THE MOVEMENT OF OCEAN WATER

The movements of water in the world's oceans dramatically affect local and global climates. Their motions are complex and are affected by a number of physical factors, including the temperature of the water and the spin of the Earth on its axis.

Understanding Ocean Waves

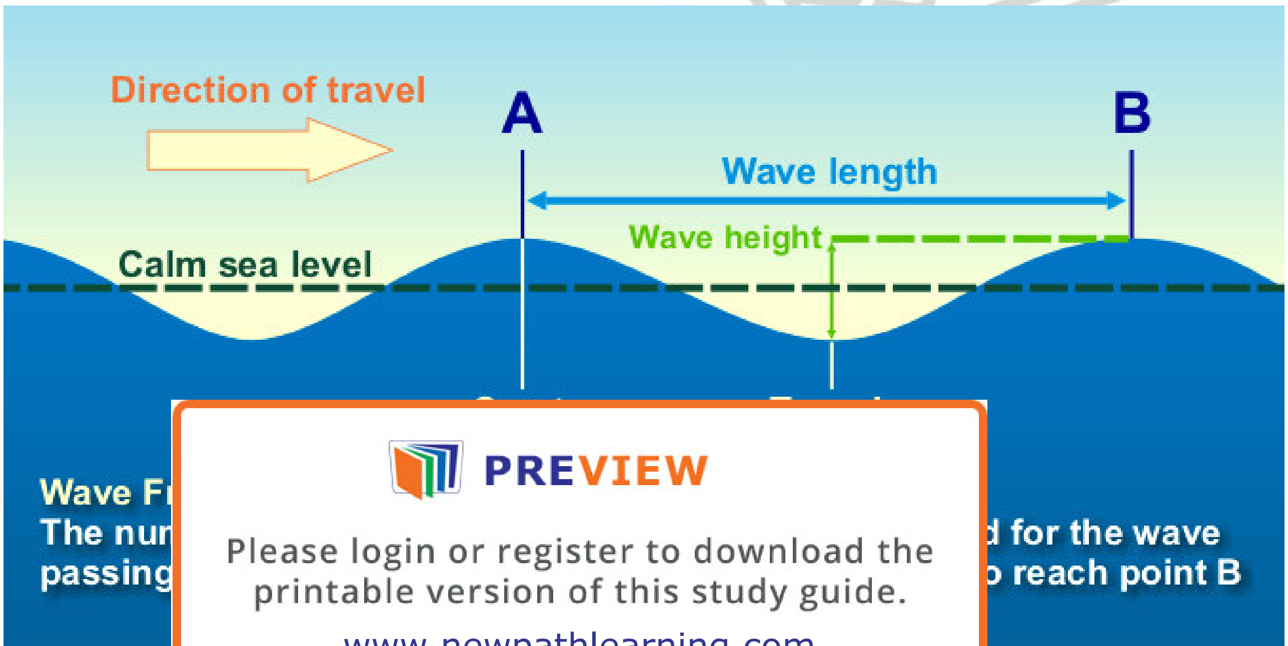
In order to understand the effects of waves it is important to first understand the structure and movement of waves. A **wave** is not so much moving water as it is energy moving *through* the water. As the wave energy moves through the water, the water itself stays in place and moves in a circular motion. It is easy to think that a wave is an amount of water that itself moves from deeper to shallower parts of the ocean. A wave, however, is actually energy that is moving through the water, and the water responds to the energy, but stays in place.

(Scientists have discovered, however, that there is a slight forward movement of water, especially with larger waves. This is probably due to the friction between the wind and the surface of the ocean.)

The anatomy of waves determines the effect they will have on a shoreline as they come near shore. The **crest** of a wave is the highest point of the wave. The lowest point of a wave is the **trough**. The distance between two adjacent crests is the **wavelength**. The **wave height or wave amplitude** is the distance from the crest to the trough. The **wave frequency** is the number of waves that pass a given point each second. The **wave period** is the amount of time it takes for the crest of one wave to travel to the crest of the next adjacent wave (that is from A to B on the graphic). The **wave period** is used to determine the speed of a wave. The speed is calculated by dividing the wavelength by the wave period.

$$\left(\frac{\text{wavelength}}{\text{wave period}} = \text{wave speed.}\right)$$

Fast waves, therefore, have long wavelengths and short wave periods; slow waves have short wavelengths and long wave periods.



Shallow-water waves are taller and more pronounced than **deep-water waves**. Deep-water waves become shallow water waves when the depth from the wave crest to the ocean floor is ½ the wavelength of the waves. This is because the waves begin to "feel" or make physical contact with the bottom. This causes the wave to slow down and the peak to grow higher. When the peaks get high enough they become unstable and fall or **break** forward.

Waves generally make contact with a beach at an angle. Once the water has washed up onto the shore, it returns to the ocean at a 90 degree angle to the shore. This repeating pattern of waves washing in at an angle and leaving the beach at 90 degrees moves sand particles down the beach. This also creates a current that runs roughly parallel to the shore. This is called a **longshore current**.

