



TIDES LESSON PLAN

The Moon Made Me Do It!

Focus

Effects of lunar cycles on living organisms

Grade Level

9-12 (Life Science)

Focus Question

What effects do lunar cycles have on living organisms?

Learning Objectives

- Students will be able to explain forces that cause and affect tides.
- Students will be able to discuss some of the effects in living organisms that have been attributed to lunar cycles, and explain in general terms how these effects might be produced.
- Students will be able to describe investigations that could be done to determine whether lunar cycles affect specific phenomena in living organisms.

Materials

- Access to the Internet and National Ocean Service education site (<http://www.nos.noaa.gov/education/tides/welcome.html>)
- Copies of “Tides and Water Levels Student Worksheet” (Part I only); one copy for each student

Audio/Visual Materials

None

Teaching Time

Part I (Researching and Exploring Tides):

One or two 45-minute class periods [Note: If Internet is not accessible, a classroom discussion using Background Information and access to various text references may be used to complete Part I of the Student Worksheet.]

Part 2 (Effects of Lunar Cycles on Living Organisms):

Two or three 45-minute periods, plus time outside of class for research and preparation

Seating Arrangement

Part 1: as appropriate for working with Internet resources

Part 2: groups of four or more students

Maximum Number of Students

32

Key Words

Tide

Tidal current

Ebb

Flood

Spring tide

Neap tide

Perihelion

Aphelion

Perigee

Apogee

Lunar cycle

Lunar effects

Background

Tides are the periodic rising and falling of ocean waters caused by the gravitational forces of the sun and moon. The vertical motion of tides is accompanied by a horizontal movement of ocean waters called tidal currents. Oceanographers say that tides rise and fall, while tidal currents ebb (during a falling tide) and flood (during a rising tide).

For a simple explanation of tides, it is sufficient to consider only the effects of the moon (the magnitude of the moon's effect is about twice that of the sun, since the moon is closer to the Earth). At any point in a day, one side of the Earth will be closer to the moon than the opposite side. Ocean waters on the closer side of the Earth will experience a greater gravitational pull from the moon than waters on the opposite side of the earth (tide-generating forces vary inversely as the cube of the distance from the tide-generating object). This causes a "bulge"

in the waters closest to the moon, and creates a high tide. At the same time, inertial forces on the opposite side of the Earth causes a similar “bulge” creating another high tide. Low tides occur at longitudes that are 90° from the longitudes of locations that are experiencing high tides.

The sun also exerts a gravitational force on ocean waters. Depending upon the positions of the sun and moon relative to the Earth, the sun’s gravity may enhance or diminish the tidal effect caused by the moon. When the sun and moon are aligned (at the time of full moon or new moon), their gravitational forces act in the same direction and produce more pronounced high and low tides that are called spring tides. When the sun and moon are at right angles relative to the Earth, the gravitational force of the sun partially cancels out the gravitational force of the moon. The result is less pronounced high and low tides that are called neap tides. The magnitude of tides is also affected by the actual distances between the sun, moon, and Earth: Gravitational attraction is increased when the Earth is closest to the sun (perihelion) or moon (perigee). For more information on the causes and types of tides, visit <http://www.nos.noaa.gov/education/tides/welcome.html>.

For centuries, people who live and work near seacoasts have understood the importance of being able to predict tides and tidal currents. Low tides may prevent ships from entering harbors, while high tides may make it impossible for ships to pass beneath bridges. Tidal currents may significantly increase the speed of a vessel, or may carry it into dangerous waters. Recreational boaters who anchor near shore may find themselves stranded by a falling tide. Fishermen throughout the world have learned that catches are likely to be much larger during certain portions of the tidal cycle than others.

Many people who live thousands of miles from any ocean also pay close attention to the same lunar cycles that produce tides. Traditional agricultural practices often prescribe planting and harvesting during times when the moon is at a specific location relative to the Earth. Some traditional forestry practices link lunar cycles with specific properties of wood including strength, resistance to decay, and resonance for musical instruments. Lunar cycles have also been linked with many aspects

of human biology, behavior, and folklore including crime, suicide, mental illness, birthrates, fertility, werewolves, and vampirism.

The first part of this lesson is intended to introduce students to tides and tidal currents, and improve their understanding of how these phenomena are measured and predicted.

In the second part of this lesson, students will research and analyze various phenomena in living organisms that have been attributed to lunar cycles.

Learning Procedure

Part 1: Researching and Exploring Tides

1.

Direct students to the Tides and Water Levels tutorials at: <http://www.nos.noaa.gov/education/tides/welcome.html>. If you choose to have students work in groups, you may want to assign different tutorial sections to each student. Have each student or student group answer questions in Part I of the “Student Worksheet.” To save class time, you may want to assign this portion of the lesson as homework.

