ExploreWorldOcean, http://www.oceansonline.com/

supports ***Exploring the World Ocean***, an introductory oceanography textbook written by Sean Chamberlin, PhD, at Fullerton College, and Tommy Dickey, PhD, at the University of California, Santa Barbara.

The information below is copied from pages in the website's section, "Marine Life."

Introducing Marine Viruses

http://www.oceansonline.com/pages/marinelife/viruses.php

In the late 1980s, oceanographers, led by Jed Fuhrman and others, began to appreciate the role of marine viruses in controlling the abundance and distribution of marine bacteria. Although their status as a true "life form" is debated, their importance in the ocean merits their introduction here. Marine viruses, like other viruses, consist of small amounts of genetic material encapsulated in protein. These viral particles (20-200 nm in length) exist solely at the expense of their host: viruses have no metabolic machinery of their own. Nearly all known viruses are specific to a single species or genus and all organisms appear to be susceptible to viral infection. Viruses use their hosts to reproduce their genetic material, essentially hijacking the genome of the host cell to cause it to produce multiple copies of the viral particle. The infected host may continue to release viral "progeny" over several generations (chronic infection), the viral genome may become a "permanent" part of the host genome (lysogeny) or the virus may kill the host, causing the host to explode as a means for releasing copies of its viral progeny (lytic infection). **Viral lysis**, the bursting of host cells by viral reproduction, may result in the mortality of 10-40% of marine bacteria. Thus, viruses may play a significant role in controlling populations of marine bacteria under certain conditions. One consequence of viral lysis is the release of dissolved organic matter which may stimulate the activity of surviving marine bacteria. Much remains to be learned about marine viruses but their importance in marine food webs has now been accepted.

Introducing Marine Bacteria

http://www.oceansonline.com/pages/marinelife/bacteria.php

For nearly 2 billion years, marine bacteria ruled the Earth. During the Age of Bacteria (from ~3.5 – 1.8 bya), all of Earth's biogeochemical cycles were established. But for bacteria, Earth's material resources would have been bound into an irretrievable form a long time ago. Yet while the role of bacteria as "nature's recyclers" is well-appreciated, less well known is their importance as a food source. Nourished by pools of dissolved organic carbon, marine bacteria play a central role in marine food webs providing nutrition to a host of small microorganisms. In doing so, they "recapture" energy in the form of carbon compounds that might otherwise be lost to the system. This **microbial loop**, the component of a marine food web that recycles minerals (e.g., regeneration of biologically important nutrients) and captures carbon and energy from dissolved organic matter, represents an integral component of marine food webs, especially in the open ocean. In recognition of their importance in the world ocean, oceanographers now often refer to water column bacteria as **bacterioplankton** ("bacteria drifters"). To this ever-growing list of accomplishments among marine bacteria, we must also emphasize their role as autotrophs, producers of organic matter (aka primary producers). **Photosynthetic bacteria** abound in the world ocean. In fact, oceanographers estimate that the contribution of photosynthetic bacteria to primary production exceeds that of all other primary producers in the ocean.

Much of what we know about marine bacteria has emerged since the 1980s. The application of molecular biology techniques to studies of marine bacteria has advanced considerably our knowledge of their diversity and distribution, but much remains to be learned regarding the types and scales of their metabolic activities. One of the major puzzles concerns the discrepancy between marine bacteria that can be cultured and those that cannot. As far back as 1959, oceanographers recognized that the number of bacteria appearing under a microscope was far greater than the number that grew out on agar plates, a type of solid, nutrient-enriched sterile medium designed to study bacterial growth. This “great plate count anomaly”, as it came to be known, remained a puzzle until ocean genomics revealed a diverse suite of marine bacterioplankton. Intriguingly, the most abundant gene sequences (specifically, ribosomal DNA genes) found in the world ocean belong to groups that can not be cultured in a laboratory.

On the basis of gene sequencing, eleven major groups of bacterioplankton are recognized in the world ocean, including the two groups of Archaea. Of these, only two groups contain species that have been cultured. Little is known about the most abundant group, discovered in 1990 and known simply by its gene cluster, **SAR11**. Its presence throughout the world ocean from shallow lagoons to the deep ocean suggests this “species” may be the most abundant marine bacteria in the world ocean. The ***Roseobacter*** group has been found throughout the world ocean and represents one of two culturable marine bacteria. While they exhibit diverse metabolic modes that change with environmental conditions, they all appear to utilize organic or inorganic sulfur compounds. Nevertheless, their ecological role remains uncertain. Perhaps the most well-known marine bacteria are the other culturable group, the **cyanobacteria** (literally, the blue-green bacteria), the dominant member of the **picophytoplankton** (see Table above). Unseen in the world ocean until the late 1970s, cyanobacteria are now believed to be the most abundant and possibly the most productive photosynthetic microorganisms on Earth. Two major groups of cyanobacteria can be found in the world ocean. The cyanobacterium ***Synechococcus*** (sin-eh-ko-KOK-us), discovered by John Waterbury in 1979, measures 1.5 – 2.5 µm in size. It seems to prefer high-light, tropical and subtropical waters, like the Sargasso Sea, although it may be found throughout the world ocean, including polar regions. Its cousin, ***Prochlorococcus*** (pro-chlor-oh-KOK-us) was found by Penny Chisholm in 1988 and measuresless than 0.7 µm in diameter (about 1/100th the width of a human hair), making it the smallest known photoautotroph on Earth. *Prochlorococcus* has been found to inhabit waters between 40º N – 40º S (cold temperatures may be lethal) in at least two **ecotypes** (genetic variants): one that prefers high light and one that prefers low light. Both species appear to have very small genomes yet exhibit considerable plasticity in their ability to adapt to varying oceanic conditions. Both ecotypes may be capable of nitrogen fixation and **heterotrophy** (i.e., metabolizing organic substrates).