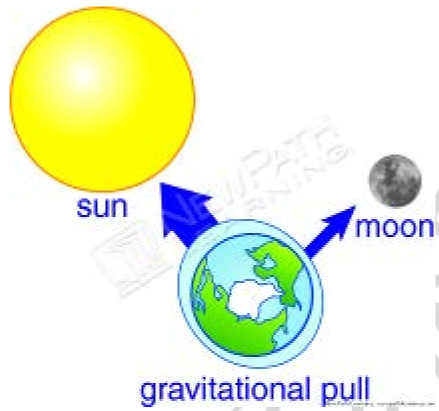
There are some extraordinary waves that occur under extraordinary circumstances. When an earthquake is centered under the ocean, the P-wave energy from the earthquake travels through the water. This enormous energy creates waves of tremendous size. These waves are extremely destructive when they hit land. A wave created by an underwater earthquake is called a **tsunami**. Tsunamis have exceptionally long wavelengths and very short wave periods. The result is waves that can travel at over 500 miles per hour! They are dramatically destructive.

Lesson Checkpoint:
What is a wave?

Tides

Waves are created by wind energy blowing across the surface of the ocean (the one exception being tsunamis created by earthquake energy centered in the ocean crust). **Tides**, by contrast, are the regular swelling of the oceans caused by the gravitational pull of the moon and ... h closest to the mo... **w tides** occur in th... n. This is called **gra**... the level of the oce... **tidal range**.

Different high tides are produced depending on the relative positions of the Earth, sun and moon. A **spring tide** occurs when the sun, moon and Earth are all in line with each other. Spring tides are higher than other high tides because the gravitational pull of the moon and the sun on the oceans adds together to create larger gravitational deformation of the ocean water. A **neap tide** occurs when the sun and moon are at a 90 degree angle with each other relative to the Earth. In this case the gravitational pull of the sun works against the gravitational pull of the moon resulting in a lower high tide.



Spring tides occur every 14 days. Neap tides occur 7 days after a Spring tide and then the Neap tide repeats every 14 days as well.

During exceptional storms such as hurricanes, the hurricane-force winds can actually push more water onto shore than would rise during a high tide. This is known as a **storm surge.**

Ocean Currents

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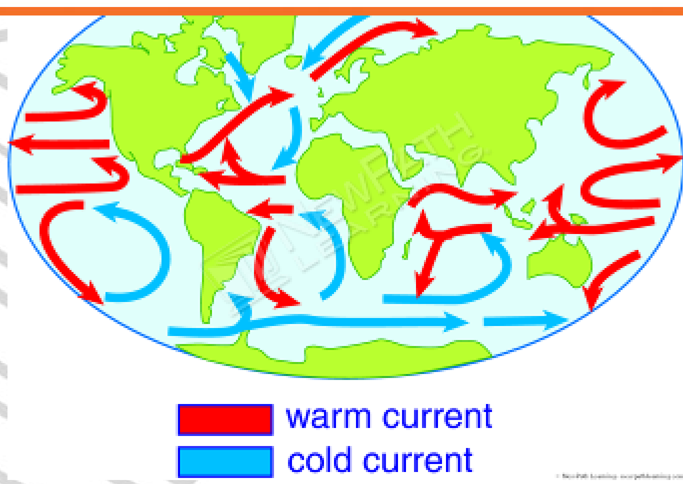

In general, the surface currents in the Northern hemisphere move in a clockwise direction. In the Southern hemisphere, they move in a counterclockwise direction. These surface currents are created by the direction of the prevailing winds blowing in these regions. Prevailing winds blow across the oceans' surfaces, and so we would conclude that surface currents move in a relatively straight line.

The rotation of the Earth on its axis, however, causes the surface currents to curve. This is called the **Coriolis effect**. The motion of surface currents is also affected by the continents that deflect the currents as they come into contact with the continental margins.

Ocean currents that are not affected by wind or the Coriolis effect move far below the oceans' surface, right down to the ocean floor. These currents are called **deep ocean currents**. They are created by temperature and density differences in the water. For instance, cold polar surface waters are denser than warmer tropical waters. Cold, dense water settles toward the ocean floor. As it does it gets colder and denser. This deep, cold water moves from the poles toward the equator. As it reaches more tropical regions, the deep water begins to warm. Warmer water is less dense so it begins to rise toward the surface. When this water reaches the surface it becomes surface water and travels in surface currents. And around and around the water flows in this interaction of surface and deepwater currents.

Temperature changes the density of ocean water. Changes in salinity also change its density. As ocean water freezes at the poles, the salt does not freeze into the ice; it remains in the ocean water. The more ice that forms, the more salt that remains in solution in the remaining ocean water. This ocean water is, therefore, more dense. This is another reason that ocean water at the poles sinks toward the ocean floor and moves in deepwater currents.

Currents have a moderating effect on the climates of the continents they move past. For example, as the Gulf Stream waters move from the equator toward the North Atlantic Ocean, they bring warmer water toward England. This raises the air temperature so that it is higher than it would be without these currents. By comparison, Southern California can be very hot, particularly in the summer months. But the Cold-water current from the North that travels southward along the California coast makes the air cooler than it would otherwise be.

Ocean temperature differences can even have global consequences. Due to the build up of warm water in the western Pacific Ocean, there is an upwelling of cold water in the eastern Pacific. A periodic change of the position of these cold and warm surface waters is called El Nino. These dramatic changes in surface water temperatures can cause widespread climatic changes affecting seasons and even hurricane activity.

The world's oceans are dramatic and dynamic and are constantly in motion. waters are moving, af .