2.

Review students’ answers to questions on the “Student Worksheet.” Lead a brief discussion of ways in which knowledge of tides can be useful and important. See http://www.nos.noaa.gov/education/tides/supp_tides_roadmap.html for additional resources on tides and water levels.

Part 2: Effects of Lunar Cycles on Living Organisms

Have student groups research and prepare written reports on at least three phenomena in living organisms that are allegedly affected by lunar cycles. Assign one of the following topics to each student group:

- effects of lunar cycles on reproductive activity in marine animals;
- effects of lunar cycles on behavior (other than reproduction) in marine animals;
- effects of lunar periodicity on the human reproductive cycle;
- relationships between lunar cycles and crime;

- relationships between lunar cycles and emergency room visits;
- biodynamic gardening;
- effects of lunar cycles on plants; or
- relationship between lunar cycles and farming practices.

Tell students that in addition to their assigned topic, they should identify and report on two additional phenomena in living organisms that are allegedly affected by lunar cycles. Reports should include hypotheses or discussions of the mechanism(s) through which lunar cycles might affect the phenomena being discussed. Direct all groups to review the discussion of lunar myths at: <http://skepdic.com/fullmoon.html>.

3.

Have each student group present an oral presentation of their research results and analyses. When all groups have made their presentations, lead a discussion of the pooled results. Reports should reflect a mix of well-documented effects of lunar cycles, as well as “effects” that have no demonstrated factual basis. Discuss possible reasons for widespread belief in “effects” (such as emergency room admissions) for which there is little or no supporting evidence. The discussion at <http://skepdic.com/fullmoon.html> explores the influences of media, folklore, tradition, misconceptions, cognitive biases, and communal reinforcement. Encourage students to discuss how the same factors may affect other popular perceptions about natural phenomena and scientific investigations.

Be sure students realize that lunar cycles almost certainly are important in the timing of some phenomena (such as reproduction in many marine animals). Discuss possible mechanisms through which lunar cycles might affect these phenomena. In many cases these mechanisms are not well-understood, even when the cause-and-effect relationships are well-documented. Neuro-endocrine systems are thought to be involved in many cases, but the precise ways in which these systems detect variations in lunar cycles are not known. Given the large gaps in our knowledge about these mechanisms, it is entirely possible that many biological phenomena are sensitive to lunar cycles. While skepticism for claims about lunar effects is certainly warranted, it is also important to keep an open

mind. In an article about lunar influences on women's reproductive cycles, Winnifred Cutler and co-authors concluded, "Historical indication that fertility rites were scheduled with consideration for the phase of the moon may have been reflecting accurate perceptions which we have yet to discover."

The Bridge Connection

www.vims.edu/bridge/ – Click on "Ocean Science Topics" in the navigation menu to the left, then "Physics," and then the "Tides" button at the top of the page.

The "Me" Connection

Have students write a short essay on why knowledge about tides and water levels is (or might be) important in their own lives.

Extensions

The rise and fall of ocean tides involve huge amounts of energy. Have students or student groups prepare a report on how this energy could be captured in a form that could be used by humans. Reports should include a plausible mechanism for converting tidal motion into useful energy, a strategy for transporting captured energy to potential users, and a rough estimate of the energy that might be available from tidal sources. A keyword search on "tide energy" will produce lots of starting points.

Resources

http://www.nos.noaa.gov/education/tides/supp_tides_roadmap.html
– NOAA's National Ocean Service Web site's Roadmap to Resources about tides and water levels, with links to many other sources of tide data and background information

<http://pao.cnmoc.navy.mil/Educate/Neptune/quest/wavetide/waves.htm>
– U.S. Naval Meteorology and Oceanography Command Web site with information on waves and tides

<http://mdc.mo.gov/conmag/1998/11/5.html> - Article about "Lunar Lore" on the Missouri's Conservation Commission Web site

<http://skepdic.com/fullmoon.html> – Article about evidence and beliefs concerning full moon and lunar effects

Cutler, W. B., W. M. Schleidt, E. Freidmann, G. Preti, and R. Stine. 1987. Lunar influences on the reproductive cycle in women. *Human Biology*. 59(6).

