



Stressed Out!

Lesson Overview

GRADE LEVEL: 9-11

TIME ALLOTMENT: Three or four 45-minute class periods

OVERVIEW:

The rupture that occurs when bending stresses within earth's rock exceeds the strength of the rock itself is known as an earthquake. Earthquakes cause seismic waves, which move both through earth and along its surface. Earthquakes can occur anywhere near earth's surface, but most often happen at the boundaries between lithospheric plates. The seismic waves generated by earthquakes represent a transfer of energy, and can be recorded by devices known as seismometers. The seismic waves earthquakes generate are also used to investigate the structure of earth's interior.

Earthquakes are significant natural hazards capable of destroying life and property on a massive scale. Scientists are anxious to perfect the art of predicting earthquakes to save lives and limit economic loss, but have achieved very limited success. The additional danger posed to coastal development by earthquake-generated tsunamis lends urgency to this task.

In this lesson, students will identify methods for detecting and locating earthquakes, utilizing excerpts from the NATURE episode "Can Animals Predict Disaster?" The class will simulate the action of P and S waves, and analyze seismic data and use seismic data to determine the epicenter of an earthquake.

Student understanding will be assessed throughout the lesson using a self-check quiz, a knowledge tracking chart, responses to in-class discussions, and successful completion of virtual lab activities. Students should have basic knowledge of waves, wave propagation, and potential energy prior to completing this lesson.

This lesson can be used immediately before students complete the New York State Regents Earth Science Lab activity "Locating an Epicenter" (<http://www.bernard.p.sardissecondary.ca/files/science%2010%20-%20experiment%208%20-%20locating%20an%20epicenter.pdf>.) It can also be used prior to the *NATURE: Window into Science* lesson "Feeling Hot, Hot, Hot!"

SUBJECT MATTER: Earth Science

LEARNING OBJECTIVES:

- Express an understanding of the dynamics of earthquakes;
- Explain the basic principles of plate tectonics, as they relate to earthquakes;
- Explain how the energy released in an earthquake travels as P waves, S waves, and surface waves;



- Describe how earthquakes can be detected and located;
- Compare the differing behaviors of P waves and S waves;
- Recognize P waves and S waves on a seismograph;
- Utilize data and graph skills to determine the epicenter of an earthquake.

STANDARDS AND CURRICULUM ALIGNMENT:

National Science Education Standards:

<http://www.nsta.org/publications/nses.aspx>

CONTENT STANDARD D: *Earth and Space Science*

All students should develop an understanding of:

Energy in the Earth System

- Earth systems have internal and external sources of energy, both of which create heat. The sun is the major external source of energy. Two primary sources of internal energy are the decay of radioactive isotopes and the gravitational energy from the earth's original formation.
- The outward transfer of earth's internal heat drives convection circulation in the mantle that propels the plates comprising earth's surface across the face of the globe.
- Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents.

New York State Regents Core Curriculum Alignments

Physical Setting: Earth Science Core Curriculum

<http://emsc.nysed.gov/ciai/mst/pub/earthsci.pdf>

STANDARD 1: Analysis, Inquiry, and Design: Scientific Inquiry:

Key Idea 1: The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing creative process.

STANDARD 2: Students will access, generate, process, and transfer information, using appropriate technologies.

Key Idea 1: Information technology is used to retrieve, process, and communicate information as a tool to enhance learning.

STANDARD 4: Students will understand and apply scientific concepts, principles and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.



Key Idea 2: Many of the phenomena that we observe on Earth involve interactions among components of air, water, and land. Earth may be considered a huge machine driven by two engines, one internal and one external. These heat engines convert heat energy into mechanical energy.

PERFORMANCE INDICATOR 2.1

Use the concept of density and heat energy to explain observations of weather patterns, seasonal changes, and the movement of Earth's plates.

2.1i. The lithosphere consists of separate plates that ride on the more fluid asthenosphere and move slowly in relationship to one another creating convergent, divergent and transform plate boundaries. These motions indicate that Earth is a dynamic geologic system. These plate boundaries are the sites of most earthquakes, volcanoes and young mountain ranges.

