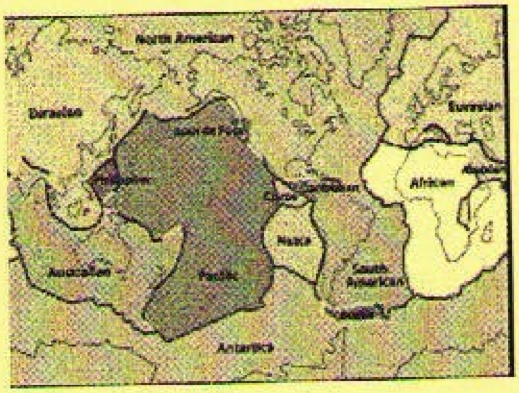
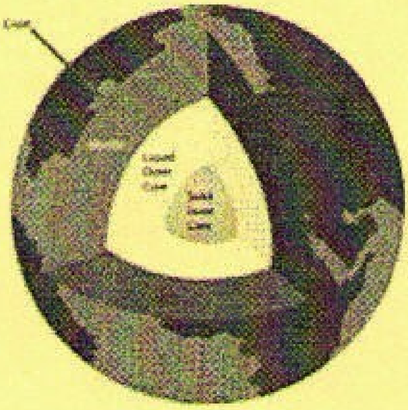
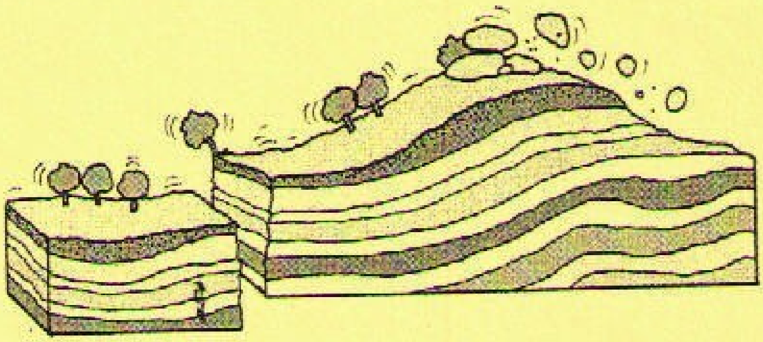






CATASTROPHIC EVENTS NOTEBOOK:

Earthquakes, Volcanoes & Rocks

FRIENDSHIP JR. HIGH SCHOOL

Student Name: ____

Science Teacher: ____

Science Period: ______________

2012-2013 School Year

Lesson 10: Introducing Earthquakes

Name: ____________________

Date: ____________ **Period:** ______

TITLE: Simulating the Motion of Earthquake Waves

PROBLEM: Which type of earthquake waves moves faster? Which type of waves cause the most damage to buildings on Earth?

BACKGROUND INFORMATION:

- ____________________
- ____________________
- ____________________

HYPOTHESIS: ____________________

____

____

____

____

EXPERIMENT:

MATERIALS NEEDED:

- 1 copy of the lab
- 1 slinky with string tied to one end
- 1 meter stick
- 1 stopwatch
- 1 sheet of construction paper
- masking tape

PROCEDURE:

Part A

1. Look at the slinky, the stopwatch, and the masking tape. How might you use these materials to study earthquake waves?
2. Watch as student volunteers demonstrate various ways to move the slinky. Draw how the slinky moves each time. Record these drawings in your data/observation section for part A.

3. There are two basic types of movements: push and pull; side to side. Energy from an earthquake moves through the Earth, and on or near its surface in waves. Classify each of the above drawings according to the type of wave movement: push/pull or side/side. Record this information in the same data table.

Before beginning the lab, observe Figure 11.1 on page 123. DO NOT stretch the spring too far. DO NOT let go of the spring suddenly. It will tangle. DO NOT play with the spring in the air. Work with the spring only on the floor.

Part B

4. Gather your group's materials. Check the string on your spring. Make sure the two ends of the string are attached tightly to the spring.

5. Lay the spring (slinky) on the floor. Be careful not to tangle it. Have one group member hold the string (Figure 11.3B). Have another group member hold the other end of the spring 4 meters away.

6. Before collecting data, test the motion of the spring by getting it to move in the ways your class did earlier.

7. Lay the construction paper on the floor, on the end opposite the string, as shown in Figure 11.4. In one quick motion, pull the spring back the length of the paper and quickly push the spring forward (to the end of the paper) one time. DO NOT let go of the spring. Follow the directions for Figure 11.4 on page 125.

8. Observe what happens to the spring in the above step. Discuss your observations with your group. This result models an earthquake "P-wave". (Think of it as a "push and pull" wave that moves through the Earth).

9. Repeat step 8 to get a good sense of how the spring behaves when you pull and push it. Sketch the movement of the spring when you push and pull it in the data/observations section.

10. Time the motion of the wave as it makes one complete trip, from your hand, to the chair, to your hand again. Record the time (in seconds) in your data table. Repeat this step three times. Record the information for all three trials in the table. Average all three of your results.

Part C

11. Now test the motion of a side-to-side wave. This time turn the paper widthwise (see Figure 11.5, page 125). In one quick motion, shake the spring one time from side to side, but keep it on the floor within the borders of the paper. Discuss with your group what happened. This result models and earthquake "S-wave". (Think of it as a "side to side" wave that travels through Earth).

12. Shake the spring once again from side to side. Sketch the movement of the spring when you move it from side to side in the data table.

13. Time the motion of the wave as it makes one complete trip, from your hand, to the chair, to your hand again. Record the time (in seconds) in your data table. Conduct three more trials. Remember to move the spring the same distance each time. Record each trial and the average of the three in your data table.