<http://www.edusite.com/sci/tides.htm> – Links to educational resources on ocean science topics

<http://www.internet4classrooms.com/tide.htm> – Links to internet resources dealing with tides

<http://school.discovery.com/curriculumcenter/oceans/> – Discovery Channel School resources on ocean science topics

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Motions and forces

Content Standard C: Life Science

- Behavior of organisms

Content Standard D: Earth and Space Science

- Energy in the earth system

Content Standard E: Science and Technology

- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Personal and community health
- Natural resources
- Natural and human-induced hazards



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Tides & Water Levels Student Worksheet

Part I: Background on Tides and Water Levels

Begin your information search by using the text resources provided by your teacher or by accessing the Internet and logging onto: <http://www.nos.noaa.gov/education/tides/welcome.html>

As you read through the Tutorial on Tides and Water Levels, answer the questions below that correspond to each section of the tutorial.

What are Tides?

1. What is a basic definition of a tide? Where do tidal waves originate, and where do they end?
2. What is a high tide? What is a low tide?
3. What is tidal range? What is a tidal current?
4. Compare and contrast a flood and ebb current. When are they strong? When are they weak?
5. How do tidal currents perform in the open ocean? How do they perform near the entrances to estuaries?

What Causes Tides?

6. Tides are caused by the gravitational attraction of what two celestial bodies?
7. What does Newton's law of universal gravitational state?
8. Which parameter has a greater effect on tidal forces on Earth?
9. Which celestial body has a greater effect on tidal forces on Earth? How is this possible? Compare and contrast the masses and distance of the Earth to the moon and sun.

Gravity, Inertia, and the Two Bulges

10. What is inertia?
11. How does the moon create a bulge?
12. What causes a bulge to be created on the opposite side of the Earth or the "far side" from the moon?

Changing Angles and Changing Tides

13. Describe how changes in the relative positions of the moon and sun change in relation to the Earth?

14. At what point is the sun at its minimum declination and its maximum declination?

Frequency of Tides - The Lunar Day

15. Compare and contrast a solar and lunar day. How long is a lunar day?
16. Why do most coastal areas experience two high tides and two low tides?
17. How long does it take for high tide to occur? How long is the time between low and high tide?

Tidal Variations - The Influence of Position and Distance

18. What is the magnitude of solar tides and how are they expressed?
19. What causes spring tides? What causes neap tides? How many spring and neap tides occur in a lunar month?
20. How are tide-generating forces affected when the moon is closest to the Earth (or perigee)? when the moon is farthest away from the Earth (or apogee)? How does this affect the tides that are produced?
21. How are tide generating forces affected when the Earth is closest to the sun (or perihelion)? when the Earth is farthest from the sun (or aphelion)? How does this affect the tides that are produced?

Types and Causes of Tidal Cycles: Diurnal, Semidiurnal, Mixed Semidiurnal; Continental Interference

22. If the Earth were perfect, how many high and low tides would all points on the earth experience in one day? What causes tidal patterns to change? Why is the water unable to move freely?
23. Describe a semidiurnal tide. How do the tidal heights compare in a lunar day? Where might you experience a semidiurnal tide in the continental United States?
24. Describe a mixed semidiurnal tide. How do the tidal heights compare? Where might you experience a mixed semidiurnal tide in the continental United States?
25. Describe a diurnal tide. Where might you experience a diurnal tide?

What Affects Tides in Addition to the Sun and Moon?

26. How are the magnitudes of tides affected by shorelines? by mid-ocean islands?
27. How does a funnel-shaped bay compare to a narrow inlet and shallow water?
28. What is the affect of strong tidal rivers on tides in estuaries?
29. What other abiotic factors affect tides? Compare and contrast wind and weather patterns that affect tides.

The Importance of Monitoring the Tides and Their Currents

30. Explain why commercial fisherman would be interested in tidal shifts. How do tides affect their livelihood?
31. Explain the importance of monitoring tides to maneuver sailing ships. How are today's ships different from old sailing ships?
32. Explain why coastal engineers are required to monitor tides. How do tides affect their planning?
33. Describe why scientists would be interested in monitoring tides? What could an ecologist learn from tides? an oceanographer? an atmospheric scientist?

How are Tides Measured? - The Old System

34. What United States governmental agency is responsible for monitoring tides in the United States? How long have they been monitoring tides?
35. Describe the function and process of a "stilling" well.
36. Before computers, how was water level data recorded? How was the data processed? (Click on the images in the tutorial for further explanation.)
37. How did processing water level data change in the 1960s?
38. What were the limitations of measuring water level using "stilling" wells, pen and ink strip charts and mechanical punch recorders?

How are Tides Measured? - The New System

39. How has microprocessor based technologies improved water level monitoring today?
40. How do today's monitoring stations used acoustics and electronics to function?
41. What other oceanographic and meteorological parameters are measured by the new stations?

42. How are geostationary operational environmental satellites used in conjunction with monitoring stations? How often are the data recorded? How often are the data transmitted?
43. In the event of storms or foul weather, how can the stations be monitored?