

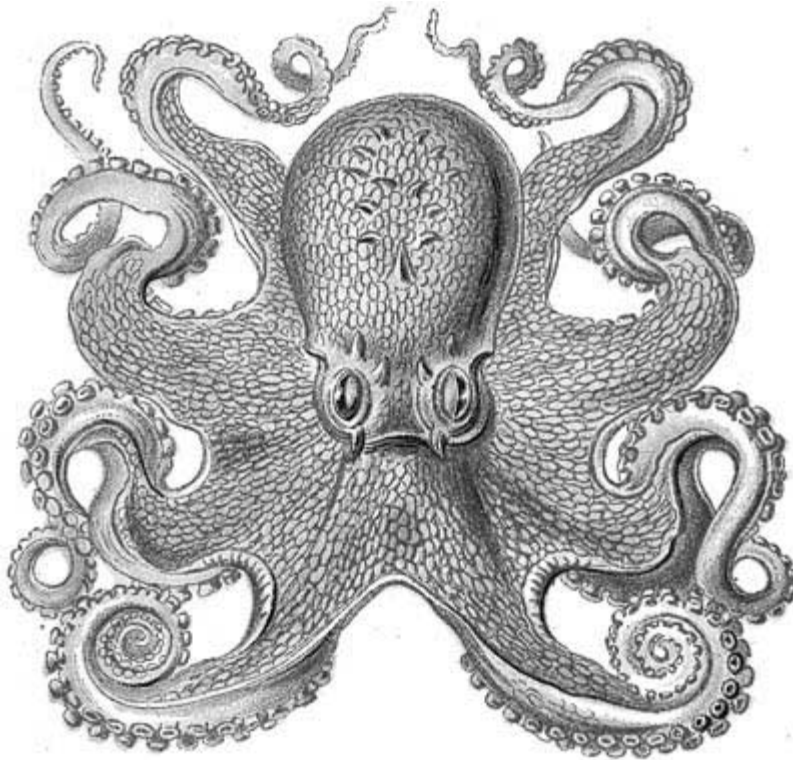
Twenty-Thousand Leagues Under the Sea

Based on the novel by Jules Verne
By Brian Meredith and Bruce Miller

Co-produced by the Carpenter Science Theatre
Company of the Science Museum of Virginia



Classroom
Study
Guide
Student Pages



Travel the oceans of the world aboard the Nautilus with Captain Nemo and his crew! What awaits you on this watery adventure?

Did You Know . . .

- . . . water covers almost three-quarters of the surface of planet Earth? Seawater makes up 97 percent of all the Earth's water. Seawater is salty. If all of the salt in the ocean were collected into a single pile, it would be larger than all the land in Africa above sea level.
- . . . the oceans are actually one continuous mass of water? The major oceans are the Pacific, Atlantic, Indian, Antarctic, and Arctic. The Pacific is the largest. It covers more surface area and has more water than the Atlantic and Indian oceans combined.
- . . . humans impact the ocean environment through their everyday activities? Even if you far inland - like Oklahoma - the water you use will end up in the ocean. So no matter how far inland you live, your life impacts life in the ocean.

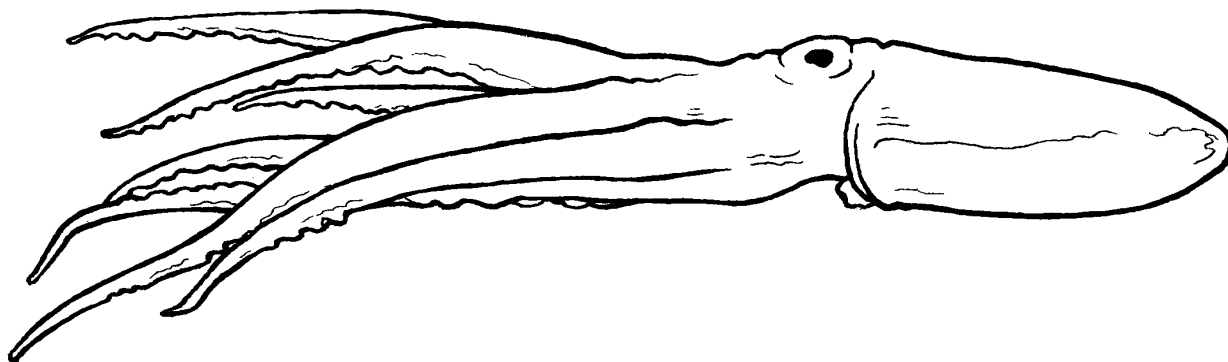
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Navigating the Treacherous Seas

Captain Nemo and his crew encounter many hazards as they travel beneath the oceans of the world in the submarine called the "Nautilus." The captain and his crew face octopi, sharks and other mysterious creatures of the deep as they journey from coral reef to the icy waters of the Arctic Circle.