Part D

14. Fasten a piece of masking tape on the end of the spring, near the string (see Figure 11.6 on page 126). The tape represents structures on Earth's surface. The spring represents an earthquake wave moving through Earth. Push and pull the spring again. How does the tape move with a P-wave? Now move the spring from side to side. How does the tape move with an S-wave? Discuss your observations with your group.

15. Complete questions 1 and 2 in your conclusion section.

16. Put five pieces of tape on five different coils along the spring (see Figure 11.7 on page 126). Move the spring from side to side. Answer question 3 in your conclusion section.

17. Clean up all materials. Remove the masking tape from the spring.

18. Answer all conclusion questions.

DATA/OBSERVATIONS:

Part A

Trial	Drawing of Slinky Movement	Classification of Movement (push/pull or side/side)
1		
2		
3		

Part B and C

Type of Earthquake Body Wave	**Sketch of How Spring Moves**	**Time for Wave to Travel Back and Forth One Complete Trip (seconds)**			
		Trial 1	**Trial 2**	**Trial 3**	**Average**
Push/Pull (P-wave)					
Side/Side (S-wave)					

CONCLUSION:

1. Write P-wave or S-wave below each picture

2. Think about how the tape on the spring moved. Draw arrows on each house in Question 1 to show how the earthquake body wave might move the ground.

3. In this experiment, what was your control (the part that remained the same or constant)? What was your variable (the part that was being tested or changed)?

____

____

____

4. How do you think a side-to-side wave on the surface of the Earth moves the ground? How would this type of movement affect the structures on the surface (buildings, bridges, trees, houses, rivers, etc.)?

____

____

____

____

5. Describe the two types of seismic waves you investigated in this lab (P-wave and S-wave). Be specific.

____

____

____

____

6. Look at your data table. Which type of wave moved faster? What may have affected your results?

____

____

____

____

7. An earthquake sends out two types of waves from its focus: P-waves and S-waves. Use the data collected in this lab to help explain the following: which waves arrive first, which waves arrive second, which waves do more surface and structural damage.

____

____

____

____

____

Name ______________________ Date __________ Class __________

SECTION 2-2 **SECTION SUMMARY**

Measuring Earthquakes

Guide for Reading

- How does the energy of an earthquake travel through Earth?
- What are the different kinds of seismic waves?
- What are the scales used to measure the strength of an earthquake?

2

The point beneath Earth's surface where rock under stress breaks to cause an earthquake is called the **focus.** The point on the surface directly above the focus is called the **epicenter.** During an earthquake, vibrations called **seismic waves** move out from the focus in all directions. **Seismic waves carry the energy of an earthquake away from the focus, through Earth's interior, and across the surface.**

There are three types of seismic waves: P waves, S waves, and surface waves. P waves compress and expand the ground like an accordion. **S waves** vibrate from side to side and up and down. When P waves and S waves reach the surface, some are changed into surface waves. **Surface waves** move more slowly than P waves and S waves, but they produce the most severe ground movements.

Scientists measure and record the vibrations of seismic waves with instruments called **seismographs.** An earthquake's **magnitude** is a measurement of its strength based on seismic waves and movement along faults. Three rating scales can be used to measure an earthquake. The **Mercalli scale** rates earthquakes by describing their effects on people, buildings, and the land surface in a given location. The **Richter scale** rates earthquakes according to the size of seismic waves as measured by a seismograph. The **moment magnitude scale** rates earthquakes by estimating the total energy they release. **The moment magnitude scale can be used to rate earthquakes of all sizes, near or far.**

When an earthquake strikes, P waves arrive at a seismograph first and S waves next. The farther away the epicenter is, the greater the difference between the two arrival times. This time difference tells scientists how far from the seismograph the epicenter is. The scientists then use the information from three different seismograph stations to plot circles on a map. Each circle shows the distance from one seismograph station to all the points where the epicenter could be located. The single point where the three circles intersect is the location of the earthquake's epicenter.

Name ____________________ Date __________ Class __________

SECTION 2-2 REVIEW AND REINFORCE

Measuring Earthquakes

◆ Understanding Main Ideas

Answer the following questions in the spaces provided.

1. What are seismic waves?

____

____

2. In what order do the three types of seismic waves arrive at a seismograph?

____

____

3. Which type of seismic wave produces the most severe ground movements?

____

4. Describe the moment mangitude scale and explain why it is useful in measuring earthquakes.

____

____

____

5. How do geologists locate the epicenter of an earthquake?

____

____

____

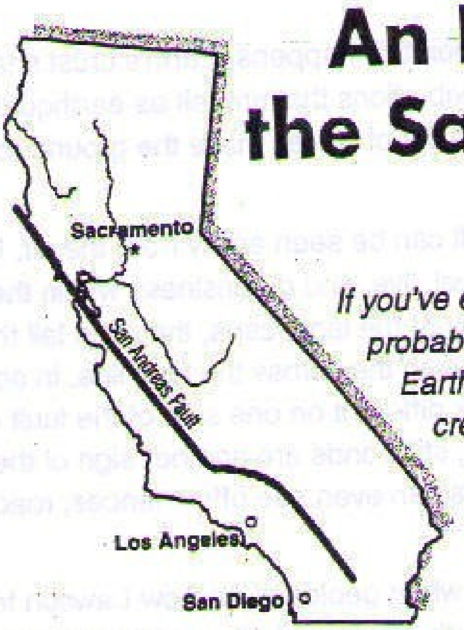
2

◆ Building Vocabulary

Match each term with its definition by writing the letter of the correct definition in the right column on the line beside the term in the left column.

