FYI

Tides — Nature's Tug of War

Figure 3-8: Diagram of Earth's tides in the Earth-moon system. (NOT to scale; neither the distances between nor the sizes of the worlds or the tides are to scale.) The gravitational force of the moon is primarily responsible for producing two tides per day in most parts of the world.

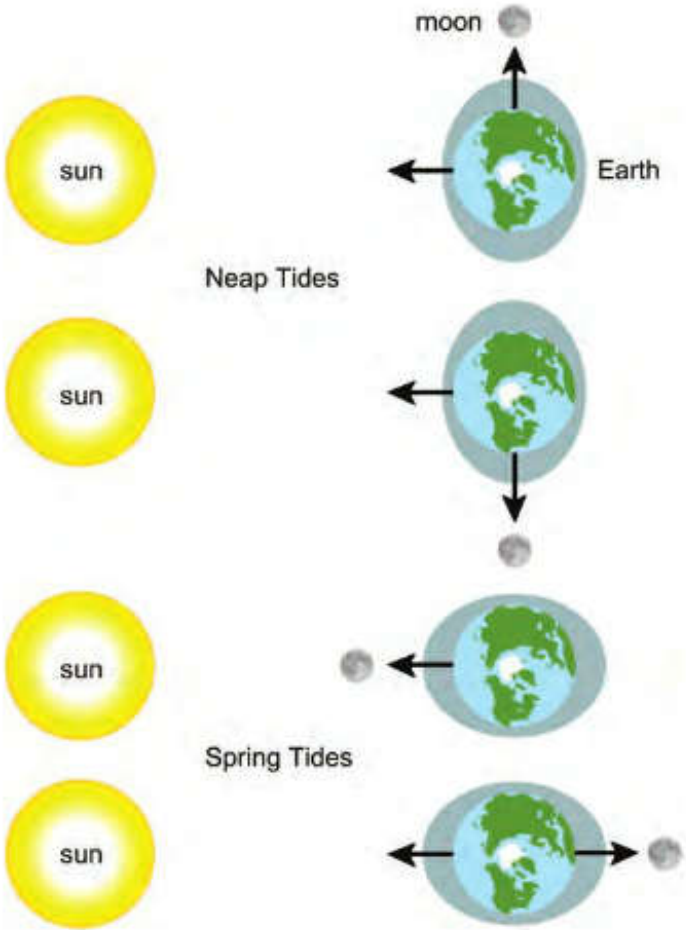

Figure 3-9: Diagram of Earth's tides in the sun-Earth-moon system. (NOT to scale; neither the distances among nor the sizes of the sun, Earth, moon, or tides are to scale.) When gravitational forces of the sun and moon are aligned, spring tides result. When the sun and moon are at angles to each other, the net force pulling on the ocean water is reduced.

The regular pattern of the rising and falling of Earth's ocean surface is called **tides**. The gravitational forces exerted by the sun and moon upon Earth cause tides. The moon is much closer to Earth than to the sun, but the sun is massive compared to the moon. Since the sun is 389 times farther from Earth than the moon is, the moon's influence on the tides is much greater. The tidal force of the sun is only 46% of that produced by the moon. In most parts of the world, there are two tides per day, about 12 hours and 25 minutes apart. The reason there are two tides per day instead of one has to do with the nature of gravitational force.

The strength of the pull supplied by gravitational force decreases with increasing distance. Therefore, as the ocean surface is closer than the ocean floor to the moon, the water is pulled up toward the moon away from the ocean floor. On the opposite side of Earth, the sea floor, which is effectively attached to the center of Earth, is pulled more strongly toward the moon than the water on the surface, leaving a bulge of water rising away from the moon.

Even though the sun is far away, it still produces a significant tidal effect on Earth. The strength of the tidal pull felt by oceans is the sum of the pulls of the moon and the sun. If the sun and moon are aligned, as they are when the moon is new or full, a larger tide, called a **spring tide, occurs**. When the sun and moon are at right angles to each other as they are when the moon is in a 1st or 3rd quarter phase, a smaller tide, called a **neap tide, occurs**.

Although it might appear that there should be two tides everywhere on Earth, and that they should be about the same height, this is almost never the case. Since the moon is not lined up with Earth's equator, one tidal bulge may be entirely in the northern hemisphere while the other is in the southern hemisphere. Also, the continents prevent the tidal bulges from simply following the moon. In addition, the shape of each ocean basin gives it a different pattern of tides. In the North Atlantic, tides cycle in

Figure 3-10: Images of the Bay of Fundy at high (top) and low (bottom) tides. Tides in the Bay of Fundy can change dramatically in just a few hours.

a counterclockwise direction every 12 hours or so, much like water sloshing in a gigantic bowl. In parts of the Gulf of Mexico, there is only one high and one low tide per day. These are called daily or **diurnal tides**. In the Pacific Ocean, there are two tides, but they are never the same height.

Also, the moon is not always the same distance from Earth. Thus, tides are a little higher when the moon is closest to Earth in its orbit and lower when the moon is farthest away.

Local topography can also affect the magnitude of tidal change. Where water is restricted in narrow channels, large differences in water height can be observed between high and low tides. One location famous for its tides is the Bay of Fundy. The length of the Bay is just such that the tidal waves increase in amplitude, much like when water being splashed or churned up in a bathtub gets higher and higher with more vigorous motion. In the Bay of Fundy, the difference in water height between tides can be over 12 meters.

Checking In

1. What factors influence the occurrence of tides in a particular location?
2. Explain how the tides would change if Earth did not have a moon.