAA to better understand their exact roles. For many decades, NOAA has been involved in marine microbial science and is presently increasing its efforts focusing on the identification of microbe diversity, number, distribution and role in the ocean.