2.1k The outward transfer of Earth's internal heat drives convective circulation in the mantle that moves the lithosphere plates comprising Earth's surface.

2.1j Properties of Earth's internal structure (crust, mantle, inner core, and outer core) can be inferred from the analysis of the behavior of seismic waves (including velocity and refraction).

Analysis of seismic waves allows the determination of the location of earthquake epicenters, and the measurement of earthquake magnitude, this analysis leads to the inference that Earth's interior is composed of layers that differ in composition and states of matter.

STANDARD 7: Students will apply the knowledge and thinking skills of mathematics, science, and technology to address real life problems and make informed decisions.

MEDIA COMPONENTS:

Video

NATURE: *Can Animals Predict Disaster?*, selected segments:

Clip 1: "Destructive Forces"

Describes instances of animals mysteriously surviving natural disasters.

Clip 2: "Waves of Destruction"



Anatomy of a tsunami.

Access the streaming and downloadable video segments for this lesson on the Video Segments Page (<http://www.pbs.org/wnet/nature/lessons/stressed-out/video-segments/1538/>).

WEB SITES

Dynamic Earth

<http://www.learner.org/interactives/dynamicearth/index.html>

This interactive site allows users to delve into the earth's interior, learn about its tectonic plates and their movements, and discover how mountains, volcanoes, and earthquakes are formed.

Seismograph

<http://content.answers.com/main/content/wp/en/a/a6/Seismogram.gif>

This site features an image of a seismograph.

Virtual Earthquake

<http://www.sciencecourseware.org/VirtualEarthquake/VQuakeExecute.html>

This activity illustrates how seismic waves are used to locate an earthquake's epicenter.

Materials

For the class:

- One computer with Internet access for class demonstration
- One LCD projector for the computer
- A hard-boiled egg with a cracked shell
- Water
- Pen
- Plastic ruler
- Stick or twig
- Glob of play-dough or clay
- Rubber band
- Safety goggles (for teacher)
- A slinky
- Stressed Out! Self Check Quiz Answer Key
- Stressed Out! Vocabulary Organizer Answer Key



For each group of 3-4 students:

- Computer with Internet access
- A tuning fork
- A 1000ml beaker

For each student:

- Knowledge Tracking chart
- Stressed Out! Self Check quiz
- Stressed Out! Vocabulary Organizer

PREP FOR TEACHERS:

Prior to teaching this lesson, you will need to:

Preview all of the video clips and Web sites used in the lesson.

Download the video clips used in the lesson to your classroom computer, or prepare to watch them using your classroom's Internet connection.

Bookmark the Web sites used in the lesson on each computer in your classroom. Using a social bookmarking tool such as del.icio.us or diigo.com (or an online bookmarking utility such as portaportal.com) will allow you to organize all the links in a central location.

Gather the necessary materials listed above in advance of teaching the lesson. Download and print each of the student organizers listed above, and make copies for each student in your classroom.

Read through the lesson prior to class, and try out each of the activities. When practicing the tuning fork activity, try varying the depth at which the tuning fork is placed in the water to get the best waves; you may get best results by keeping the fork closer to the surface of the water.

INTRODUCTORY ACTIVITY

1) Show your students the pen, plastic ruler, stick or twig, play-dough or clay, and rubber band. Explain to your students that you are going to break or destroy all of these items, and you'd like them to watch, listen, and observe what happens as each object is broken. Put on your safety goggles. Pick up each of the items and break each in half or pull them apart. Do not discuss what students are seeing or hearing until you have broken all of the objects. (Alternatively, if you have enough safety goggles and willing students, ask students to break the objects.)



2) Ask your students what they saw, heard, and observed as you broke or pulled apart the objects. (*Students should point out that you applied force or pressure, which resulted in the breaking. The breaking sometimes resulted in a sound, and it changed the shape and structure of the objects.*) As a class, come to a consensus that when force was applied, in each case, energy was released. Explain to students that stress built in each object as force was applied, to a point when the item broke and energy was released. Students should deduce that in all cases when force is applied to the objects to try and break them, potential or stored energy is converted to kinetic energy in the form of heat and/or sound. Tell students that this is analogous to the build up of stress and the release of energy in an earthquake. They will be exploring the forces and factors that contribute to earthquakes during the next few class periods.

