FIGURE 1–2

The Greek philosopher and early marine biologist Aristotle.[2]

FIGURE 1–3

Captain James Cook, the first scientific oceanographer to make skillful measurements.[3]

In fact, nearly half of the population on our planet lives within 150 miles of a coastline. Close to one-third of the petroleum and natural gas that we use is harvested from the ocean floor. Moreover, the ocean is a primary shipping and communications route. The ocean has been utilized by humans for thousands of years.

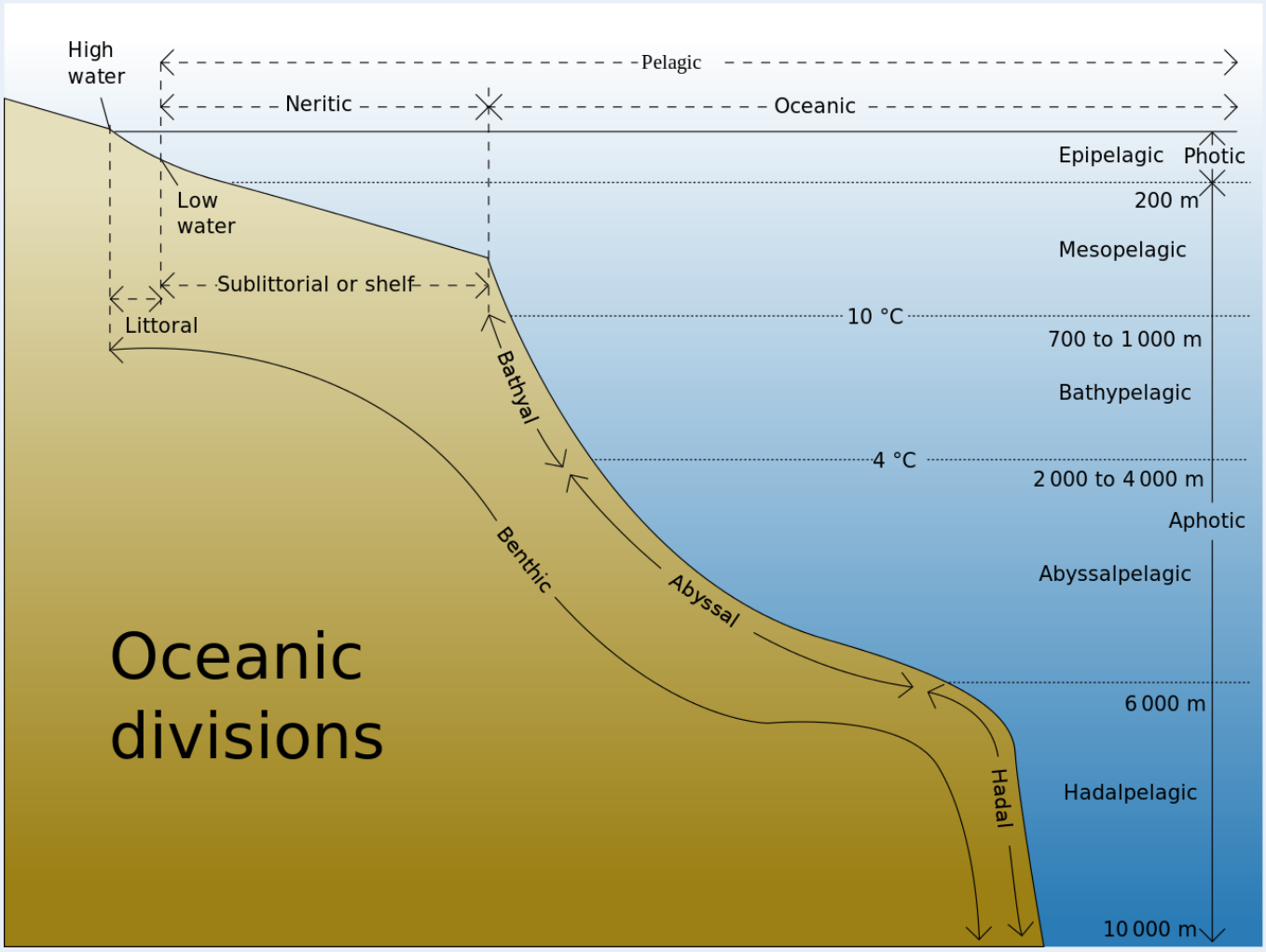
The History of Marine Biology and Oceanography

The history of marine biology and oceanography really starts with the history of voyaging. As people gained skills in seamanship and navigation, knowledge of the ocean expanded. The history of ocean exploration began with early Melanesians nearly 10,000 years ago, although early exploration was confined primarily to coastal areas. Later, ancient Pacific Islanders, who were talented voyagers, began exploring vast reaches of oceans in the Polynesian Triangle starting at least as early as 1500 BCE. These ancient Pacific Islanders were knowledgeable about marine life and had detailed information about wind, waves, and navigation patterns that had been passed down through oral traditions.