Though our knowledge of bacterioplankton species is limited, we do know that they inhabit different layers in the water column. We also know that bacteria associated with suspended particles are different from free-living types. As oceanographers are better able to attribute biochemical transformations and rate processes to specific groups of marine bacteria, our knowledge of their ecological roles will grow. We have much to learn and the future holds great promise for this exciting and rapidly growing field of oceanography.

Introducing Marine Archaea

http://www.oceansonline.com/pages/marinelife/archaea.php

There is a growing body of evidence that the first forms of life originated and evolved in extreme environments, like hydrothermal vents. The perfect candidate for such an existence is the **Archaea**, a group of "ancient" microbes commonly found in the most hostile environments on our planet. Archaea inhabit the hot acidic pools of Yellowstone, the salt flats of San Francisco and the deep-sea vents on the Juan de Fuca ridge. Oceanographers have even discovered subterranean forms of Archaea that live in the fluids and rocks beneath the sea floor. Though widely known as extremophiles, Archea have been discovered throughout the water column in the world ocean. The abundance of these **pelagic Archaea** rivals that of marine bacteria.

Some scientists prefer the term Archaea instead of Archaebacteria because these microbes differ substantially from bacteria. Their cellular and genetic makeup exhibit some similarities to eukaryotic cells, the type of cells that comprise all forms of life except bacteria, including humans.

Two major groups of Archaea are commonly recognized: the **Crenarchaeota** and the **Euryarchaeota**. The Crenarchaeota include the **thermoacidophiles**, the hot- and acid loving microbes that thrive in warm-to-hot, acidic, sulfurous environments (e.g., Yellowstone Park). This group, comprised of several species, may tolerate temperatures as high as 110 degrees C; most die at temperatures approaching the human body temperature (37 degrees C). These organisms may use elemental sulfur as an energy source to fix carbon dioxide, a form of metabolism called **chemolithoautotrophy**. They may also utilize simple organic molecules, a form of heterotrophy**.** Thus, these organisms are classified as **facultative autotrophs** (meaning they are capable of autotrophy but do not depend on it exclusively).

The Euryarchaeota include two groups of microbes living in quite different habitats, the methanogens, who live in anaerobic sediments, and the extreme halophiles, who live in extremely salty environments. The **methanogens** produce methane in the absence of oxygen, i.e., anaerobically, and are responsible for at least 90% of the world's natural gas supply, as well as swamp gas and **gas hydrates,** the frozen deposits of methane found on the sea floor. Because of their intolerance of oxygen, methanogens are found in anaerobic sediments (in shallow or deep waters) and in the guts of animals, like cows. Methanogens are unable to use proteins, carbohydrates and sugars, like most organisms. Rather, they utilize hydrogen gas to reduce ("fix") carbon dioxide. Their conversion of the organic breakdown products of other organisms serves one of the most important roles on Earth: the return of buried carbon to the atmosphere (as methane which quickly reacts or is converted by organisms to carbon dioxide). Without methanogens, there would be no carbon cycle, oxygen would build up in the atmosphere and Earth would experience uncontrollable fires! The **halophiles** are salt-loving microbes, found in hypersaline springs and lagoons and salt flats, like those that border San Francisco Bay. They may be observed as a pinkish tinge in a salt flat, a color that results from pink pigments (carotenoids) that allow them to tolerate intense sunlight. These microbes require sunlight to carry out a form of **non-oxygenic photosynthesis** (using bacteriorhodopsin, a bacterial photosynthetic pigment) that allows them to synthesize the energy-carrying molecule, ATP. Otherwise, halophiles respire oxygen and are considered heterotrophs.

Both groups also include pelagic Archaea of which little is known. The contrast between these free-living water column forms and the extreme forms tells us we have much more to learn about the physiology and ecology of these microbes. Clearly, these microbes extend their range beyond extreme habitats and make use of alternative energy sources and metabolic pathways. Pelagic non-thermophilic crenarchaeota may comprise up to 20% of all the world's ocean picoplankton (organisms with a size range from 0.2 - 2 µm) (Karner et al., 2001).