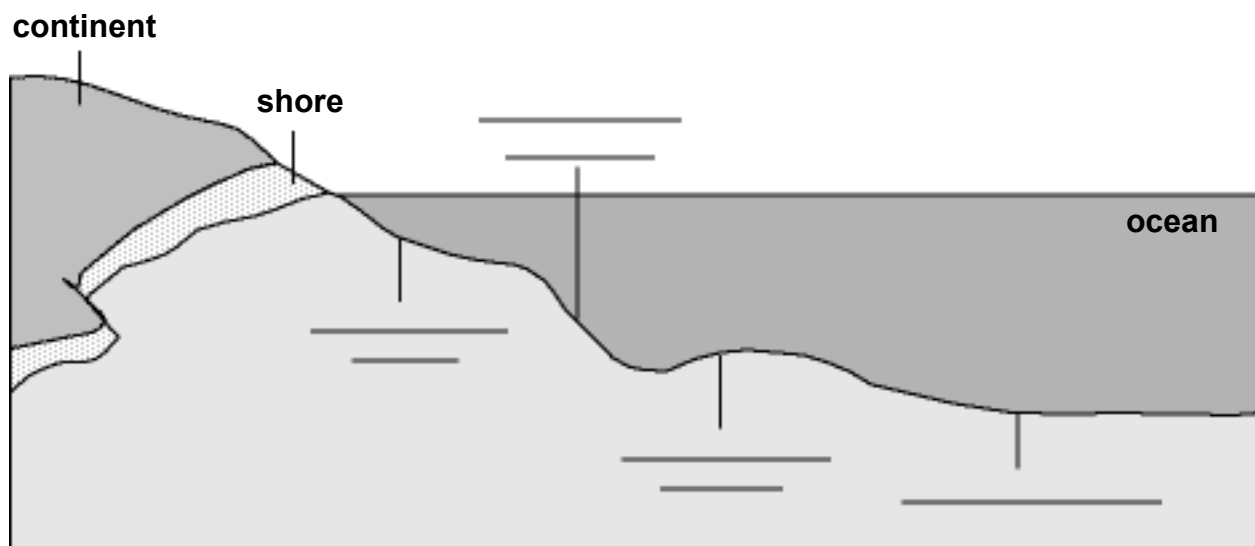


Nemo's crew must catch enough fish to eat, find fresh water, and surface often enough to keep their oxygen supply fresh - but did you know that the Nautilus must also maneuver around mountains in the oceans? The sea floor has many shapes that are similar to those on dry land. There are mountains, plateaus, plains, and trenches at the bottom of the oceans.

Just off the coast, there is a region of shallow water called the **continental shelf**. At the outer edge of this shelf, the ocean floor slants steeply down, forming the **continental slope**. The **continental rise** separates the continental slope from the ocean floor. At the very bottom of the ocean, there is an area in which sediments collect and settle into large flat areas called **abyssal plains**.



Can you find each of the bolded terms on the diagram below?



Did you know that the highest mountains and the deepest trenches in the world lie at the bottom of the ocean?

Water, Water Everywhere!

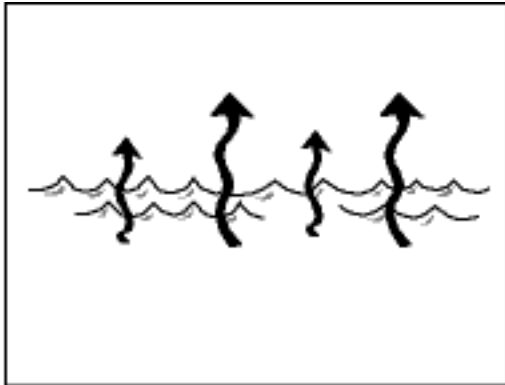
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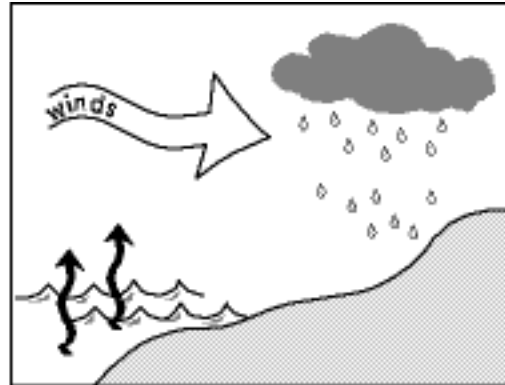
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Long ago when the Earth was fiery and new, water vapor made up an important part of the Earth's atmosphere. As the Earth cooled, water fell as rain and created the first oceans. Over millions of years, the first supercontinent, Pangaea, broke apart and the oceans we know today began to form.

