The Motions of the Oceans

Grade Level: 6th Grade Science
Written by: Christi Glenn, Aurora Academy, Aurora, Colorado
Length of Unit: Five lessons (approximately two weeks (10 days), one day = 60 minutes)

I. ABSTRACT

This unit focuses on the *Core Knowledge Sequence* 6th grade topic of Oceans. Students will learn about ocean waves, currents and tides. Students will be doing a variety of activities including class discussions, group work, and hands-on experiments.

II. OVERVIEW

A. Concept Objectives (Colorado Science Standard - CSS)
1. Students will understand that science involves a particular way of knowing and understanding common connections among scientific disciplines. (CSS 6)
2. Students will recognize and understand the processes and interaction of Earth's systems and the structure and dynamics of Earth. (CSS 4)
3. Students will understand the processes of scientific investigation. (CSS 1)

B. Content from the *Core Knowledge Sequence*
1. Oceans - Science: Grade 6 (page 153)
   a. Currents, tides, and waves
      i. Surface currents: large streams kept in motion by prevailing winds and rotation of the earth; Gulf Stream (North Atlantic), Kuroshio (North Pacific)
      ii. Subsurface currents are caused by upwelling from prevailing offshore winds (Peru, Chile) and density differences (Antarctica); the upwelling pushes up nutrients from the ocean floor
      iii. Tides are caused by gravitational forces of the sun and moon; there are two tides daily
      iv. Waves are caused by wind on the ocean's surface
         a) Water molecules tend to move up and down in place and not move with the wave
         b) Crest and trough, wave height and wavelength, shoreline friction
         c) Tsunamis: destructive, fast-moving large waves caused mainly by earthquakes

C. Skill Objectives (Colorado Science Standard – CSS) (Colorado Science Grade Level Expectation – CSGLE)
1. Students will know major sources of water, its importance, and cyclic patterns of movement through the environment. (CSS 4.3)
2. Students will identify variables and conditions related to change. (CSGLE 6d)
3. Students will identify and illustrate natural cycles within systems. (CSGLE 6e)
4. Students will use a model to understand a process. (CSGLE 6f)
5. Students will understand the composition of the Earth and the natural process that shape it. (CSS 4.1)
6. Students will recognize that patterns exist within systems. (CSGLE 6.6g)
7. Students will know that energy can be carried from one place to another by waves. (CSGLE 6.2h)
8. Students will use appropriate tools and measurement units to gather and organize data. (CSGLE 1e)

9. Students will interpret and evaluate data in order to form conclusions. (CSGLE 1f)
10. Students will create a diagram that illustrates a concept developed from an inquiry. (CSGLE 6.1d)

III. BACKGROUND KNOWLEDGE

A. For Teachers
1. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters*. New Jersey: Prentice Hall, 2000 (Teacher's Edition) ISBN: 0-13-434565-7
2. Ganeri, Anita. *The Oceans Atlas*. USA: Dorling Kindersley, Inc. 1994 ISBN: 1-56458-475-5
3. Rodgers, Howell, Smith, Clarke and Henderson. *The Usborne Internet-Linked Science Encyclopedia*. England: Usborne Publishing, Ltd. 2000 ISBN: 0-7460-3833-X

B. For Students
1. Students should have past knowledge of the following from the *Core Knowledge Sequence*:
   a. Living Things and Their Environments: Oceans and Undersea Life from Science: Grade 1 (page 37)
   b. Cycles in Nature: The Water Cycle from Science: Grade 2 (page 59)
   c. Chemistry: Properties of Matter from Science: Grade 4 (page 104)

IV. RESOURCES

A. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters*. New Jersey: Prentice Hall, 2000 (Teaching Resources) ISBN: 0-13-434940-7 (Lessons Two and Three)

B. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters*. New Jersey: Prentice Hall, 2000 (Student's Edition) ISBN: 0-13-434484-7 (Lessons One, Two and Three)

C. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters*. New Jersey: Prentice Hall, 2000 (Teachers Edition) ISBN: 0-13-434565-7 (Lesson Two and Four)

D. VanCleave, J. Oceans for *Every Kid: Easy Activities that Make Learning Science Fun*. USA: John Wiley & Sons, 1995 ISBN: 0-471-12454-0 (Lesson Four)

V. LESSONS

Lesson One: Currents (approximately two 60-minute class periods)

A. *Daily Objectives*
1. Concept Objectives
   a. Students will understand that science involves a particular way of knowing and understanding common connections among scientific disciplines. (CSS 6)
   b. Students will recognize and understand the processes and interaction of Earth's systems and the structure and dynamics of Earth. (CSS 4)
2. Lesson Content
   a. Oceans: Surface currents - Science: Grade 6
   b. Oceans: Subsurface currents - Science: Grade 6
3. Skill Objectives
   a. Students will know major sources of water, its importance, and cyclic patterns of movement through the environment. (CSS 4.3)
   b. Students will identify variables and conditions related to change. (CSGLE 6d)
   c. Students will identify and illustrate natural cycles within systems. (CSGLE 6e)

d. Students will use a model to understand a process. (CSGLE 6f)

B. *Materials*
1. Paper and pencil for students
2. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters*
3. Handout, Appendix A: Ocean Currents (one copy per student)
4. Handout, Appendix B: Ocean Currents Teacher's Key
5. Two colored pencils per student
6. Handout, Appendix C: Water Currents Lab
7. The following is needed for each group:
   a. Two flasks
   b. Hot and cold water
   c. Food coloring
   d. Thin cardboard

C. *Key Vocabulary*
1. Surface Current – an ocean current caused by wind
2. Subsurface Current – an ocean current caused by tides, rain, runoff and ocean bottom topography
3. Gulf Stream – North Atlantic current (one of the strongest currents known, moving along through the Gulf of Mexico, past the east coast of the U.S. and on to Northern Europe)
4. Kuroshio – North Pacific current
5. Upwelling – an upward flow of cold water from the ocean depths

D. *Procedures/Activities*
1. Using the Prentice-Hall text, students will read about and then discuss as a class, ocean currents beginning on page 134 and continuing through page 140.
   Note to teachers: If this text is not available, any reliable source on the ocean currents may be substituted.
2. Example discussion questions:
   a. *Does the wind cause ocean currents?* (Yes - Winds affect the ocean's surface only. The winds that most affect the oceans' currents are:
      i. The Westerlies (40-50 degree latitudes) blow east to west
      ii. The Trade Winds (20 degree latitudes) blow east to west
      Both winds are a result of warm air from the tropics moving to the poles and incorporating the rotation of Earth into their movement. In the Northern Hemisphere, they move clock wise. In the Southern Hemisphere, they move counter-clockwise.)
   b. *Does temperature cause ocean currents?* (Yes – Differences in temperatures between the cold waters of the poles and the warm waters near the equator cause currents. Cold water currents occur as the cold water at the poles sinks and slowly moves toward the equator. Warm water currents travel out from the equator along the surface, flowing toward the poles to replace the sinking cold water.)
   c. *What else causes currents?* (Currents are also caused by tides, rain, runoff, and ocean bottom topography.)
   d. *What is the Gulf Stream?* (The Gulf Stream is one of the strongest currents known. It moves along through the Gulf of Mexico, past the East Coast of the United States and on to Northern Europe. Without the warm Gulf Stream, England and other places in Europe would be as cold as Canada.)
3. Divide the class into groups of two-three. Hand out Appendix C: Water Currents Lab.

4. Students are to complete the lab as a group following the directions as demonstrated by the teacher.
5. After completing their lab work and write-up, students will individually map ocean currents on a world map.
6. Hand out Appendix A: Ocean Currents. Using their text, students are to shade in the cold and warm ocean currents on the world map. They may also label the major currents found on the map.