3) Distribute the Knowledge Tracking Chart to your students. Write the following list of focus questions on the board for your students:

- a. What is an Earthquake?
- b. What are P and S waves?
- c. What are the most destructive waves?
- d. How can we detect an earthquake?
- e. How can we use data to locate an earthquake's epicenter?

Instruct students to write the questions they know and their corresponding answers in the first column of the Knowledge Tracking Chart, and to write the others in the second column of the Knowledge Tracking Chart. Tell them that over the course of the lesson, they will engage in activities that will help them find answers to these questions. As they find the answers to their questions, they should complete their charts. Explain to students that the completed charts will be collected at the conclusion of the lesson as an assessment.

4) Ask your students if they can recall any recent earthquakes. Ask your students if they know what can cause very serious additional damage after an earthquake occurs? (*Student answers will vary.*)

5) Tell your students that they are about to watch a video clip showing devastation that can occur as a result of an earthquake. Provide your students with a FOCUS FOR MEDIA INTERACTION, asking them to identify destructive forces that can result from an earthquake. PLAY Clip 1, "Destructive Forces" (access the video segments for this lesson on the Video Segments Page, <http://www.pbs.org/wnet/nature/lessons/stressed-out/video-segments/1538/>). Check for comprehension, and ask students to name additional destructive forces that can result from an earthquake. (*Tsunamis and fires.*) Remind students that the clip suggested that animals *may* be able to predict natural disasters. Ask your students if people are capable of predicting natural disasters. (*Accept all responses; students may point out that weather disasters-such as hurricanes-can be predicted through the use of satellite imagery and weather data such*



as barometric pressure.) Ask students if humans can predict earthquakes. (*Accept all student responses; point out that our ability to predict earthquakes is not terribly great.*) Do they think it is important for us to develop a better understanding of earthquakes, in order to improve our ability to predict them? (Yes.)

6) Explain to students that scientists use several tools to help understand, measure, and locate earthquakes, and that throughout the lesson, they will learn about some of these tools. Explain to your students the video clip showed the aftermath of an Indonesian earthquake in 2004. The earthquake occurred when rocks along a fault, more than 1000 km long in the Indian Ocean, suddenly shifted about 20 meters.

LEARNING ACTIVITIES

1) Tell your students that in order to understand how earthquakes work, they need to understand the structure of the earth. Distribute the “Stressed Out!” Vocabulary Organizer to your students. Ask your students to log on to the Dynamic Earth Web site (<http://www.learner.org/interactives/dynamicearth/index.html>). Provide your students with a FOCUS FOR MEDIA INTERACTION, asking them to identify the three primary layers that make up the earth. Give your students a minute or so, and check for comprehension. (*The three primary layers that make up the earth are the crust, mantle, and core.*) Ask your students to write record these definitions on their Organizers. Explain that the crust and mantle are made up of several different areas. Provide your students with a new FOCUS FOR MEDIA INTERACTION, asking them to determine the difference between the “lithosphere” and the “asthenosphere.” Give your students a minute or so, and check for comprehension. (*The lithosphere is made up of the crust and a tiny bit of mantle; it is divided into several plates of solid rock that hold the continents and oceans. The asthenosphere is a hot, semiliquid, malleable zone of the mantle. The lithosphere is more flexible than the asthenosphere, and the plates of the lithosphere “float” on the asthenosphere.*) Ask your students to write the definitions of these terms on their Organizers.