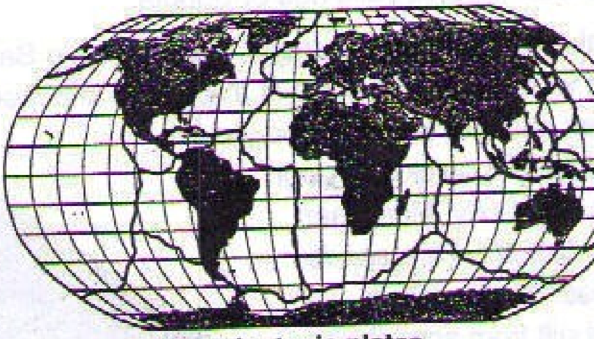
______ **6.** focus	**a.** records ground movements caused by seismic waves as they move through the Earth
______ **7.** epicenter	**b.** slowest seismic waves that produce the most severe ground movements
______ **8.** surface waves	**c.** the point beneath Earth's surface where rock under stress breaks and triggers an earthquake
______ **9.** seismograph	**d.** a measurement of earthquake strength
______ **10.** magnitude	**e.** the point on the surface directly above where an earthquake occurs

An Inside Look at the San Andreas Fault



If you've ever lived in or visited California, you've probably heard of the San Andreas Fault. Earthquakes along the San Andreas Fault have created some of California's best scenery and worst trouble. In order to understand how these "big shakes" happen, you need to know a bit about what lies far beneath your feet.

Earth's crust is made up of solid sections of rock called tectonic plates that float and slide on Earth's molten mantle. Sometimes one plate's edge slides under another plate. Deep trenches on the ocean floors are proof of this kind of movement. Sometimes two plates collide, making mountains. Sometimes plates slide past each other. Movements of tectonic plates cause faults, or large breaks, in the crust.



tectonic plates

The San Andreas Fault is in western California. It is more than 650 miles (1,046 km) long and 10 miles (16 km) deep. It extends from north of San Francisco southward to San Bernardino. It is the boundary of two of the Earth's moving plates, the Pacific plate on the west and the North American plate on the east.

These two plates creep at the slow rate of a few centimeters a year. They have moved only 350 miles (563 km) in the past 20 million years. As they move, they slide against each other. At some places along the fault, this slide is slow and continuous. This even, steady creep does not cause earthquakes. At other points along the fault, the rocks of the plates get caught on one another as they slide. For one hundred or more years at a time, these "locked" sections do not move at all. Over time, pressure builds up in these areas.

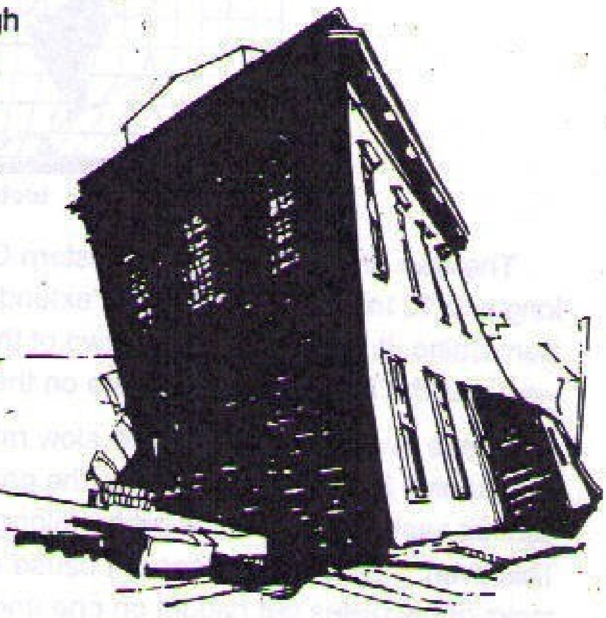
Then the strain is released in a single lurch. When this happens, Earth's crust snaps into a new position. This sudden "faulting" causes vibrations that are felt as earthquakes. The first vibration waves produce a "thud." The next set of waves make the ground roll and sway.

The ridges and valleys of the San Andreas Fault can be seen easily from the air. From the ground its features are less striking. People travel, live, and do business within the fault zone without knowing it. Yet, if they look closely at the landscape, they can tell they are in the zone. Streams make sudden right turns when they cross the fault line. In some spots along the fault, the vegetation and terrain look different on one side of the fault than on the other. High, narrow ridges surrounding deep, still ponds are another sign of the fault zone. In some places along the fault, observers can even see offset fences, roads, and rows of trees moved by earlier earthquakes.

The San Andreas Fault was discovered in 1893 when geologist Andrew Lawson took a close look at the landscape. He found signs of earth movement all along the way from San Diego to San Francisco. Lawson defined the borders of a fault. He named it the San Andreas because its features were most clear around San Andreas Lake.

Thousands of tiny earthquakes occur along the San Andreas Fault each year. Two of the strongest earthquakes in recent history occurred in 1857 and 1906. The 1857 earthquake struck Southern California. No towns were located near the center of the quake so little damage was done to buildings or people.

The 1906 earthquake caused more damage. It occurred in San Francisco where many people lived and worked. The shaking of the quake knocked down buildings. It also broke power lines and overturned wood stoves, causing fires. The fires spread quickly through the wooden structures of the city. More than 700 people died in the disaster. Thousands more were left homeless. Much of San Francisco had to be rebuilt from scratch.