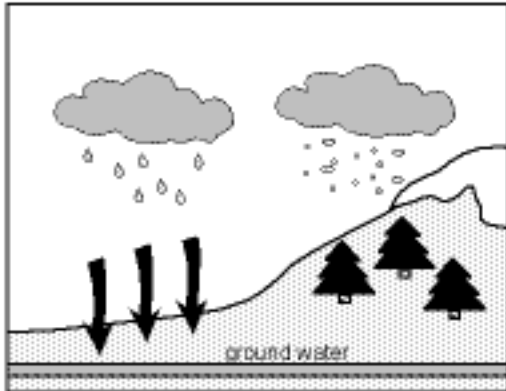
The water cycle that began many millions of years ago continues today.



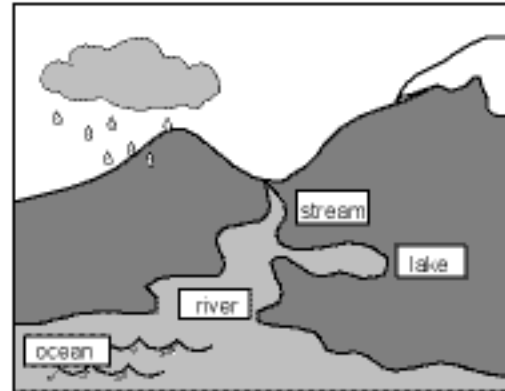
The sun's energy heats the Earth and water evaporates.



Water vapor accumulates in clouds until it cools enough to condense into water droplets.



These droplets in turn become precipitation and the cycle begins again.



Water from precipitation eventually finds its way into the world's streams, lakes, rivers, and oceans.

Water is one of the things that makes life on Earth possible. The Earth is just the right distance from the sun so that it isn't too cold or too hot; so water occurs naturally on the Earth in all three phases - ice, water and water vapor.

Water has many unusual characteristics. For example, because of the way its molecules freeze, it is less dense in its solid form than in its liquid form. This is a rare property and causes ice to float. This means that Captain Nemo and his crew must watch out for icebergs, which are large pieces of ice that have broken away from polar ice sheets or from glaciers that have formed on land.



Did you know that salt is a natural antifreeze? Try freezing a cup of salt water in your freezer at home. What happens?

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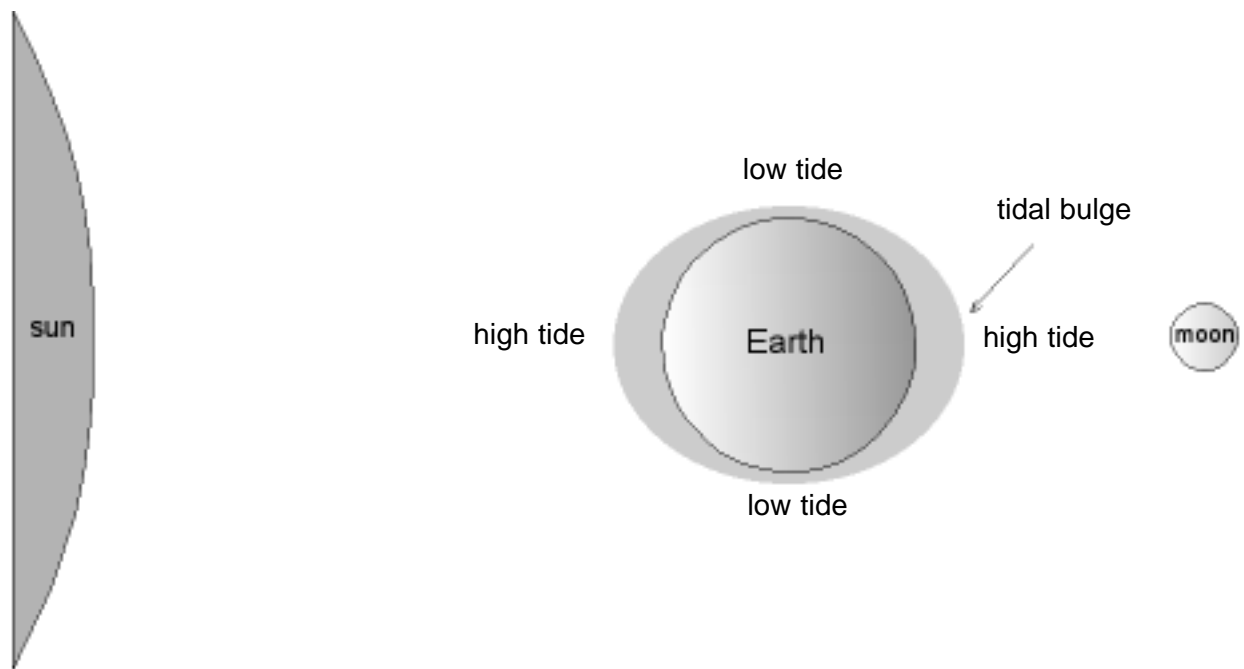
The Ocean in Motion:

Winds, Waves, Tides, and Currents

The water of the world is always in motion - not just because of the water cycle, but because of the waves, tides and currents that move through the water.