2) Show your students the hard boiled egg with the cracked shell you prepared before class. Pass the egg around the room. Tell your students to imagine that the earth is the egg; each portion of the egg shell is a different plate of the lithosphere. The hard-boiled center of the egg is soft and spongy, like the asthenosphere. Remind students that as a result of heat within the earth, the plates are constantly in motion. Ask your students to click on the link at the top of the Web page that reads, “Plates and Boundaries.” Provide your students with a FOCUS FOR MEDIA INTERACTION, and ask them to define “boundary” as well as the three different types of boundaries between plates. Give your students five minutes or so, and then check for comprehension. (*A “boundary” is the border between two plates. Types of boundaries include convergent boundaries-where plates push toward each other, divergent boundaries-where plates are moving apart from each other, and transform boundaries, where plates move past each other.*) Ask your students to write these terms and their definitions in their notebooks.



3) Explain to your students that earthquakes often occur at these boundaries. Ask students to log on to the “Slip, Slide, and Collide” section of the Dynamic Earth Web site (<http://www.learner.org/interactives/dynamicearth/index.html>). Students should scroll down the page to the heading “Transform Boundary-Grinding Plates.” Provide your students with a FOCUS FOR MEDIA INTERACTION, asking them to identify what a fault is, and to describe what causes an earthquake at a strike-slip fault. Give your students five minutes or so to complete this task. Check for comprehension, and ask your students to define “fault.” (*A fault is a crack or fracture in the earth’s crust.*) Ask your students what causes earthquakes at strike-slip faults? (*As the plates grind past each other, the jagged edges strike each other, catch, and stick, “locking” the plates in place for a time. Because the plates are locked together without moving, a lot of stress builds up at the fault line. This stress is released in quick bursts when the plates suddenly slip into new positions. The sudden movement is the shaking and trembling of an earthquake.*) Remind your students about when you broke the items at the beginning of the lesson, and explain that the building of stress, and its sudden release, is similar to what happens during an earthquake. Be sure your students write the definition of “fault” on their organizer.

4) Explain to students that when earthquakes occur, they generate waves, which can be tracked and measured. Tell students they will be carrying out an activity to simulate the movement of earthquake waves, and that you would like them to make careful observations. Ask students to divide into eight groups. Each group should fill their 1000 ml beaker with water up to the 700 ml mark. Students should then strike the tuning fork on the edge of their desk or table, and immediately immerse the tip of the tuning fork in the water. Students should create a drawing in their notebooks to record their observations. Ask one student to come to the front of the room and illustrate what they saw on the chalkboard or whiteboard. The student’s drawing should indicate concentric circles that spread out and away from the point of contact between the tuning fork and the water. Tell students that earthquake waves travel in much the same manner.

5) Explain to students they will now watch a video clip demonstrating a similar action that occurs in the earth. Write the terms “focus” and “epicenter” on the board. Tell students they will be labeling their diagrams with these terms after watching the video. Provide students with a FOCUS FOR MEDIA INTERACTION, asking them to compare the animation of the wave action in the video with the drawing on the whiteboard and the drawing they made. PLAY Clip 2, “Waves of Destruction” (access the video segments for this lesson on the Video Segments Page, <http://www.pbs.org/wnet/nature/lessons/stressed-out/video-segments/1538/>). Check for comprehension, and ask your students how the animation of the wave action compares to the in-class diagrams. (*They are very similar.*) Explain to your students that the “focus” of the earthquake is the zone within the earth where the displacement-or break-first occurs. Ask your students where the focus of the December 26, 2004 earthquake was. (*Somewhere in the earth deep beneath the bottom of the ocean, where the initial displacement between plates occurred.*) Explain to your students that the “epicenter” of an earthquake is the surface location directly above the focus. Ask your students where the epicenter of the December 26, 2004 earthquake was. (*The point on the ocean’s floor directly above the focus.*) Ask your students to accurately label their drawings with



“focus” and “waves,” and to record the definitions of “focus,” and “epicenter” on their organizer.

6) Tell students that earthquakes create two separate kinds of waves that travel through the earth. The speed of these waves is directly proportional to the rigidity of the rock through which they pass, thus yielding important information about the composition of earth’s interior to geologists. These waves are called P-waves and S-waves. Create the following chart on the chalkboard or whiteboard:

P waves	S waves
AKA:	AKA:
Travel:	Travel
Wave Direction:	Wave Direction:
Particle Motion:	Particle Motion:
Travels through:	Travels through:
Diagram:	Diagram:

Explain to students that you will be using a Slinky to demonstrate the action of two different types of waves, and that as you demonstrate, they should complete the chart on their handout.