E. *Assessment/Evaluation*
1. Grade student's Ocean Currents handout (Appendix A) using Teacher's Key (Appendix B).
2. Teacher observation of student participation during the discussion and the lab. Also, a lab grade may be taken from the Observations portion of lab handout (Appendix C).

Lesson Two: Tides (approximately one 60-minute class period)

A. *Daily Objectives*
1. Concept Objectives
   a. Students will understand that science involves a particular way of knowing and understanding common connections among scientific disciplines. (CSS 6)
   b. Students will recognize and understand the processes and interaction of Earth's systems and the structure and dynamics of Earth. (CSS 4)
2. Lesson Content
   a. Oceans: Tides - Science: Grade 6
3. Skill Objectives
   e. Students will know major sources of water, its importance, and cyclic patterns of movement through the environment. (CSS 4.3)
   a. Students will use a model to understand a process. (CSGLE 6f)

B. *Materials*
1. Pencil and paper for students
2. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters*
3. Handout, "Tides" from Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters* (one copy per student)
4. Small water balloon
5. Piece of string about half a meter long
6. Handout, Appendix D: Tides (one copy per student)

C. *Key Vocabulary*
1. Neap tide – a tide with the least difference between low and high tide that occurs when the sun and moon pull at right angles to each other
2. Spring tide – a tide with the greatest amount of difference between high and low tide that occurs when the sun and the moon are aligned in a line with Earth
3. Tide – the daily rise and fall of Earth's waters on shores

D. *Procedures/Activities*
1. Using the Prentice-Hall text, students will read about the earth's tides beginning on page 122 and continuing through page 126.
   Note to teachers: If this text is not available, any reliable source on the Earth's tides may be substituted.
2. Lead students in a demonstration on the earth's gravitational pull and tidal bulges adapted from an activity from the Prentice-Hall teacher's edition text.
   a. To illustrate the pull of gravity on water, show the students a small water-filled balloon attached to a string. Carefully swing the balloon

around your body at the end of the string. (You may want to do this activity outside.)

b. Ask the students:
   i. If you are the sun and the balloon is Earth, what is the string? (gravity)
   ii. What does the bulge represent? (a tidal bulge)

c. Guide students in seeing how this is similar to the pull of the sun's gravity on Earth's oceans. Point out that the moon's gravity, though weak, has an even greater pull of Earth's oceans because the moon is so close to Earth.

3. Distribute copies of Appendix D: Tides, and review with students the differences between neap tides and spring tides.
4. They will then complete the handout "Tides" from Prentice-Hall Teaching Resources, pages 104-105.

E. *Assessment/Evaluation*

1. Completed Prentice-Hall worksheet will be turned in for grade.

Lesson Three: Wave Action (approximately three 60-minute class periods)

A. *Daily Objectives*

1. Concept Objectives
   a. Students will understand that science involves a particular way of knowing and understanding common connections among scientific disciplines. (CSS 6)
   b. Students will recognize and understand the processes and interaction of Earth's systems and the structure and dynamics of Earth. (CSS 4)
2. Lesson Content
   a. Oceans: Waves - Science: Grade 6
3. Skill Objectives
   a. Students will know major sources of water, its importance, and cyclic patterns of movement through the environment. (CSS 4.3)
   b. Students will use a model to understand a process. (CSGLE 6f)
   c. Students will understand the composition of the Earth and the natural process that shape it. (CSS 4.1)
   d. Students will identify and illustrate natural cycles within systems. (CSGLE 6e)
   e. Students will recognize that patterns exist within systems. (CSGLE 6.6g)
   f. Students will know that energy can be carried from one place to another by waves. (CSGLE 6.2h)

B. *Materials*

1. Pencil and paper for students
2. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters*
3. Handout, "Wave Action" from Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters* (one copy per student)
4. Handout, Appendix F: Wave Action Crossword Puzzle
5. Handout, Appendix E: Wave Action Notes
6. The following is needed for each student:
   e. One empty 1-liter soda bottle (with screw on top)
   f. Vegetable oil
   g. Water
   h. Food coloring
7. Rubric, Appendix G: Wave Bottle Lab

8. Paint-roller pan
9. Five cups sand
10. Two quarts tap water
11. Pencil
12. Two cups gravel

C. *Key Vocabulary*
1. Breaker – a wave whose crest falls forward and crashes into the trough
2. Friction – the force that slows the motion of two things that touch each other
3. Crest - the highest point of a wave
4. Trough – the lowest point of a wave
5. Wave – the movement of energy through a body of water
6. Wave height – the vertical distance from the crest of a wave to the trough
7. Wavelength – the horizontal distance between two wave crests

D. *Procedures/Activities*
1. Students will begin by creating Wave Bottles to observe water moving in waves and to begin a discussion about why waves move in similar patterns.
   a. Give each student a plastic soda bottle.
   b. Ask students to fill the bottle two-thirds full of water.
   c. Direct students to add a few drops of food coloring to the water.
   d. Ask students to fill the bottle to the top with oil and then screw on the top tightly.
   e. Tell students to turn the bottle on its side and gently rock the bottle back and forth by lifting the top then lifting the bottom to make waves.
2. Lead a discussion about why this happens:
   a. The oil in the bottle will begin to roll and move just like the waves in the ocean. We have created a miniature ocean in a bottle.
   b. Waves are energy that moves through water. It is not the water that moves, but rather the energy in the water that causes waves to form. Ocean waves are generated by the gravitational pull of the moon on the earth's surface, the geological formation of the ocean floor, and the movement of wind across the surface of the water. You can artificially create waves in a soda bottle and observe wave action that is quite similar to that which occurs throughout the oceans of the world.
3. Using the Prentice-Hall text, students will read background information on ocean waves beginning on page 114 and continuing through page 121.
   Note to teachers: If this text is not available, any reliable source on the ocean waves may be substituted.
4. They will then complete the handout "Wave Action" from Prentice-Hall Teaching Resources, pages 100-102.
5. Distribute Appendix G: Wave Action Notes. Read aloud as a class about waves and the parts of a wave. Students will complete the written portion of the worksheet on their own.
6. To illustrate the effect of waves when they hit the shore, present the students with a demonstration using a small-scale version of a shoreline.
7. Demonstrate:
   a. Cover the bottom of the pan with 4 cups of the sand, building up a small "beach" at the shallow end.
   b. Pour the water into the deep end of the pan.
   c. Tell the students to make a mental note of the appearance of the sandy beach in the pan.

d. Make waves by laying the pencil in the deep end of the pan and quickly moving the pencil up and down with your fingertips.
e. Mound the gravel in the center of the shoreline.
f. Pour the remaining 1cup of sand on the beach to replace all or part of the sand that washed away.
g. Make waves again with the pencil

8. Lead a class discussion connecting the results with the ocean and its shorelines.
   a. Results: Without the gravel more sand is washed from the beach. With the gravel, very little beach sand is washed away, but part of the gravel is.
   b. Why: Without the gravel the waves hit the sandy beach moving some of the sand down into the water. With the gravel, fewer waves hit the beach and less sand is washed away. With the gravel in place, some of the waves hit the beach, but many are deflected back toward the deep end of the pan. Since the pan is small, these waves bounce off the pan's wall and return to the shore again. These deflected waves lose energy every time they change direction. Even if they hit the beach instead of the gravel, they do not remove much sand.
9. Distribute Appendix F: Wave Action crossword puzzle for students to complete as a homework assignment using their Prentice-Hall textbooks.