Today we know how to construct buildings that are less likely to fall or burn in earthquakes. We know which kinds of soil are safe to build on. We even have instruments that help us predict when and where earthquakes might occur. Living in the San Andreas Fault zone is much safer today than it was in 1906.

Name ______________________________

Questions about
An Inside Look at the San Andreas Fault

Fill in the bubble that best answers each question.

1. Which of these is **not** a land feature of the San Andreas Fault?
   - ○ sudden turns in streams
   - ○ deep, still ponds
   - ○ numerous purple wildflowers
   - ○ high, narrow cliffs
2. Why are some sections of the San Andreas Fault called "locked"?
   - ○ Geologists cannot do research on locked sections because they are in deep wilderness.
   - ○ Tourists cannot visit locked sections because no roads lead to them.
   - ○ Locked sections of the San Andreas Fault have fences around them.
   - ○ Locked sections of the fault do not move for a hundred or more years at a time.
3. Which movement listed is **not** a movement that tectonic plates experience?
   - ○ Plates collide.
   - ○ Plate edges slide under one another.
   - ○ Plates slide past each other.
   - ○ Plates creep at the rate of one mile per year.
4. What causes earthquakes?
   - ○ the steady, even creeping of tectonic plates sliding past each other
   - ○ locked sections of a fault moving suddenly and sending out vibrations
   - ○ heavy rock avalanches that send out vibrations
   - ○ unusually strong wave action in the world's major oceans
5. How many earthquakes occur in California each year?
   - ○ about five
   - ○ no more than one hundred
   - ○ thousands of major earthquakes
   - ○ thousands of tiny earthquakes
6. Why was the 1906 earthquake in Northern California more destructive than the 1857 earthquake in Southern California?
   - ○ The 1906 earthquake burst water lines causing a major flood to follow the earthquake.
   - ○ The Northern California earthquake occurred in an unpopulated area.
   - ○ The Southern California earthquake occurred in an unpopulated area.
   - ○ The 1857 earthquake did not last as long.

Name ______________________

Vocabulary

Find words in the story to complete the puzzle.

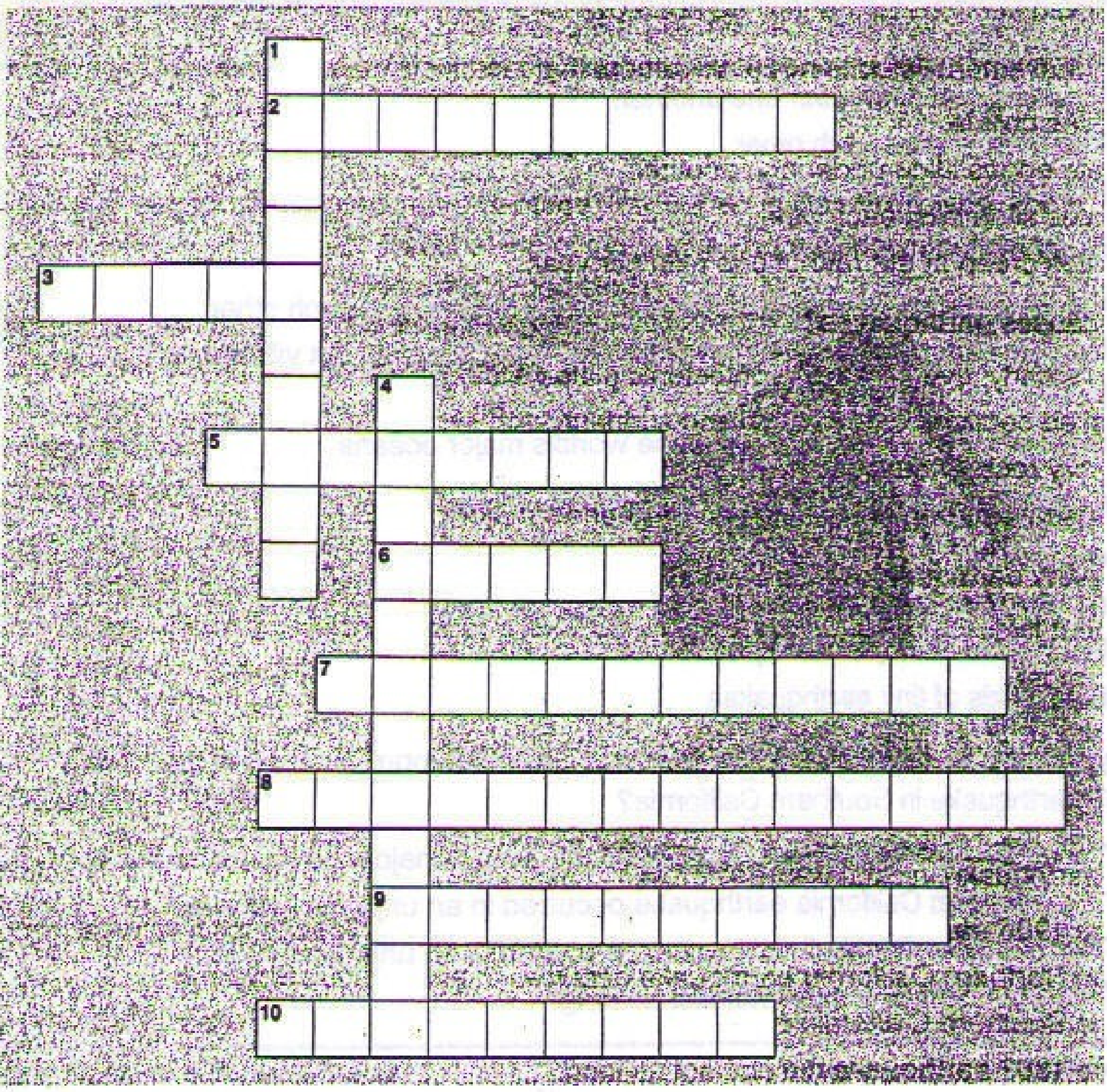
Across

2. a vibration caused by sudden movement along a fault
3. the outer layer of the Earth
5. something that causes great trouble
6. a large break in the Earth's crust
7. a tectonic plate west of the San Andreas Fault
8. sections of the Earth's crust
9. a major earthquake fault in California
10. a scientist who studies the formation of the Earth