Tell students that P waves are also known as “primary waves.” P waves travel faster than S waves. To demonstrate the action of the P wave, attach one end of the Slinky to a fixed point. Stretch/elongate the entire Slinky. Pull the end of the Slinky in your hand toward you, and then sharply push it away towards the fixed point. The action of the Slinky will demonstrate compression and wave direction. Ask your students if this wave direction is up-and-down, sideways, or push-pull. (*The P-wave direction is push-pull. Conveniently, “push-pull” corresponds to P wave.*) Explain to students that **P** waves travel through “**pr**actically anything,” including solids, liquids, and semiliquids. Ask one student to draw a diagram on the chalkboard or whiteboard drawings to show the forward direction of wave travel and the forward and backward particle motion. Students should make their own drawings in the space provided on the handout.

Tell students that S waves are also known as “secondary waves.” **S** waves travel slower than P waves. To demonstrate the action of the S wave, attach one end of the slinky to a fixed point.

Stretch or elongate the entire Slinky. Shake the slinky from side to side. Ask your students if they wave direction is push-pull. (*No.*) Is it sideways? (*Yes.*) Is it up and down? (*To a degree, yes.*) (*The S wave direction is side to side, or shear wave direction. Conveniently, “side-to-side” and “shear” correspond to S wave.*) Explain to students that **S** waves travels only through solid rock, and do not travel through semiliquid or molten rock. Ask one student to draw a diagram on the chalkboard or whiteboard drawings to show the sideways and perpendicular movement to the wave motion. Students should make their own drawings in the space provided on the handout.



Review the contents of the chart on the chalkboard or whiteboard to re-enforce student understanding.

P waves	S waves
AKA: Primary waves	AKA: Secondary Wave
Travel: Faster	Travel: Slower
Wave Direction: Push-pull , or compression	Wave Direction: Side to side , or shear
Particle Motion: Forward and Backward	Particle Motion: Sideways or perpendicular to direction of wave travel particle motion
Travels through: Practically anything	Travels through: Solids only
Diagram: (student diagram goes here)	Diagram: (student diagram goes here)

7) Explain to students that while P waves and S waves travel *through* the earth, a third type of wave, surface waves, travel through the more flexible rock on the earth's surface, moving slowest, but causing the most damage. Surface waves are sometimes referred to a L waves (and you can remember it because they take a long time to travel over the earth). Be sure your students record the definition of L waves on their organizers.

8) Ask students to refer to their Knowledge Tracking Charts, and to complete the charts with information they have learned during the lesson. Then, give students 5-10 minutes to review their "Stressed Out Vocabulary Organizer." Ask students to put their Vocabulary Organizers away, and give each student a copy of the Self-Check Quiz. Ask students to complete the quiz by filling in each blank with the appropriate term. Collect and grade quiz to assess student understanding of key terms, and collect Knowledge Tracking charts as well.

CULMINATING ACTIVITY

1) Return Knowledge Tracking Charts to students. Tell them to review answers they have written so far and write any new information that can be used to answer the questions. Explain to students that the earth's movement through earthquake waves can be recorded by instruments known as "seismometers." The records that these instruments create (either paper or digital) are called "seismographs." Students should record these definitions on their organizers.

Pose to your students the following questions: based on their knowledge of earthquake waves, which waves would appear on a seismograph *first*? (*P waves; they travel the fastest.*) Which would appear on a seismogram *second*? (*S waves, they are slower than P waves, but not the slowest of all*). Which waves would appear on a seismograph *third*? (*Surface waves, they are the slowest of all*).