E. *Assessment/Evaluation*
1. Completed Wave Action handouts from Prentice-Hall and Appendix E will be collected for grading.
2. Evaluate labs using rubric in Appendix G.
3. Completed Wave Action crossword puzzle handouts: Appendix F will also be collected for grading.

Lesson Four: Waves (approximately two 60-minute class periods)

A. *Daily Objectives*
1. Concept Objectives
   a. Students will understand that science involves a particular way of knowing and understanding common connections among scientific disciplines. (CSS 6)
   b. Students will understand processes of scientific investigation. (CSS 1)
2. Lesson Content
   a. Oceans: Waves - Science: Grade 6
3. Skill Objectives
   a. Students will use appropriate tools and measurement units to gather and organize data. (CSGLE 1e)
   b. Students will recognize that patterns exist within systems. (CSGLE 6.6g)
   c. Students will know that energy can be carried from one place to another by waves. (CSGLE 6.2h)

B. *Materials*
1. Pencil and paper for students
2. Aquarium
3. Water
4. Metal washers
5. Corks
6. Thread
7. Handout, Appendix H: View Finder Lab (one copy per student)
8. The following is needed for each group:

a. Scissors
b. Ruler
c. Two 3 x 5 inch (7.5 x 12.5 cm) index cards
d. Transparent tape
e. Colored, transparent, plastic report folder
f. Black marking pen

9. Rubric, Appendix I: View Finder

C. *Key Vocabulary*

1. Molecule – the smallest unit of a substance that retains all of the properties of that substance

D. *Procedures/Activities*

1. Lead students in a demonstration on the earth's waves adapted from an activity from the Prentice-Hall teacher's edition text.
   a. To illustrate how waves formed at the surface affect deeper water, fill the largest aquarium that you have available about three-quarters full of water.
   b. Tie enough metal washers to a cork so that the cork floats about 3 cm from the bottom of the tank.
   c. Repeat Step b with more corks so that they float 9 cm from the bottom, 15 cm from the bottom and so on until the last cork floats on the surface.
   d. Make small steady waves in the tank by moving your hand up and down in the water. Tell the students to note what happens to each cork.
   e. Repeat Step d, increasing the height of the waves by moving your hand faster.
   f. Ask the students:
      i. *How does increasing the wave height affect the motion of each cork?*
      ii. *Do you think you would be more likely to become seasick in a boat or a submarine?*
      (You would be more likely in a boat, because being at the surface of the water, the boat will move more in the waves.)
2. Divide the class into groups of two-three and then distribute Appendix H: Wave Viewer Lab to each student. Students will complete each step of the lab as they read the directions and follow the teacher's example.
3. Students are to complete the exercise at the end of the lab and turn in to be graded.

E. *Assessment/Evaluation*

1. Evaluate the View Finder labs using the rubric in Appendix I. Students are also to turn in their completed lab exercises to be graded.

Lesson Five: Tsunamis (approximately two 60-minute class periods)

A. *Daily Objectives*

1. Concept Objectives
   a. Students will understand that science involves a particular way of knowing and understanding common connections among scientific disciplines. (CSS 6)
   b. Students will understand processes of scientific investigation. (CSS 1)
2. Lesson Content
   a. Oceans: Waves - Science: Grade 6

3. Skill Objectives
    a. Students will use appropriate tools and measurement units to gather and organize data. (CSGLE 1e)
    b. Students will interpret and evaluate data in order to form conclusions. (CSGLE 1f)
    c. Students will create a diagram that illustrates a concept developed from an inquiry. (CSGLE 6.1d)

B. *Materials*
1. Pencil and paper for each student
2. The following is needed for each group:
    a. Two plastic containers of the same length but with different widths (one should be significantly narrower than the other)
    b. Water
    c. Masking tape
    d. Small rock, ball of clay, or other object that can be dropped into the water-filled containers
    e. Ruler or tape measure
3. Handout, Appendix J: Tsunamis Lab Write-Up (one copy per student)
4. Rubric, Appendix K: Tsunamis

C. *Key Vocabulary*
1. Fjord – a narrow inlet of the sea between cliffs or steep slopes
2. Surge – a large wave or billow
3. Tsunamis – destructive fast-moving large waves caused mainly by earthquakes (also called tidal waves)

D. *Procedures/Activities*
1. Review with students what they already know about tsunamis from Lesson Three. During this discussion, bring out the possible causes of an ocean tsunami:
    a. Undersea earthquakes
    b. Volcanic eruptions
    c. Landslides
    d. Impact of a large meteorite falling into the ocean
2. Continue the discussion by letting students know that a tsunami can also occur in a fjord - a narrow inlet of the ocean with cliffs on either side. Fjord tsunamis are generally caused by portions of icebergs plummeting into the waters.
3. Divide the students into groups of two-three. Explain to them that they are going to perform an experiment to find out the difference in wave patterns between tsunamis that occur in the ocean and in a fjord. Distribute materials to each group.
4. The group's first challenge is to design an experiment with the material provided that will simulate the two types of tsunamis so that the difference in their wave patterns can be observed. Students should come up with a procedure similar to the one that follows:
    a. Attach a strip of masking tape down the inside of each plastic container.
    b. Fill each container with water so that the depth is the same in each one.
    c. Trim the strip of tape in each container to that it reaches half a centimeter above water level.
    d. They will then drop an object from the same height into each container and measure the distance the resulting wave travels from the point of impact to where it drops below the level of the masking tape.
5. The students will need to record their results and with their group, graph the results of the experiment.

6. Hold a class discussion about the experiment. Students should be aware that the wider container represented the ocean and the narrow container, a fjord. The object that was dropped represented a meteorite falling into the ocean or a huge chunk of ice falling into a fjord.
7. Next ask the students how they know that the difference in wave pattern was not due to the difference in water depth. (The experiment required the depth of the water in each container to be the same.)
8. Continue the discussion by having students determine which type of tidal wave would cause the most destruction – one occurring in the ocean or in a fjord. Have the class propose recommended safety precautions for both fjord regions and ocean coastal regions based on their findings.
9. Hand out Appendix J: Tsunamis Lab Write-Up for the students to present their findings and answer follow-up questions. Give the students time in class to finish their lab write-ups.

E. *Assessment/Evaluation*
1. Evaluate lab using rubric in Appendix K.
2. Grade lab write-ups (Appendix J).

VI. CULMINATING ACTIVITY

A. "Currents, Tides and Waves" Exam (Appendix L) on concepts covered throughout the previous weeks will be given at the end of the unit.
B. Use "Currents, Tides and Waves" Exam Teacher's Key (Appendix M) to grade.

VII. HANDOUTS/WORKSHEETS

A. Appendix A: Ocean Currents
B. Appendix B: Ocean Currents Teacher's Key
C. Appendix C: Water Currents Lab
D. Appendix D: Tides
E. Appendix E: Wave Action Notes (two pages)
F. Appendix F: Wave Action Crossword Puzzle (two pages)
G. Appendix G: Rubric: Wave Bottle Lab
H. Appendix H: Wave Viewer (three pages)
I. Appendix I: Rubric: Wave Viewer
J. Appendix J: Tsunamis Lab Write-Up
K. Appendix K: Rubric: Tsunamis
L. Appendix L: Currents, Tides and Waves Exam
M. Appendix M: Currents, Tides and Waves Exam Teacher's Key