Down

1. plant life
4. a California city struck by a major earthquake in 1906

Word Box	
crust	Pacific plate
disaster	San Andreas
earthquake	San Francisco
fault	tectonic plates
geologist	vegetation



Earth SCIENCE

Earthquakes

This puzzle contains hidden words. They can go up and down, across, at an angle, forward, or back. All the hidden words are in the list below. When you find one, circle it and look for another.

Aftershock
Blocks
Boundary
Collide
Crust
Energy
Epicenter
Fault
Force
Friction
Lithosphere
Magnitude
Mantle
Movement
Pacific
Plate
Pressure
Reflectors
Richter
Rift
Seismograph
Shaking
Sliding
Tiltmeter
Tsunami

Y	M	E	N	E	E	R	R	A	N	N	E	I	N	N	T	Y	T
B	I	P	R	L	C	F	I	D	B	O	U	N	D	A	R	Y	E
L	F	I	S	O	I	R	A	F	C	T	L	C	O	E	G	D	A
O	R	C	L	O	R	T	U	U	T	E	F	E	R	R	I	E	F
C	I	E	I	U	O	E	H	S	L	P	S	U	E	L	C	D	T
K	C	N	D	S	E	D	F	O	T	T	S	N	L	R	E	U	E
S	T	T	I	H	C	D	M	L	S	S	E	O	O	T	A	D	R
E	I	E	N	A	K	C	I	M	E	P	C	F	R	E	R	I	S
E	O	R	G	K	P	M	B	R	O	C	H	I	E	K	I	O	H
E	N	T	C	I	A	O	P	E	B	V	T	E	N	Y	C	A	O
P	M	A	G	N	I	T	U	D	E	F	E	O	R	W	H	U	C
T	A	D	U	G	R	D	E	N	T	S	S	M	R	E	T	H	K
O	N	S	A	U	C	P	A	C	I	F	I	C	E	S	E	N	E
N	T	E	T	I	L	T	M	E	T	E	R	D	P	N	R	R	O
A	L	L	A	E	E	T	L	L	D	A	I	O	N	L	T	T	T
N	E	T	K	E	I	U	D	I	A	C	E	S	E	L	A	C	N
E	A	A	O	I	A	C	Q	O	E	C	D	E	T	M	H	T	T
S	E	I	S	M	O	G	R	A	P	H	I	C	L	N	R	S	E

15

Lesson 12: Recording Earthquake Waves

Name: ______________________
Date: ______________________ Period: ______

TITLE: Recording Vibrations

PROBLEM: How do seismologists record and study earthquake waves?

BACKGROUND INFORMATION:

- ____
- ____
- ____

HYPOTHESIS:

____

____

____

____

EXPERIMENT:

MATERIALS NEEDED:

- 1 metric ruler
- 1 seismograph
- 1 roll of seismogram paper
- 1 copy of the lab
- 1 student book
- 1 sharpie marker

PROCEDURE:

Part A: Getting Started

1. Observe as your teacher demonstrates the use of one of the sample seismographs.
2. Gather all of the materials needed for this lab.
3. Look at the sample seismograph. You will use this to record vibrations made by shaking or pounding. How do you think this instrument works?
4. Set up your seismograph. Use Figure 12.1 on page 137 of your student book for guidance.

5. Listen to your teacher's directions. You will experiment with the seismograph for 5 minutes. List in the Data/Observation section two things your group discovered about the model and how it works. Record these observations in your data table.

Part B: The Variables

6. Discuss with your class how you can test the following variables:

   Direction: How does changing the direction of your pounding (location of your hand) affect the waves that the seismograph records on the paper?

   Distance: How does the distance of your pounding from the seismograph affect the waves it records?

   Force: How does the strength of your pounding affect the waves it records?

7. Record the class ideas in the Data/Observation section for part B.

Part C: Recording Movement

8. Test the seismograph. Pull the paper strip very slowly through the paper frame. DO NOT shake the table at all. Make sure the pen is marking the paper. If not, call your teacher over to have the pen readjusted. If it did mark the paper, label this paper strip "Control- No Vibrations". DO NOT tear off the paper yet.

9. Interpret your seismogram. Describe how the ink on the paper looks. Why does it look that way? Record these observations in the Data/Observation section of the lab for part C.

10. Test the variable of direction first. As one person slowly pulls the paper through the frame, have a second person do the following:

   A. Pound on the front of the table parallel to the seismograph's arm, as shown in Figure 12.3, page 139. Write "parallel" on your paper. Record this information in your Data/Observation section of the lab for part C.
   B. Pound on the side of the table perpendicular to the seismograph's arm, as shown in Figure 12.4, page 139. Write "perpendicular" on the paper. Record this information in your Data/Observation section of the lab for part C.
   C. Pound on the surface of the table, as shown in Figure 12.5, page 139. Write "surface" on the paper. Record this information in your Data/Observation section of the lab for part C.