At approximately the same time, ocean exploration was also underway in the northern hemisphere. Phoenicians were among the earliest Western ocean explorers, and they developed nautical charts and thus the written record of marine biology. The Phoenicians sailed around the Mediterranean Sea, Red Sea, and Black Sea as well as the eastern Atlantic Ocean and the Indian Ocean. Ancient Greeks were also quite knowledgeable about marine life. Aristotle is sometimes considered the first marine biologist, as he described many ocean life forms and recognized that gills were the breathing apparatus of fish.

During the early Middle Ages, the formal study of marine life waned in Europe. During this time, the Vikings continued to explore the northern Atlantic and were skilled voyagers who learned about the ocean. During the Renaissance, Europeans again began to investigate the world around them. Ferdinand Magellan set sail on the first expedition to circumnavigate the globe. The advancement of scientific voyaging continued with an English sea captain, James Cook, who was a skillful navigator, cartographer, writer,

FIGURE 1–22



Oceanic divisions of the marine environment based on distance from land, water depth, and whether organisms are benthic or pelagic.[22]

enough light to see by, but not enough light to support photosynthesis. The deepest parts of the ocean are the bathypelagic, the abyssopelagic, and the hadopelagic zones. The bathypelagic zone is considered the midnight zone and extends from 1,000 to 4,000 meters. The abyssopelagic zone is considered the lower midnight zone and extends from 4,000 meters to wherever it meets the seafloor. Lastly, the hadopelagic zone is deep and dark and is the water in the trenches. The bathypelagic, abyssopelagic, and hadopelagic make up the deep-sea environment.

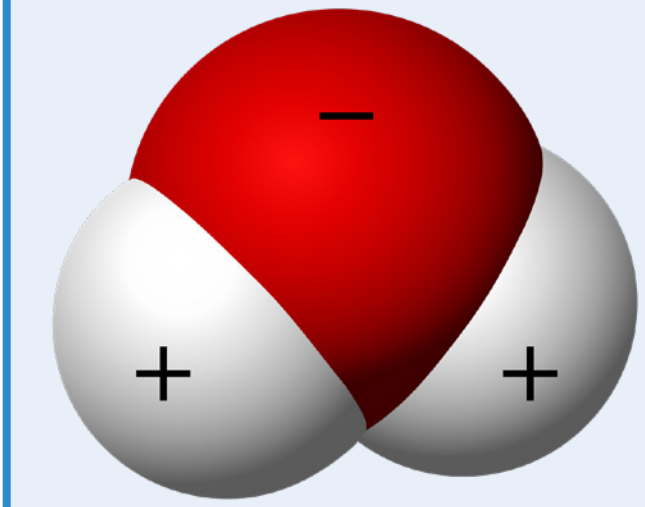
WATER AND SEAWATER

Water is all around us and is so common we often take it for granted. Water is a unique substance with few properties shared by other substances. Furthermore, the chemical properties of water are essential for life, with water being the primary component of all living organisms. Water on our planet makes life possible. In fact, when we look for life elsewhere, we look for water.

The Chemical and Physical Properties of Water

Water molecules are a compound of two hydrogen atoms and one oxygen atom. A compound is a substance that contains two or more different elements in fixed proportion. Atoms are the building blocks that make up elements. A molecule is a group of two or more atoms held together by mutually shared

FIGURE 1–23

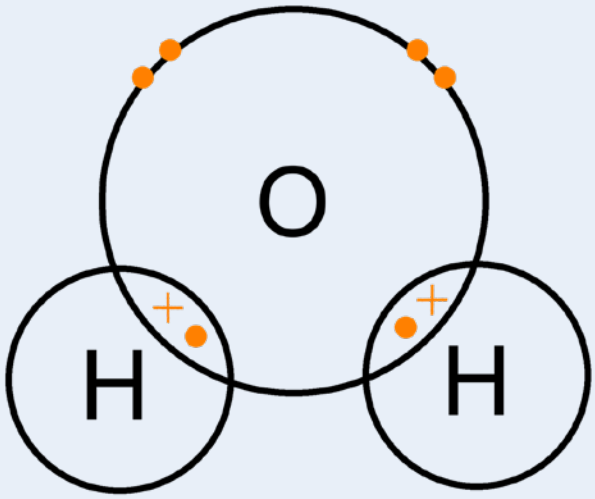


A water molecule is comprised of two hydrogen atoms and one oxygen atom.[23]

electrons. Atoms are composed of subatomic particles called protons, neutrons, and electrons. Protons and neutrons are bound together in the nucleus by strong forces. Protons have a positive electrical charge, while neutrons have no electrical charge. Electrons are found surrounding the nucleus and have a negative charge. Thus, the electrical attraction between the positively charged protons and the negatively charged electrons holds the electrons in shells around the nucleus.