VIII. BIBLIOGRAPHY

A. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters.* New Jersey: Prentice Hall, 2000 (Teachers Edition). ISBN: 0-13-434565-7
B. Simons, B. & Wellnitz, T.R. *Science Explorer: Earth's Waters.* New Jersey: Prentice Hall, 2000 (Student's Edition). ISBN: 0-13-434484-7
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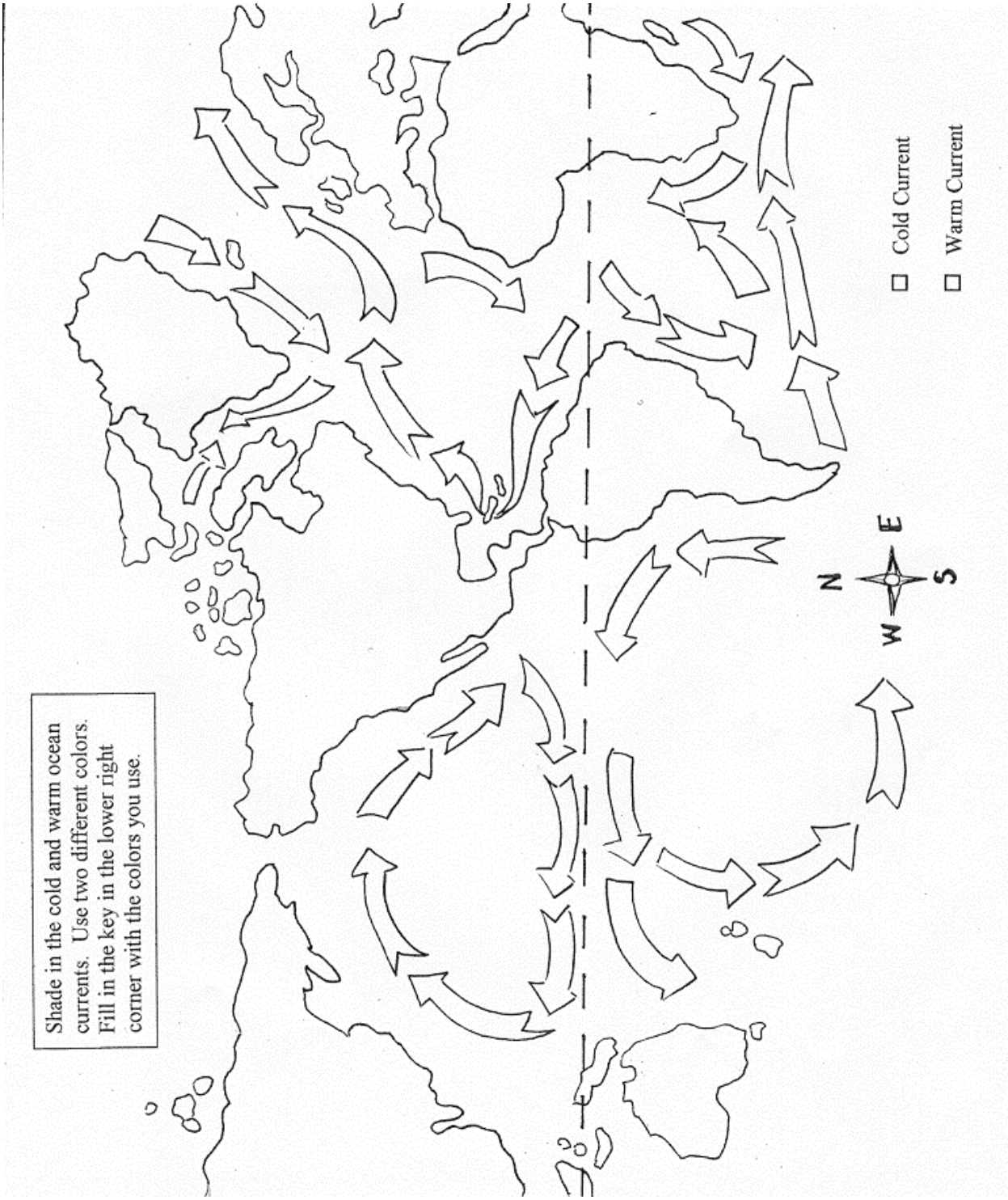
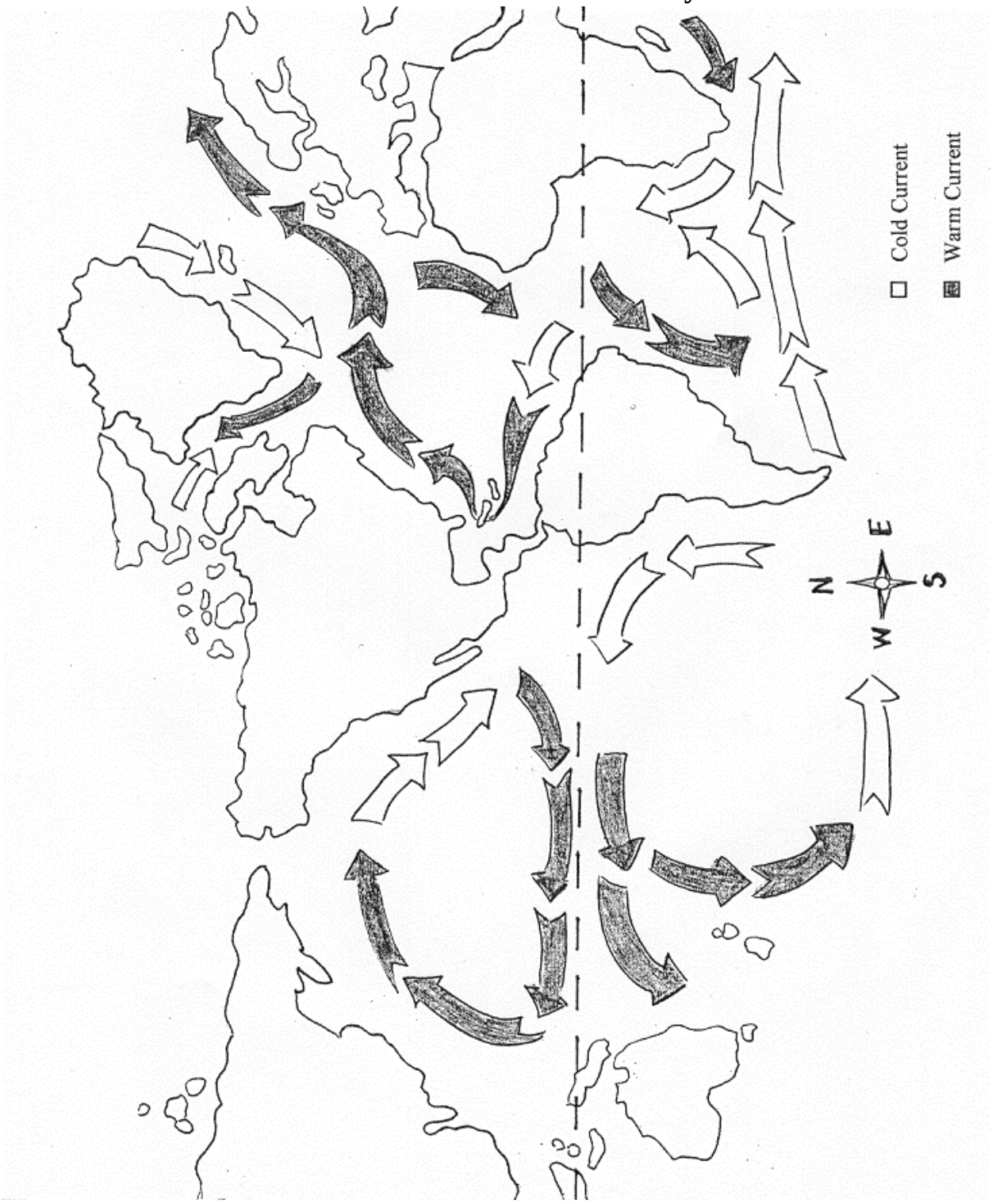
APPENDIX A
Ocean
Currents



APPENDIX B
Ocean Currents Teacher's Key



APPENDIX C
Water Currents Lab

Materials:

two identical flasks or jars
cold and hot water
food coloring
thin cardboard

Activity:

1. Using two identical flasks, fill one flask with cold water and one flask with hot, tap water.
2. Color the hot water with food coloring and allow the color to spread evenly throughout the water.
3. Use a thin piece of cardboard or stiff paper to cover the mouth of the flask containing cold water. Hold the cardboard tightly over the top of the flask.
4. Carefully turn the flask upside down. Place it on top of the flask containing the colored hot water, be sure that the mouths of the flasks are over each other.
5. Slowly and carefully remove the cardboard. Work as a team and help one another. One person can hold both flasks and the other can remove the cardboard.