11. Test the variable of distance. With each test, change the distance your seismograph is from the pounding, but keep the direction of your pounding constant. For example, do the following:

A. Pound close to the seismograph. Pound the side of the table that is perpendicular to the seismograph's arm, as shown in Figure 12.4, page 140, while your partner pulls the paper through the frame. Measure the distance. Record the distance in your data table. Label the paper "Close to Seismograph".

B. Move the seismograph far from your hand, approximately 30 to 40 cm, as shown in Figure 12.6, page 140. Measure the distance. Remember to pound in the same way and from eh same directions as you did when you pounded close to the model. Label the paper "Far from Seismograph".

12. Now test the variable of force. Remember to keep the distance and the direction constant. Try the following:

A. DO NOT pound at all. Keep the table still as you pull the paper strip. Mark the paper strip "Control-No Force". Record this information in your Data/Observation section of the lab for part C.

B. Very gently, pound the side of the table close to and perpendicular to the seismograph's arm. See Figure 12.4, page 140. Pull the paper through as you pound gently. Mark you're your paper strip "Small Force". Record this information in your Data/Observation section of the lab for part C.

C. Pound much harder this time. Make sure you pound from the same direction so that you are only changing one variable at a time. Mark your paper strip "Large Force". Record this information in your Data/Observation section of the lab for part C.

13. Tear your paper strip and put your group member's names on the backside.

14. Clean up all materials.

DATA/OBSERVATIONS:

Part A

Observations of Seismograph	**How did the Seismograph Work/Move**

Part B

Variable	Ideas Of How To Test
Direction	
Distance	
Force	

Part C

Direction	**Seismogram Drawing**
A	
B	
C	

Distance	**Seismogram Drawing**
A Distance = ______ cm	
B Distance = ______ cm	

Force	**Seismogram Drawing**
A	
B	
C	

CONCLUSION QUESTIONS:

1. What was the control in this experiment? Why?

2. What were the variables in this experiment? Why?

3. What happened when you changed the direction of your pounding (perpendicular movement, parallel movement, vertical movement)?

4. How could your answer from the above question help to explain why seismologists used multiple seismographs to record ground movement?

5. What happened when you changed the distance of pounding from the seismograph?

6. How could your answer from the above question explain the strength of an earthquake at its epicenter compared to surrounding areas?

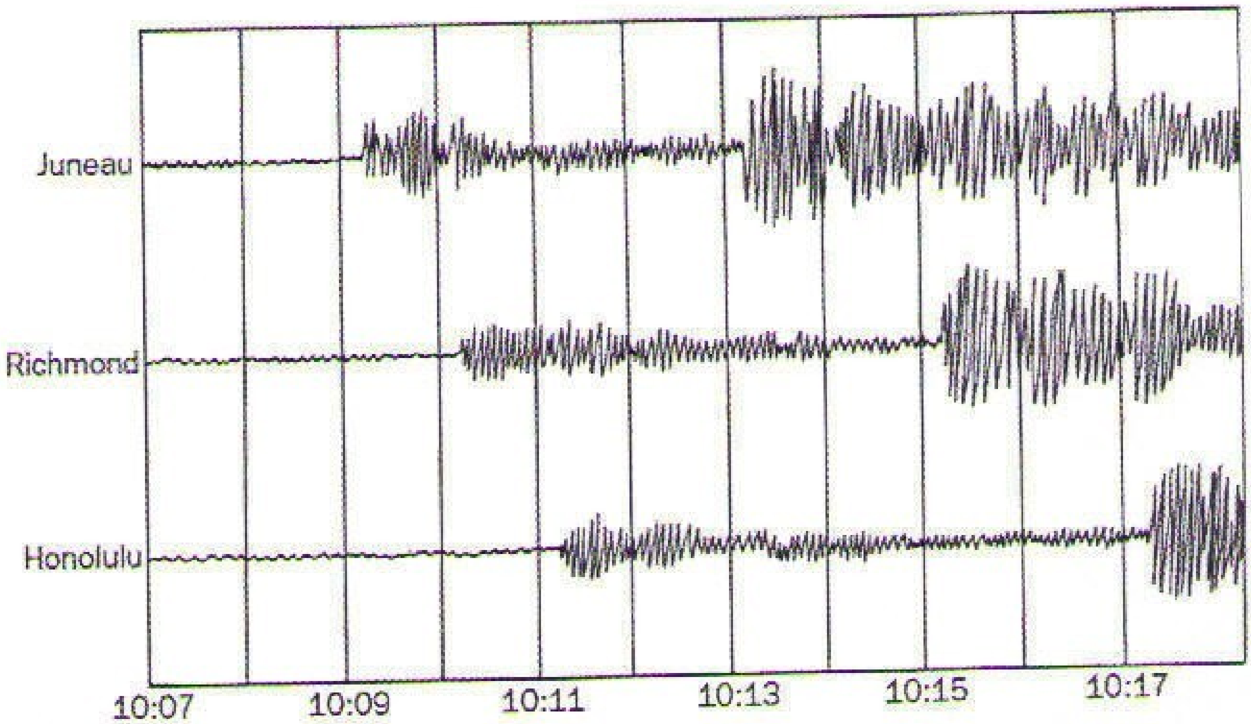
7. Explain what happened when you changed the force of the pounding?

8. Why is there always more damage to structures that are built close to the source of the earthquake than structures that are farther away? Explain.

Name: ____________________
Date: ____________________ Period: ____

READING A SEISMOGRAM

Three seismograph stations around the country recorded vibrations from the same earthquake station. Look carefully at the seismograms. Then answer the questions that follow.