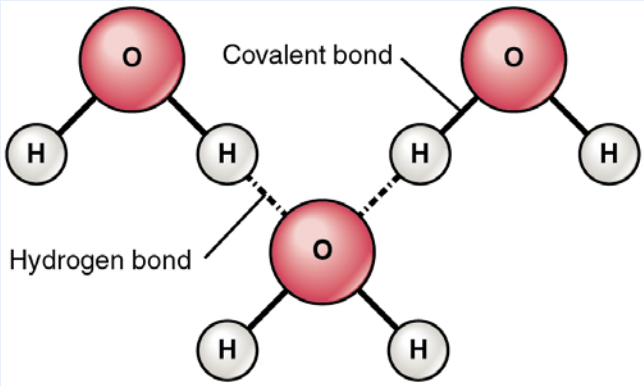
Water is a group of three atoms held together by chemical bonds. When atoms come together to form a molecule, they share or trade electrons to establish

FIGURE 1–24



Covalent bonding in a water molecule.[24]

FIGURE 1–25



Hydrogen bonds between water molecules.[25]

bonds. The chemical formula for water is H_2O, which signifies that a water molecule is composed of two hydrogen atoms and one oxygen atom. A hydrogen atom has one proton and one electron, and an oxygen atom has eight protons and eight electrons. The chemical bonds in water are covalent bonds, which are formed by shared pairs of electrons. Covalent bonds are relatively strong bonds, and thus a lot of energy is needed to break them.

The atoms of a water molecule are not bonded in a straight line, but rather they have a unique geometry which comes from the covalent bonds. The two hydrogens bound to the oxygen are separated by an angle of about 105 degrees because the oxygen atom pulls the electrons more strongly than the hydrogen atom. This angle gives a slight overall negative charge to the end of the molecule that contains the oxygen atom and a slight overall positive charge to the end of the molecule that contains the hydrogen atoms. These differences in charge across the molecule give it an electrical polarity, making water molecules dipolar. Batteries or bar magnets are common dipolar objects in our everyday lives. Somewhat like two magnets that are joined negative to positive, two water molecules can be weakly bound together at the dipolar ends via a hydrogen bond.

Hydrogen bonds between water molecules are much weaker than covalent bonds. Thus, the bonds between different water molecules are weak, while the bonds within the water molecule are strong. Although the hydrogen bonds are weaker than covalent bonds, they still give water some unique properties. In particular, hydrogen bonds between water molecules allow water molecules to cluster together and exhibit **cohesion**,

heterotrophs and autotrophs perform cellular respiration to use the energy gained from photosynthesis.

- The carbon, nitrogen, and phosphorus cycles are three major biogeochemical cycles on Earth that help cycle elements from living organisms to nonliving matter.
- Taxonomy is the study of biological classification. Organisms on Earth are currently classified into three major domains: bacteria, archaea, and eukarya. Bacteria and archaea are prokaryotes, or single-celled organisms without nuclei or organelles. Eukaryotes can be either unicellular or multicellular, but their cells have nuclei and organelles. Fungi, protists, animals, and plants are all eukaryotic organisms.
- Viruses are not included in the tree of life because biologists are not in agreement that viruses are alive, and they do not agree on where to place them on the tree of life. Viruses span the living and the nonliving.
- Bacteria are prokaryotic organisms that are structurally simple but are incredibly abundant in marine ecosystems.
- Archaea cells are small and can be spherical, spiral, or rod-shaped. Although they were originally thought to be bacteria, there is genetic evidence that archaea are more closely related to eukaryotes than to bacteria.
- Algae are an incredibly diverse group of simple marine and freshwater photosynthetic organisms that range in size from microscopic to giant seaweeds.
- Plankton are pelagic organisms that live suspended in seawater, going where the ocean goes. Plankton can be animal-like or plant-like.
- Seaweeds are multicellular algae commonly found on rocky shores and in other marine environments. Seagrasses are considered true marine flowering plants, while mangroves are land plants that tolerate salt.
- Most multicellular species on Earth are animals. More than 97 percent of these animals lack a backbone. Animals without a backbone, or row of bones called vertebrae, are called invertebrates. Animals with a backbone are called vertebrates.