

## APPLYING THE LAW OF GRAVITATION

For about six hours, water slowly rises along the shoreline of many coastal areas and culminates in a high tide. The water level then slowly lowers for about six hours and returns to a low tide. This cycle then repeats. Tides take place in all bodies of water but are most noticeable along seacoasts. In the Bay of Fundy, shown in **Figure 8**, the water rises as much as 16 m from its low point. Because a high tide happens about every 12 hours, there are usually two high tides and two low tides each day. Before Newton developed the law of universal gravitation, no one could explain why tides occur in this pattern.

### Did you know?

When the sun and moon are in line, the combined effect produces a greater-than-usual high tide called a *spring tide*. When the sun and moon are at right angles, the result is a lower-than-normal high tide called a *neap tide*. Each revolution of the moon around Earth corresponds to two spring tides and two neap tides.

### Newton's law of gravitation accounts for ocean tides

High and low tides are partly due to the gravitational force exerted on Earth by its moon. The tides result from the *difference* between the gravitational force at Earth's surface and at Earth's center. A full explanation is beyond the scope of this text, but we will briefly examine this relationship.

The two high tides take place at locations on Earth that are nearly in line with the moon. On the side of Earth that is nearest to the moon, the moon's gravitational force is *greater* than it is at Earth's center (because gravitational force decreases with distance). The water is pulled toward the moon, creating an outward bulge. On the opposite side of Earth, the gravitational force is *less* than it is at the center. On this side, all mass is still pulled toward the moon, but the water is pulled least. This creates another outward bulge. Two high tides take place each day because when Earth rotates one full time, any given point on Earth will pass through both bulges.

The moon's gravitational force is not the only factor that affects ocean tides. Other influencing factors include the depths of the ocean basins, Earth's tilt and rotation, and friction between the ocean water and the ocean floor. The sun also contributes to Earth's ocean tides, but the sun's effect is not as significant as the moon's is. Although the sun exerts a much greater gravitational force on Earth than the moon does, the *difference* between the force on the far and near sides of Earth is what affects the tides.

**Figure 8**

Some of the world's highest tides occur at the Bay of Fundy, which is between New Brunswick and Nova Scotia, Canada. These photographs show a river outlet to the Bay of Fundy at low and high tide.