1. Indicate which areas represent the P-waves and which represent the S-waves for each of the three cities.
2. The earthquake was nearest to which city? ____________________
3. Around what time did the P-wave arrive in Juneau? ____________________
4. Around what time did the P-wave arrive in Honolulu? ____________________
5. Around what time did the S-wave arrive in Richmond? ____________________
6. How much time elapsed between the P-wave and S-wave arrival in Juneau? ____________________
7. Why were the arrival times for the seismic waves different for each city?
____
____
8. In which city would you expect to see the most damage? Why?
____
____

Name: ____________________

Class: __________ Date: __________

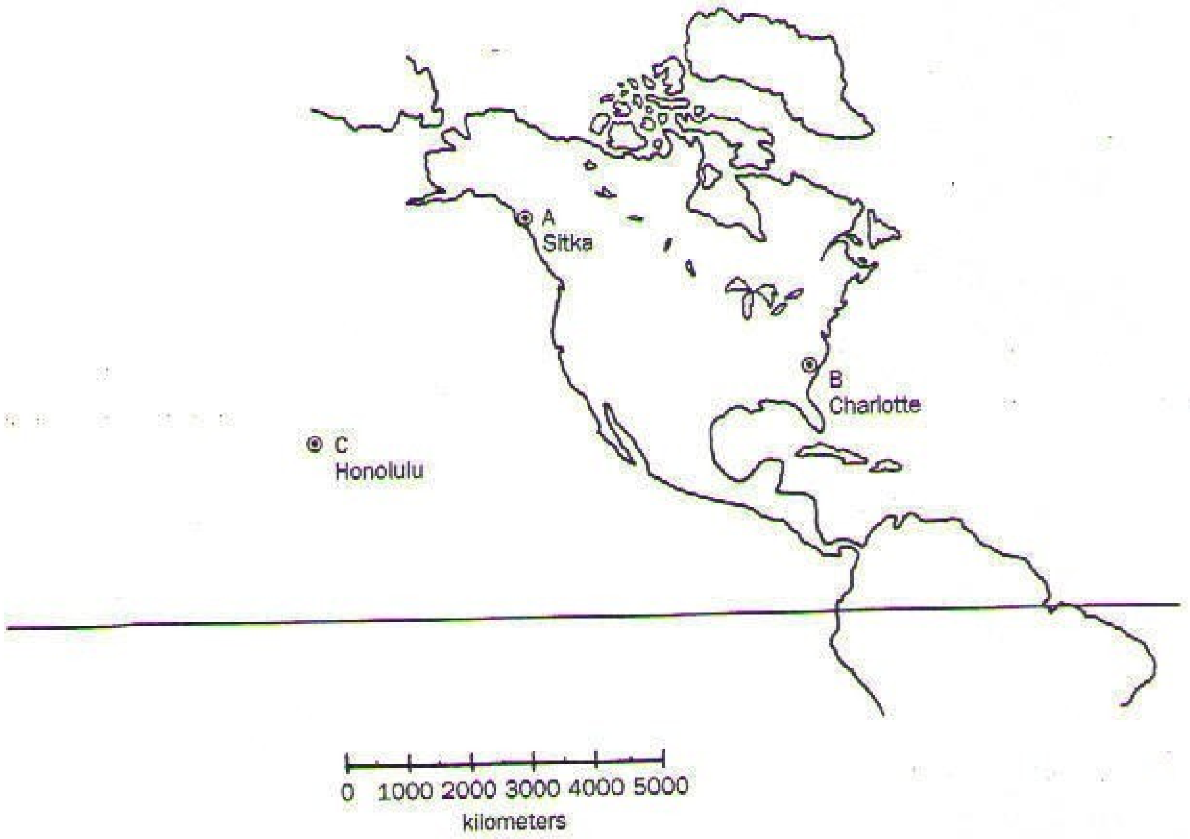
Student Sheet 12.3
Locating the Epicenter of an Earthquake

Directions Three different seismograph stations (A, B, and C) recorded an earthquake. Follow Procedure Steps 7 through 11 of Inquiry 12.3 to complete Table 1.

Table 1 Earthquake Data

Seismograph Station	Time of Arrival at Station Primary Wave (P-wave)	Secondary Wave (S-wave)	S-wave minus P-wave	Distance to the Epicenter (kilometers)
A. Sitka, Alaska	8:07	8:11	4 minutes	2500
B. Charlotte, N.C.	8:08	8:13		
C. Honolulu, Hawaii	8:09	8:15		

Directions Follow Procedure Steps 12 through 16 of Inquiry 12.3 in the Student Guide and use the map below to locate and mark the earthquake's epicenter.



INQUIRY 12.3: LOCATING THE EPICENTER OF AN EARTHQUAKE

Directions: Answer these questions once you finished steps 1 and 2. Look at the graph in Figure 12.8.

1) If it took 4 minutes for the first P-wave to arrive at the seismograph station, how far away is the earthquake's epicenter? (Hint: Look on the P-wave curve)

2) If the seismograph station were located 2500 km from the earthquake's epicenter, how long would it take the P-wave to arrive?

3) How long would it take the S-wave to travel 2500 km and reach the seismograph station?

4) Using 2500 km, which wave traveled faster: the P-wave or the S-wave?

5) At 2500 km, how many minutes elapsed between the time the P-wave and S-wave arrived at the station? What does this tell you about how far away the earthquake's epicenter is?

Directions: Answer these questions once you finished steps 4, 5, and 6. Look at the Data table 1 to help you answer these questions.