Observations:

1. What happens to the water? _____

2. How does this explain the movement of water currents? _____

Reverse the experiment. Follow the same procedure desired above, but this time, place the flask containing the colored water on top of the flask containing the cold water.

3. What happens to the water? _____

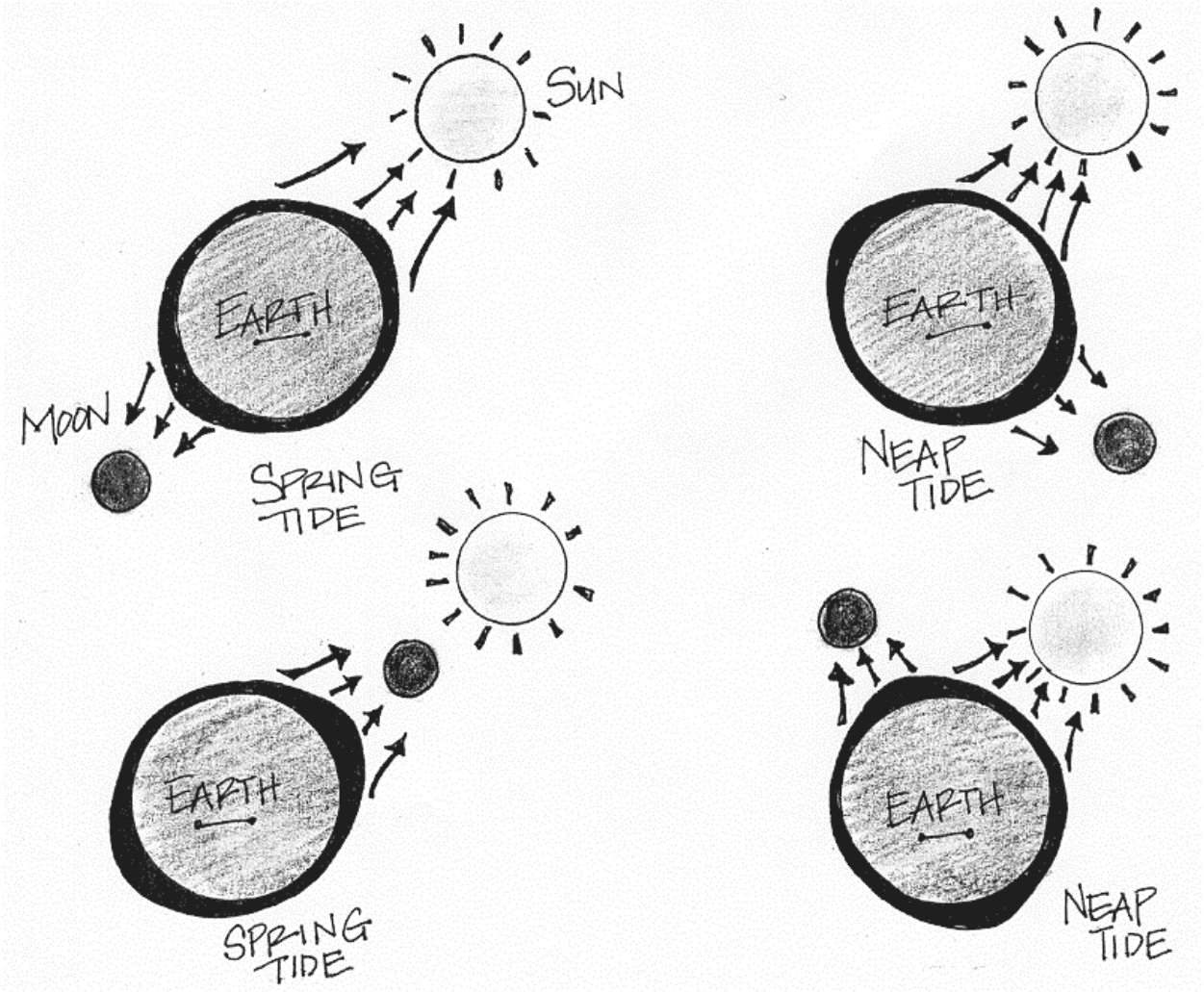
4. Using this information, explain why deep ocean currents are always cold currents.

5. Explain how deep currents form and move in the ocean.

APPENDIX D
Tides

Gravity makes tides in the ocean. The Earth's gravity holds the ocean on the planet. The pull of the Moon and the pull of the Sun make the ocean bulge out a little bit toward outer space. As the Earth turns, the shores of continents and islands pass through the bulges. The level of the ocean goes up and down during the day. When you are in a bulge, it is high tide. When you are on the side next to a bulge, it is low tide.

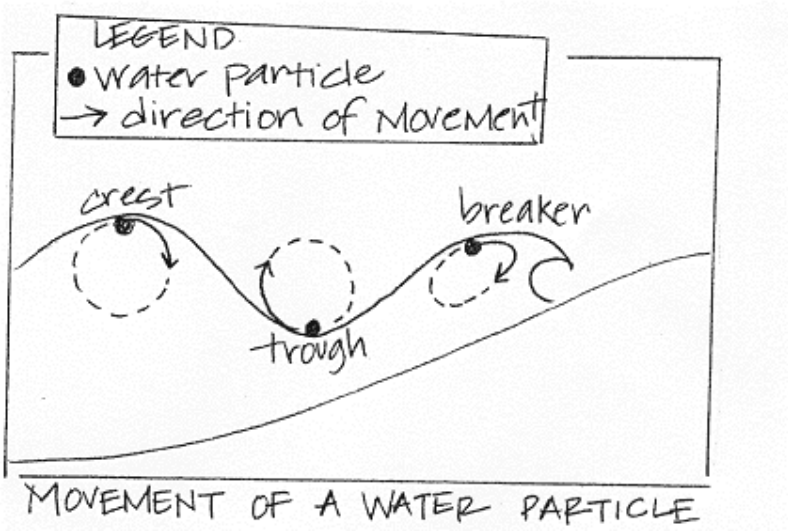
When the Moon and the Sun are lined up, the tides are the highest. They are called spring tides. When they are at right angles, the tides are the lowest. These are called neap tides. The moon does not orbit the Earth right above the equator. Is orbit is tilted, so the Earth's highest and lowest tides each day are usually on opposite sides of the equator.