2) Ask your students to log on to the Seismogram Web site (<http://content.answers.com/main/content/wp/en/a/a6/Seismogram.gif>). Provide students with a FOCUS FOR MEDIA INTERACTION, asking them to identify what is being measured on the horizontal and vertical axes of the seismograph. (*The horizontal axis*



measures TIME, the vertical axis measures VELOCITY, or speed.) Explain to students the time that elapses between the arrival of the two types of waves is the “S-P interval.” Students should record this definition on their organizer. Provide students with a FOCUS FOR MEDIA INTERACTION, asking them where the S-P interval is on the online seismograph. (*Between the green line and the red line.*) Ask students how they think the arrival time of earthquake waves on at a seismometer will be impacted by the seismometer’s distance to the epicenter. (*The farther the seismometer is from the epicenter, the longer it will take for the earthquake’s waves to reach it.*) Explain to your students that by using a time-distance graph, you can convert the S-P interval into distance. If you have data from three seismograms, you can find the epicenter of an earthquake. Tell your students you will complete an online activity to illustrate this concept.

3) Ask students to log on to the Virtual Earthquake Web site (<http://www.sciencecourseware.org/VirtualEarthquake/VQuakeExecute.html>). Provide students with a FOCUS FOR MEDIA INTERACTION, asking them to assist you in reading graphs and charts to determine the epicenter of an earthquake. Walk through the activity first as a class. Select to create an earthquake near San Francisco, CA. Examine the map of the area, as well as the sample seismogram. Note that the S-P interval on the sample seismogram is about 36 seconds. Click on the “View Seismogram” buttons, and as a class, examine the three seismograms and deduce the S-P interval for each. (*The S-P interval for the first seismogram is 49 seconds, the second seismogram is 72 seconds, and the third seismogram is 64 seconds.*)

4) After determining the S-P interval for each of the seismographs, click the “Convert SP Interval” button. Explain to students that the graph on the site enables you to convert the S-P interval from the three seismometers into distances. As a group, use the graph to determine the epicentral distance from Elko, Eureka, and Las Vegas. (*The epicentral distance from Elko is 480 miles, from Eureka is 697 miles, and from Las Vegas is 622 miles.*) Ask your students if they have any ideas for how to find a point that is a specified distance from three other points. (*Guide students to understand that if you use a map that is in scale, you can draw a circle around each location; where the three circles intersect is the point that’s the correct distance from all three.*) Click on the “Find Epicenter” button. The Web site will show three circles intersecting at a point south of San Francisco, the epicenter of the earthquake.

5) Ask students to log on to the Virtual Earthquake site (<http://www.sciencecourseware.org/VirtualEarthquake/VQuakeExecute.html>). Provide students with a FOCUS FOR MEDIA INTERACTION, asking them to find the epicenter of an earthquake near one of the other cities, using the process you used as a class for San Francisco. Give students 10-15 minutes to complete this task.

6) Collect the Knowledge Tracking Charts and Vocabulary Organizers to assess student knowledge from the lesson. Tell students that they will be applying the skills and knowledge gained from completing the lesson to an actual in-class lab as they locate the epicenter of an earthquake by triangulation. In a future class period, have students complete the New York State Regents Earth Science “Locating an Epicenter” lab. A version of the lab activity is available here:



<http://www.bernard.p.sardissecondary.ca/files/science%2010%20-%20experiment%208%20-%20locating%20an%20epicenter.pdf>.

CROSS-CURRICULAR EXTENSIONS

Science

Investigate the different scales used for measuring earthquake intensity, such as the Mercalli and Richter scales. How are they similar? How are they different?

Social Studies

Complete online research to find out how the citizens of Indonesia are coping three years after the tsunami.

Research and report on different historic earthquakes.

Trace the development of seismometer technology.

Math

Create “earthquake word problems,” describing the arrival times of P and S waves on a seismogram. Base the word problems on actual earthquakes, real distances, and earthquake prone cities.

COMMUNITY CONNECTIONS

Tell your students that although the most seismically active regions of the United States are along the plate boundaries of the West Coast, including California, Oregon, Washington, and Alaska, there are seismic sites in many states. Ask students to research your area’s geologic history, and create a list or map of earthquakes or notable seismic. They should locate and present pictures of any structural damages resulting from these events.

Invite a geologist to your classroom to discuss current research and work on predicting earthquakes.