Waves are formed by the friction produced by the wind blowing across the surface of the water. Water molecules are lifted by the wind and then sink as gravity pulls them back down. This up and down motion creates the **crests** and **troughs** that make up waves. Although the water in a wave looks as if it is moving forward, it's actually the energy of the wave that moves forward. Try watching a cork floating on a wave. The wave rolls forward, but the cork just bobs up and down.

Tides are caused by the motion of the Earth and the pull of gravity.



The moon pulls the Earth's oceans toward it, causing a bulge in the ocean nearest the moon. This bulge is called a **high tide**. The same gravitational force also pulls the solid Earth just a little bit away from the water on the far side of the Earth. This slight shift of the solid Earth - combined with the "sloshing" effect that results from the Earth's movement through space - makes a matching bulge on the far side of the Earth and causes a second high tide.

The water in between these two bulges becomes slightly flattened. These flattened areas are called **low tides**. Because the Earth spins on its axis, most coastal areas of the Earth have an average of two high tides and two low tides every day.

The sun's gravitational pull also affects the Earth's oceans. When the sun is lined up with the moon during a new moon or a full moon, the greater gravitational pull on the Earth causes the highest and lowest tides. These happen about twice a month and are called **spring tides**.

Currents are like rivers that move through the sea! Warm surface waters from the equatorial regions move toward the colder polar regions. As the warm waters cool, they sink and create the deeper ocean currents that move back toward the equator. The cold water becomes warm again and rises - and the cycle begins again.

Denizens of the Deep

The oceans of the world are home to an amazing variety of life. Just as on land, living creatures must depend on the habitats around them for their survival. Microscopic phytoplankton, floating plants that trap the sun's energy through photosynthesis, form the base of the ocean food web. These plants are eaten by tiny animals called zooplankton, which are eaten by small fish such as herrings. The small fish feed larger fish, which are, in turn, eaten by other predators.

There are thousands of predator-prey relationships in the world's oceans. Orcas, or killer whales, are sometimes called the "wolves of the sea." They hunt in packs to bring down prey that include fish, sea lions, squid, and other marine creatures - including other whales!

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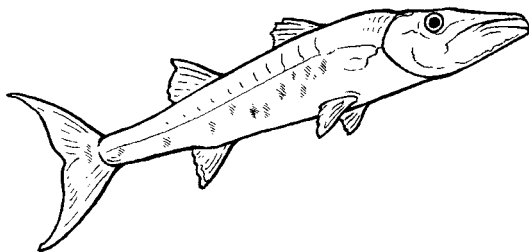
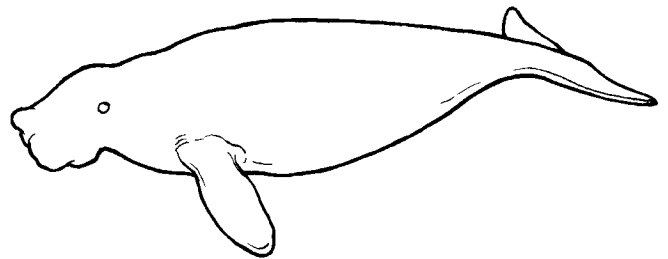
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Herbivores! Carnivores! Omnivores!

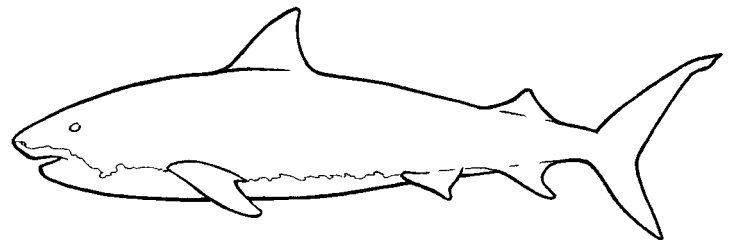
There are animals adapted to almost every habitat and ecological niche in the sea.

The gentle dugong is an example of a **herbivore** (plant eater). Dugongs live mostly in the Pacific and Indian Oceans where they feed on sea grasses.



The **carnivores** (meat eaters) include deadly hunters such as sharks, dolphins and barracuda.

Many ocean creatures are **omnivores** that eat both meat and plants. Tiger shark, for example, eat almost anything, even junk like tin cans!



Producers! Consumers! Decomposers!

Each animal in the sea is adapted in unique ways. Plants, including kelp, are **producers** because they can use the sun's energy to make food. **Consumers** are animals that depend on the plants and other animals for food. There are also **decomposers**, such as the colorful bristle worm, that clean up dead plants and animals, eventually returning these nutrients to the ecosystem.

THEATRE IV

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