APPENDIX E (page 1)
Wave Action Notes

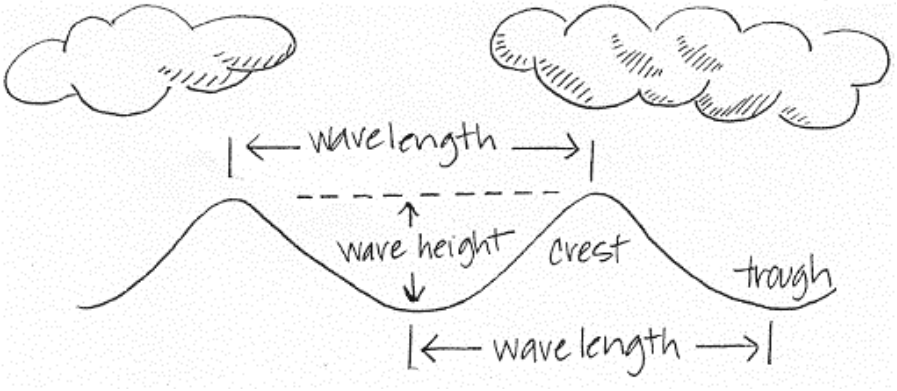
Waves

As a wave travels through deep water, each water particle moves up and down in a circular motion ending up nearly in the same position as where it started. In shallow water, near the shore, the water particles no longer move in a circle. As the water particles in the **trough** (the low point of the wave) hit against the land at the shoreline, **friction** (the force that slows the motion of two things that touch each other) slows their motion. At the same time, the particles in the high point of the wave, called the **crest**, are not slowed. This results in a **breaker**, which is a wave whose crest falls forward and crashes into the trough.



Parts of a Wave

The horizontal, or left-to-right distance between similar points of two waves in a row is called the wavelength. In other words, wavelength is the distance from one wave's crest to the next or from one wave's trough to the next. Generally, the wavelength of ocean waves varies from a few yards to a few hundred yards. The vertical, or top-to-bottom distance between the crest and trough of a wave is its wave height. Wave height depends on the speed of open water present and the duration of the wind. An increase in any one of these can cause an increase in wave height.



APPENDIX E (page 2)
Wave Action Notes

What provides the energy?

In the case of ocean waves, wind provides the energy. Wind causes waves that travel in the ocean. The energy is released on shorelines.

What determines the size of the wave?

The size of the wave depends on:

1	**The distance the wind blows (over open water) which is known as the "fetch"**
2	**The length of time the wind blows**
3	**The speed of the wind**

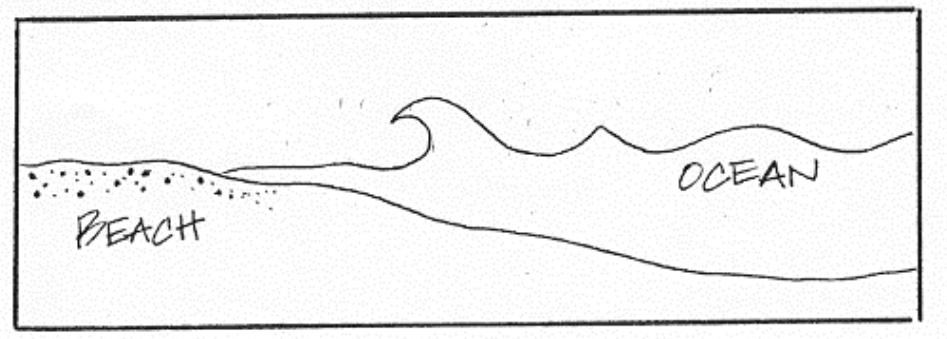
The greater these three, the larger the wave.

Where are the largest waves found?

The largest waves are found in the open ocean. Waves continue to get larger as they move and absorb energy from wind. When the wave height becomes one seventh the size of the wavelength, the wave will fall over, making white caps. As they get closer and closer to shore, most big waves have broken down in size and speed.

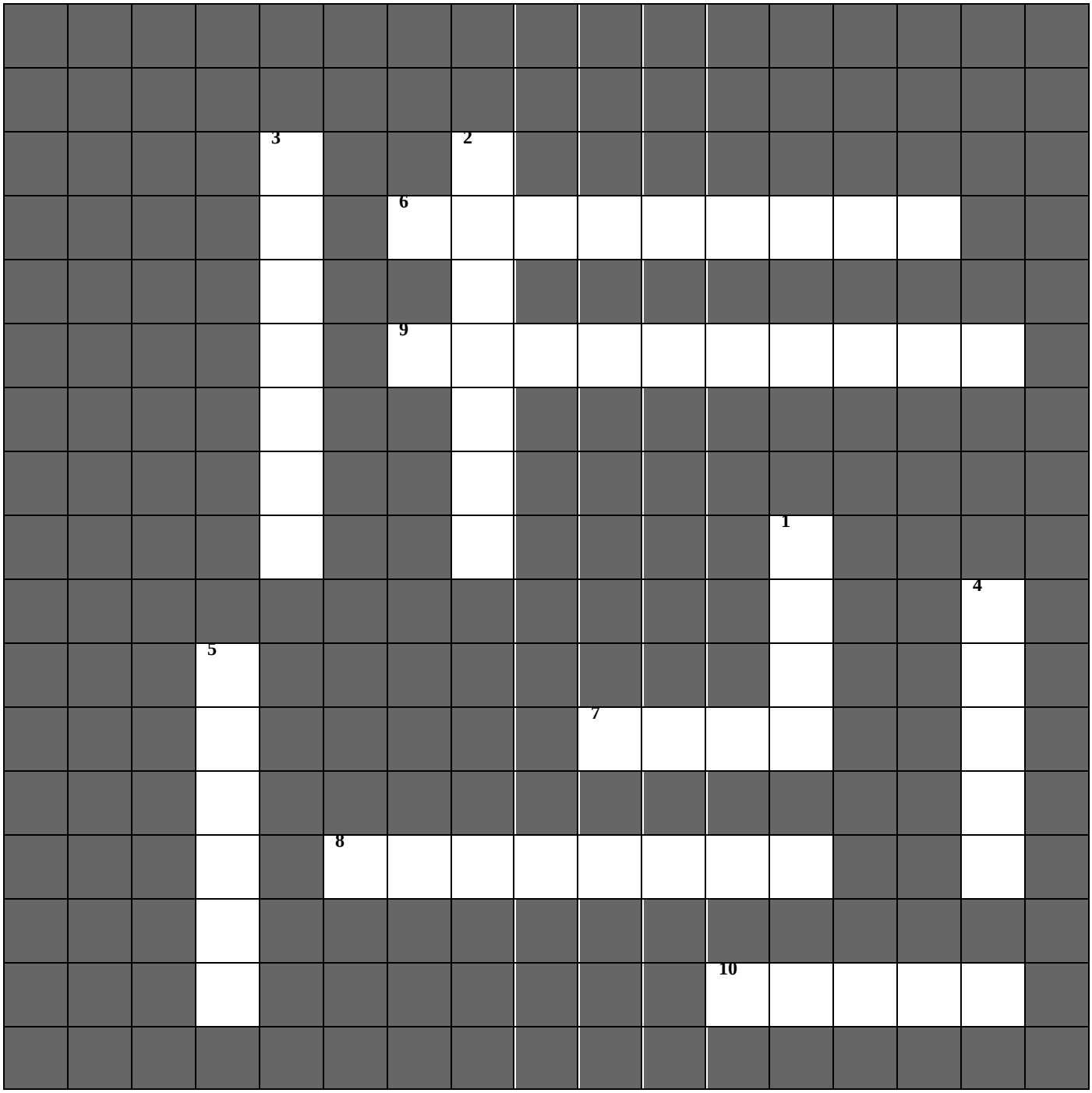
Exercise

On the diagram below, draw a wavy line where the water would be slowing down. Make an X where there is a breaker. Label a crest and a trough.