NAME: _____

DATE: _____

Earthquakes, Waves, and Epicenters

Knowledge Tracking Chart

Information I know. . .	Information I want to know. . .	Information I've learned. . .



NAME: _____

DATE: _____

Earthquakes, Waves, and Epicenters

Self-Check Quiz

Fill the blanks with the appropriate words.

1. Write the name of the point of origin of an earthquake

_____.

2. The wave that produces the most earthquake destruction is the

_____ wave.

3. The seismic wave that travels the fastest is the

_____ wave.

4. The instrument used to measure seismic waves is called a

_____.

5. The feature of an earthquake that is located on earth's surface directly above the earthquakes origin is called the _____.



NAME: _____

DATE: _____

Earthquakes, Waves, and Epicenters

Vocabulary Organizer

As the class completes the activities of the lesson, develop and record definitions for the following terms related to earthquakes.

Crust:

Mantle:

Core:

Lithosphere:

Asthenosphere:

Boundary:

Convergent Boundary:

Divergent Boundary:

Transform Boundary:

Fault:

Focus:

Epicenter:

P waves	S waves
AKA:	AKA:
Travel:	Travel:
Wave Direction:	Wave Direction:
Particle Motion:	Particle Motion:
Travels through:	Travels through:
Diagram:	Diagram:



NAME: _____

DATE: _____

L-Wave:

Seismometer:

Seismograph:

S-P Interval:



NAME: _____

DATE: _____

Earthquakes, Waves, and Epicenters

Self-Check Quiz ANSWER KEY

Fill the blanks with the appropriate words.

1. Write the name of the point of origin of an earthquake: **FOCUS**.
2. The wave that produces the most earthquake destruction is the **SURFACE, or L** wave.
3. The seismic wave that travels the fastest is the **PRIMARY, or P** wave.
4. The instrument used to measure seismic waves is called a **SEISMOMETER**.
5. The feature of an earthquake that is located on earth's surface directly above the earthquake's origin is called the **EPICENTER**.



NAME: _____

DATE: _____

Earthquakes, Waves, and Epicenters

Vocabulary Organizer Answer Key

As the class completes the activities of the lesson, develop and record definitions for the following terms related to earthquakes.

Crust: hard and rigid, it is the earth's outermost and thinnest layer.

Mantle: divided into two regions, the upper and lower mantle. This dense layer is made up of hot, semisolid rock, and is located directly below the crust.

Core: made up of two layers, the inner and outer core. The inner core is an extremely hot solid sphere of iron and nickel at the center of the earth. The outer core is the only liquid layer of the earth; a sea of mostly iron and nickel.

Lithosphere: made up of the crust and a bit of mantle; divided into several plates of solid rock that hold the continents and oceans.

Asthenosphere: hot, semiliquid, malleable zone of the mantle. More flexible than the asthenosphere.

Boundary: the border between two plates.

Convergent Boundary: a boundary where two plates push towards each other.

Divergent Boundary: a boundary where two plates are moving apart from each other.

Transform Boundary: a boundary where plates move past each other.

Fault: a crack or fracture in the earth's crust.

Focus: the zone within the earth where the displacement or break of rock in an earthquake first occurs.

Epicenter: the location on the earth's surface directly above the focus of an earthquake.

P waves	S waves
AKA: Primary waves	AKA: Secondary Wave
Travel: Faster	Travel: Slower
Wave Direction: Push-pull , or compression	Wave Direction: Side to side , or shear
Particle Motion: Forward and Backward	Particle Motion: Sideways or perpendicular to direction of wave travel particle motion
Travels through: Practically anything	Travels through: Solids only
Diagram: (student diagram goes here)	Diagram: (student diagram goes here)



NAME: _____

DATE: _____

L-Wave: earthquake waves that travel through the more flexible rock on the earth's surface. Of all earthquake waves, surface waves cause the most damage.

Seismometer: instruments that monitor the earth's movement, and record earthquake waves.

Seismograph: the paper or digital record created by a seismometer.

S-P Interval: the time that elapses between the arrival of P waves and S waves on a seismograph.