Lesson: Gravity and Tides

Overview & Objectives

This kinesthetic learning activity will help students learn about the Earth's tides by acting them out. Students will learn about the gravitational forces of the sun and moon, lunar phases, and vocabulary describing the tides.

- **Students will understand how the gravitational pull of the moon and the sun, along with differential gravitational forces, affect the ocean's movements.**
- **Students will learn the phases of the moon and vocabulary describing tides.**

Area of Study: **Watershed Studies**

Grades: **3 – 8**

Subjects: **Marine science and astronomy**

Time: **30 minutes**

Materials

- **Rubber bands (one for each student)**

Vocabulary

- **See background information, below**

Preparation

- **Gather materials**

Activity

- To begin the conversation about the causes of tidal movement, ask these questions. The answers are in parentheses.

  What makes waves on the ocean? (Wind)
  What are tides? (The tide is the cyclic rising and falling of Earth's ocean surface.)
  What makes tides go up and down? (The moon and sun)
  Does the moon have gravity? (Yes)
  Does the sun have gravity? (Yes)
  What effect does the moon's gravity have on the ocean? (It causes a tidal bulge on the side of the Earth closest to the moon)

- Place a rubber band on a table in a circular shape. It represents the oceans. Now place one finger in the middle of the rubber band. The finger represents the Earth and ocean's center of gravity. Call the finger "e". Now place a finger from your other hand along the inside edge of the rubber band. This finger represents the force the moon

exerts on the Earth's oceans. Call this finger "m." Following a straight line, slowly pull m away from e. At this point, the rubber band stretches.

This is a simplistic model of the effect of differential gravitational forces on the oceans. The moon exerts a much stronger pull on the water molecules closest to it. The molecules on the other side of the Earth receive a much weaker pull. In very simple terms, the difference in the moon's pull on the two sides of the Earth creates a stretched effect on the oceans. These pulling forces are called differential gravitational forces.

- Now have all students except one form a tight circle, sitting or standing, with their elbows interlocked and facing inward. This circle is a very simplistic model of the Earth if it were covered with water at a consistent depth.
- The lone student represents the moon and walks slowly around the outside of the circle. As the moon passes by, the students in the circle who are nearest the moon lean toward it. The students the opposite side of the circle also bulge out, representing differential gravitational forces.
- After the moon passes by, the students return to an upright position.
- If necessary, the teacher can stand in the middle of the circle and point to where students should lean outward.
- Have the moon stop at several points in the circle and let the class see where high and low tides are in relation to the moon's orbit. High tides are the areas where the students are leaning out away from the center of the circle. Low tides are at the sides of the circle, halfway between the high tides.
- Students take turns being the moon until everyone is leaning outward at the correct times.

Extensions

In addition to the moon, have another student play the sun. Students act out the combined gravitational pull of the moon and the sun. Remember the sun's gravitational pull is not as strong as the moon's.

- For this scenario only demonstrate the areas where the sun is in alignment with the moon (spring tide) and where the sun, Earth, and moon form a 90 degree angle (neap tide).
- When the sun, Earth, and moon are in alignment, the tides are more extreme.
- When the sun, Earth, and moon form a 90 degree angle, the gravitational pull of the sun and moon mostly cancel each other out. The difference between high and low neap tides is relatively small.
- Give students a copy of a current tide chart. Ask them how many times a day the high and low tides occur. Compare what happens on the tide chart when the moon is full, new, and in the first or third quarter. See the References section for information on locating a tide chart.

Background

Please note: This is a simplified introduction to a complex subject. Please see the resources section for more information.

Tidal movement is the result of the moon and sun's gravitational pull on the world's oceans. The cycle of high and low tides occurs twice a day. Each day there is one extreme high tide, called a high, high tide. This is matched with an extreme low tide, called a low, low tide. Within the same day, there is also a high tide that is less extreme than the first, which is called a low, high tide. It is coupled with an extreme low tide, called a high, low tide, which is higher than the first low tide of the day.

Gravitational pull is the attraction between two masses. The strength of the pull depends on how big and how far apart the masses are.

Lunar phases are the different appearances of the moon throughout the month. Each phase represents where the moon is in relation to the earth and the sun. The four phases are new, 1st quarter, full, and 3rd quarter.

Neap tides occur at the 1st and 3rd quarter moons when the sun, moon, and earth are at right angles to each other. At this time, the gravitational pull of the sun and moon mostly cancel each other out. The difference between high and low neap tides is relatively small.

Spring tides occur at new and full moons, when the moon and sun align. This happens twice a month, and tides rise higher and fall lower than at other times.

Differential gravitational forces are the forces responsible for the tidal bulge on opposite sides of the earth.

If the earth were entirely covered in water, the water would bulge at the points nearest and farthest from the moon. At these points high tides are occurring. The sun also has a gravitational effect, but the moon's gravitational pull is 2.5 times greater than the sun's. The most extreme tides, spring tides, occur when the sun, moon and earth align. These are times when the moon is full or new.

When the sun is at its greatest angle to the line of the moon and earth, tidal changes are smaller due to the counter-balancing influence of the sun's gravitational force against the moon. This occurs at the 1st quarter and 3rd quarter of the lunar phases, and these are called *neap tides*.

The heights of high and low tides are directly related to the phases in the moon's 27.5 day cycle. Smaller influences include the distance of the earth to the moon and to the sun, varying barometric pressure, the direction and intensity of the wind, and the variations between the depth of the shore and the depth of the ocean.

Standards

California standards

3rd grade: Science 4 b, d, e
5th grade: Science 5 a-c 6th grade:
Science 4 a
8th grade: Science 2 g, 4 e

Adapted by John Carlstroem and Linn Jensen from the Adopt-A-Beach School Education Program, Tidal Waves. 1983

References

1001 Questions Answered About the Seashore by Jacquelyn Berrill and N.J. Berrill.

Oceanography: An Invitation to Marine Science by Tom Garrison

Tide charts for the California Coast can be obtained from many coastal sporting goods stores. Saltwatertides.com and Tidesonline.com also provide free online tide charts.