APPENDIX F (page 1)
Wave Action Crossword Puzzle

Complete the puzzle:



APPENDIX F (page 2)
Wave Action Crossword Puzzle

Down

1. The movement of energy through a body of water

2. A wave whose crest falls forward and crashes into the trough

3. A large stream of moving water that flows through the ocean

4. The highest point of a wave

5. The lowest point of a wave

Across

6. The number of waves that pass a specific point in a given amount of time

7. Hills of wind-blown sand covered with plants that protect shores from erosion

8. The force that slow the motion of two things that touch each other

9. The vertical distance from the crest of a wave to the trough

10. A stone or concrete wall built out from a beach to reduce erosion

---

Answers:

Down

1. wave
2. breaker
3. current
4. crest
5. trough

Across

6. frequency
7. dune
8. friction
9. waveheight
10. groin

APPENDIX G
Rubric: Wave Bottle Lab

Possible Points: 15 points

Student Name: _____

Lab work is rated using the numbers 1-5, with 5 being the very best and 1 being the least satisfactory.

Objectives	5	4	3	2	1
Worked cooperatively and productively with group members					
Time was spent appropriately and lab was successful					
Wave Bottle is constructed correctly and is well built					

Total grade for lab work: ____ **/15**

Teacher's comments:

APPENDIX H (page 1)
Wave Viewer

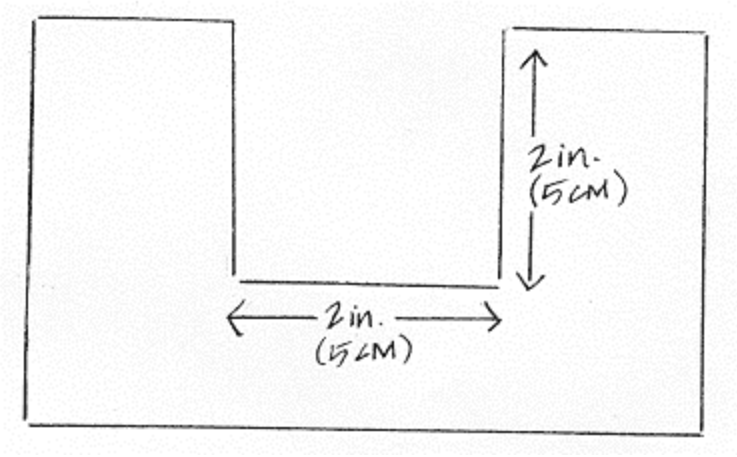
Adapted from "Oceanographer's Toolbox," Vancleave's *Oceans for Every Kid.*

Materials:

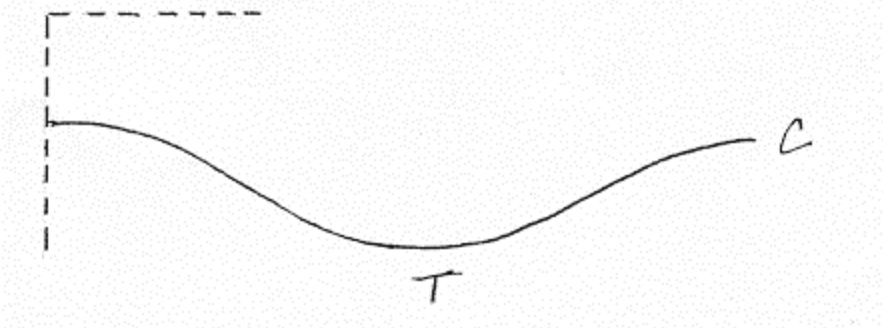
Scissors
Two 3 X 5 inch (7.5 x 12.5 cm) index cards
Colored, transparent, plastic report folders
Ruler
Transparent tape
Black marking pen

Procedure:

1. Cut a 2 x 2 inch (5 x 5 cm) window in the middle of one of the long sides of one index card.

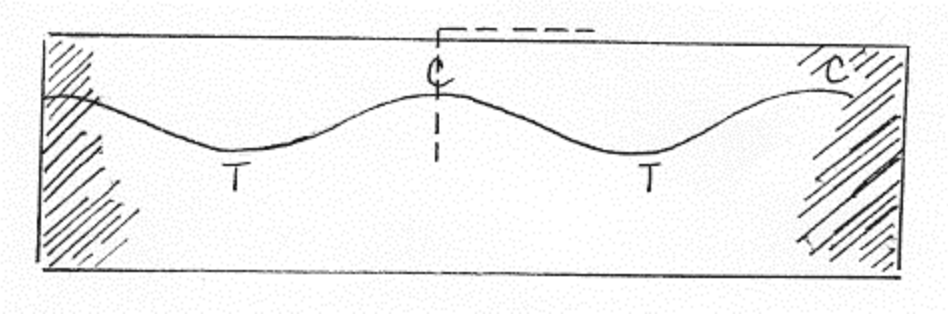


2. Place the cut card on top of the second index card.
3. Secure the two cards together with tape only on the long sides. This is your wave viewer.
4. Cut a 3 x 11 inch (7.5 x 27.5 cm) strip from the plastic folder.
5. Lay the plastic strip over the diagram of the wave so that the top left corner of the strip is in the corner formed by the dashed lines.

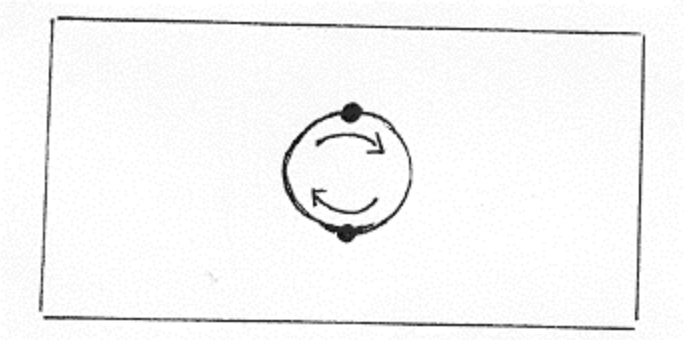


APPENDIX H (page 2)
Wave Viewer

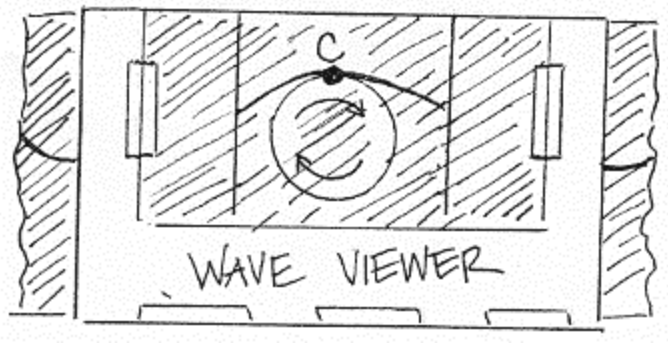
6. Trace the wave, marking the letters on the plastic.
   C marks the wave's crest and T marks its trough.
7. Move the plastic to the left until the right end of the wave traced on the plastic touches the left end of the wave in the diagram. Make sure that the top of the plastic is lined up with the horizontal dashed line then repeat step 6.



8. Cut a 2 x 4 inch (5 x 10 cm) piece from the plastic folder.
9. Lay the plastic piece over the diagram and trace the circle, dots, and arrows.



10. Insert the right short end of the long plastic strip in the wave viewer.
11. Move the strip so that the crest of a wave (the letter C dot) is centered between the right and left sides of the window in the wave viewer.
12. Lay the plastic with the circle over the wave viewer's window and position it so that the top dot on the circle touches the center of the wave's crest (the part of the wave below the letter C).
13. Tape the piece of plastic with the circle to the wave viewer.



APPENDIX H (page 3)
Wave Viewer

Activity:

Use your wave viewer to determine the motion of a water particle.

1. Lay the wave viewer on a table.
2. Hold the wave viewer in place with your right hand while you slowly push the plastic strip through the holder with your left hand.
3. Observe the direction of the arrow where the dots on the circumference of the circle touch the wave. The dots on the circle represent the water particle at the crest (top dot) and at the trough (bottom dot).
   a. When the crest passes, the water particle moves forward in the same direction as the wave is traveling.
   b. When the trough passes, the water particle moves backward.
   c. The water particle moves through a complete circle and returns to approximately the original spot.

Exercises:

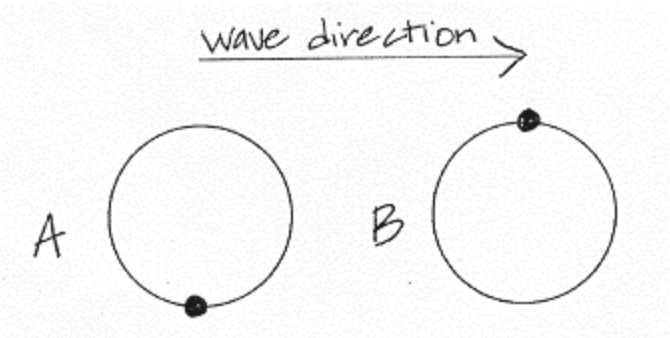
Use your wave viewer and figures A and B to answer the following questions:

1. Name the part of the wave where the water particles are located in each figure.

   A. _____

   B. _____

2. Is the water particle in figure A about to move down or up?



APPENDIX I
Rubric: Wave Viewer Lab

Possible Points: 25 points

Student Name: _____

Lab work is rated using the numbers 1-5, with 5 being the very best and 1 being the least satisfactory.

Objectives	5	4	3	2	1
Worked cooperatively and productively with group members					
Time was spent appropriately and lab was successful					
View finder is constructed correctly and is well built					
Lab is legible and all results are clearly recorded					
Lab results are accurate and findings are appropriate for class discussion					

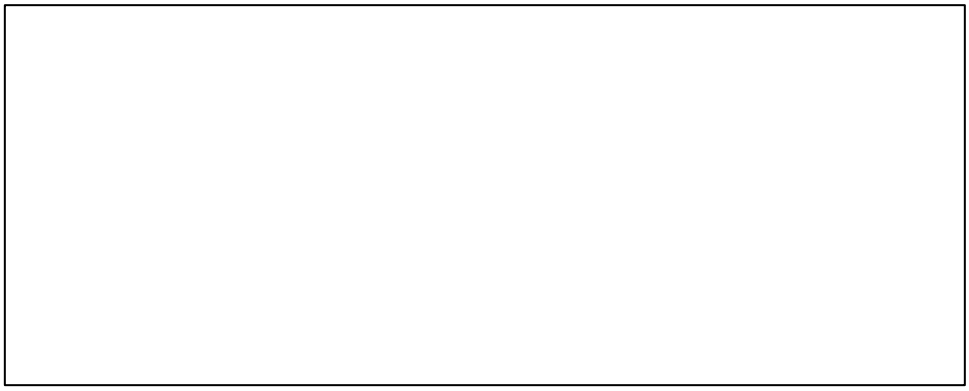
Total grade for lab work: ____ **/25**

Teacher's comments:

APPENDIX J
Tsunamis Lab Write-Up

Student Name: _____

1. *Draw a diagram that shows the experimental design and the results of your experiment.*



2. Write brief paragraph explaining what the diagram shows visually.

_____

_____

_____

_____

3. Answer the following questions on a separate sheet of paper.

1. Hypothesize why more tsunamis occur in the Pacific Ocean than in the Atlantic.

2. Compare the tsunami that occur in a fjord as a result of an iceberg breaking apart and the tsunami that occurs in the ocean as a result of an underwater earthquake.

3. Analyze the tsunami's wave as it approaches land and becomes a surge. Explain how undersea structures and coastline configuration affect the intensity of the wave.

4. Describe some of the ways tsunamis affect people who do not live on a coastline.

5. Describe architectural changes that would be required in order to tsunami-proof a beachfront home.

6. Explain how a tsunami alert warning system might function. Compare and contrast such a system to hurricane warning systems.

APPENDIX K
Rubric: Tsunamis

Possible Points: 25 points

Student Name: _____

Lab work is rated using the numbers 1-5, with 5 being the very best and 1 being the least satisfactory.

Objectives	5	4	3	2	1
Worked cooperatively and productively with group members					
Time was spent appropriately and lab was successful					
Diagram was carefully executed and shows experimental design and results					
Paragraph is clear, accurate and error-free					
Lab results are accurate and findings are appropriate for class discussion					

Total grade for lab work: ____ **/25**

Teacher's comments:

APPENDIX L (page 1)
"Currents, Tides and Waves" Final Exam

Short Answer: *Answer the following with complete sentences.*

1. What causes tides? _____

2. What causes a wave to break? _____

_____

3. In which hemisphere do currents flow clockwise, Northern or Southern? _____

4. What produces waves? _____

---

5. Name two parts of a wave? _____

6. What is a tide? _____

---

7. What is a tidal bulge? _____

---

8. How do waves change as the near a shore? _____

True or False: *If the statement is true, write true. If it is false, change the underlined word or words to make the statement true*

_____ 1. The further apart waves are, the greater their <u>wavelength</u>.

_____ 2. A <u>rip current</u> is caused by an earthquake on the ocean floor

_____ 3. <u>Gravity</u> is the force that causes tides.

_____ 4. Surface currents usually flow <u>more</u> quickly than subsurface currents.

_____ 5. A wall of rocks or concrete built outward from a beach is called a <u>dune</u>.

APPENDIX L (page 2)
"Currents, Tides and Waves" Final Exam

Completion: *Circle the correct answers.*

1. A current that flows past the eastern coast of the United States is the _____.
   Gulf Stream **North Atlantic** **West Wind Drift**

2. Temperature differences of the water in the ocean cause _____.
   currents **winds** **waves**

3. The highest part of a wave is its _____.
   bulge **trough** **crest**

4. The lowest part of a wave is its _____.
   bulge **trough** **crest**

5. Tides are produced primarily by _____.
   currents **salinity** **gravitational pull**

6. The horizontal distance between wave crests is the _____.
   frequency **wavelength** **wave height**

7. A tide with the least difference between low and high tide is called a _____.
   spring tide **neap tide** **rip tide**

8. Surface currents and waves are caused primarily by _____.
   upwelling **earthquakes** **wind**

9. Tsunamis are most common in the _____.
   Pacific Ocean **Atlantic Ocean** **Indian Ocean**

10. When a tsunami hits the shore it can be very dangerous because of the size of its _____.
    Trough **wave height** **frequency**

APPENDIX M
"Currents, Tides and Waves" Final Exam
Teacher's Key

Short Answer:

1. What causes tides? **gravitation pull of sun and moon**
2. What causes a wave to break? **the trough slows down while the crest moves quickly and tumbles over**
3. In which hemisphere do currents flow clockwise, Northern or Southern? **Northern**
4. What produces waves? **wind, earthquakes, gravitational pull of moon and sun**
5. Name two parts of a wave? **crest and trough**
6. What is a tide? **daily forward and backward motion of the ocean**
7. What is a tidal bulge? **the lifting of water caused by the gravitational pull of the moon**
8. How do waves change as the near a shore? **As the water becomes shallow, the bottoms of the waves drag on the ocean floor and slow down, the wavelength decreases and the wave height increases**

True and False:

1. True
2. False - Tsunami
3. True
4. True
5. False - groin

Completion:

1. Gulf Stream
2. currents
3. crest
4. trough
5. gravitational pull
6. wavelength
7. neap tide
8. wind
9. Pacific Ocean
10. wave height