1) In what 3 cities was the earthquake recorded?

2) When did the P-wave first arrive at Sitka?

3) When did the S-wave first arrive at Sitka?

4) How many minutes elapsed between the time the P-wave reached Sitka and the time the S-wave reached Sitka?

5) Look at the P- and S-wave arrival times for Stations B (Charlotte) and C (Honolulu). Compute the difference between these wave times. Complete column four of Table 1 on the student sheet 12.3

Conclusion

Answer the following questions based on the results of the lab

1) What did you learn about how scientists record earthquakes?

2) How does information on a seismograph tell scientists where earthquakes occur?

3) How does knowing where earthquakes occur help people reduce the risks associated with future earthquakes?

Name: ______________________
Date: ____________ Period: ____ Score: ______

Finding the Epicenter of an Earthquake

Problem: How do scientists determine the epicenter of an earthquake?

Background Information:

- The rocky plates that make up Earth's crust are constantly moving. The interactions of these plates create *faults*.
- *Faults* are ____ ____.
- The constant movement of the plates causes pressure to build up. When this energy is released, an *earthquake* will occur.
- Two types of *seismic waves* travel away from the *focus* of an earthquake. The ____________________, or *P-wave,* is a compression wave that forces rock to compress and expand in the same direction the wave travels. ____________________, or *S-waves,* are transverse waves that will displace matter that is perpendicular to the wave. Once these vibrations hit the surface, they are known as *surface waves* (these cause the most destruction).
- The *epicenter* of an earthquake is ____ ____.

Hypothesis:

____

____

____

____

Experiment:

Materials:

- Calculator
- Drawing compass
- Pencil
- Metric ruler
- Seismic Waves Graph
- Time Delay Scale (1" X 5")
- United States map
- Scratch paper

Procedure:

PART A: CALCULATING THE TIME DELAY AND DISTANCE

1. Use the P-wave and S-wave arrival time data from your data table. Calculate the difference in time (T_{s-p}) between the arrival of the P-wave and S-wave for each city. Record the time delay (in seconds) in the data table under the "Time Delay" column.

2. Obtain a time delay scale. Carefully fold the paper back on the dotted line. Crease the fold.

3. Note the delay in time for the first seismograph station, New York.

4. Using a pencil, make a small mark on the time delay scale corresponding to the delay time for New York. **See Figure 5.**

5. Turn to your Seismic Waves Graph. Place the time delay scale (with the mark you just made for New York) along the y-axis (Time) of the graph. Match the zero of the time delay scale with the zero of the graph.

6. Slowly move the time delay scale along the curved line representing the P-wave data, making sure to keep the time delay scale vertical and the zero point of the scale on the P-wave line.

7. Stop moving the time delay scale when the pencil mark you made for New York reaches the S-wave curved line. **See Figure 6.**

8. Follow the vertical edge of the time delay scale down to the x-axis (Distance) on the graph. This point represents the distance from the epicenter to the seismograph station.

9. Record the distance to then nearest hundred kilometers in the data table under the column "Distance to Epicenter (km)".

10. Repeat steps 3-9 using the data for the remaining 4 states.

PART B: LOCATING THE EPICENTER

11. Turn to your map of the United States. The scale on your map is 1 cm = 200 km.

12. Convert each recorded distance from kilometers to centimeters. Take your distance in kilometers and divide it by 200. Record each value as "Distance on Map" in the data table.

13. Obtain your drawing compass.

14. Look at your calculated value for the "Distance on Map" for New York. Using a metric ruler, open your compass to that calculated value. For example: if you calculated 5 cm for New York, then open your compass 5 cm. This will set the radius for your circle.

15. Place the point of your compass on the selected city. Move your compass to make your circle around the city. MAKE SURE THE COMPASS DOES NOT OPEN OR CLOSE WHILE DOING THIS. YOU WILL HAVE THEN CHANGED THE RADIUS. *Hint: sometimes it is easier to hold the compass still and rotate the paper, rather than rotating the compass.*

16. Repeat steps 12-15 for the remaining stations.

17. Circle the area on the map where all the circles intersect. Label this area as "Epicenter".

18. Answer all conclusion questions.

Data/Observations:

Seismograph Station	P-wave Arrival Time (hr:min:s)	S-wave Arrival Time (hr:min:s)	Time Delay T_{s-p} (s)	Distance to Epicenter (km)	Map Distance (cm)
New York, NY	5:52:40 a.m.	5:55:18 a.m.			
Louisville, KY	5:49:20 a.m.	5:50:11 a.m.			
Green Bay, WI	5:50:20 a.m.	5:51:52 a.m.			
Pueblo, CO	5:52:00 a.m.	5:54:21 a.m.			
Phoenix, AZ	5:54:40 a.m.	5:58:00 a.m.			

Conclusion Questions:

1. Compare and contrast primary and secondary waves.

____

____

____

____

2. What is the difference between the focus and epicenter of the earthquake?

____

____

____

3. Near what major city is the epicenter of this earthquake? (Look at a more detailed map of the United States map, if necessary)

____

4. Which type of earthquake waves do the most damage to buildings?

____

5. Which type of earthquake waves arrives first?

____

6. What is the purpose of a seismograph? Why are they useful?

____

____

____

____

7. Why must data be obtained from at least three seismograph stations to locate the epicenter of an earthquake?

____

____

____

____

____

8. Vibrations from a primary wave were detected on a seismograph at 2:04:54 p.m. The secondary wave arrived at 2:09:13 p.m. Determine how much time in seconds elapsed between the arrivals of the two waves.

____

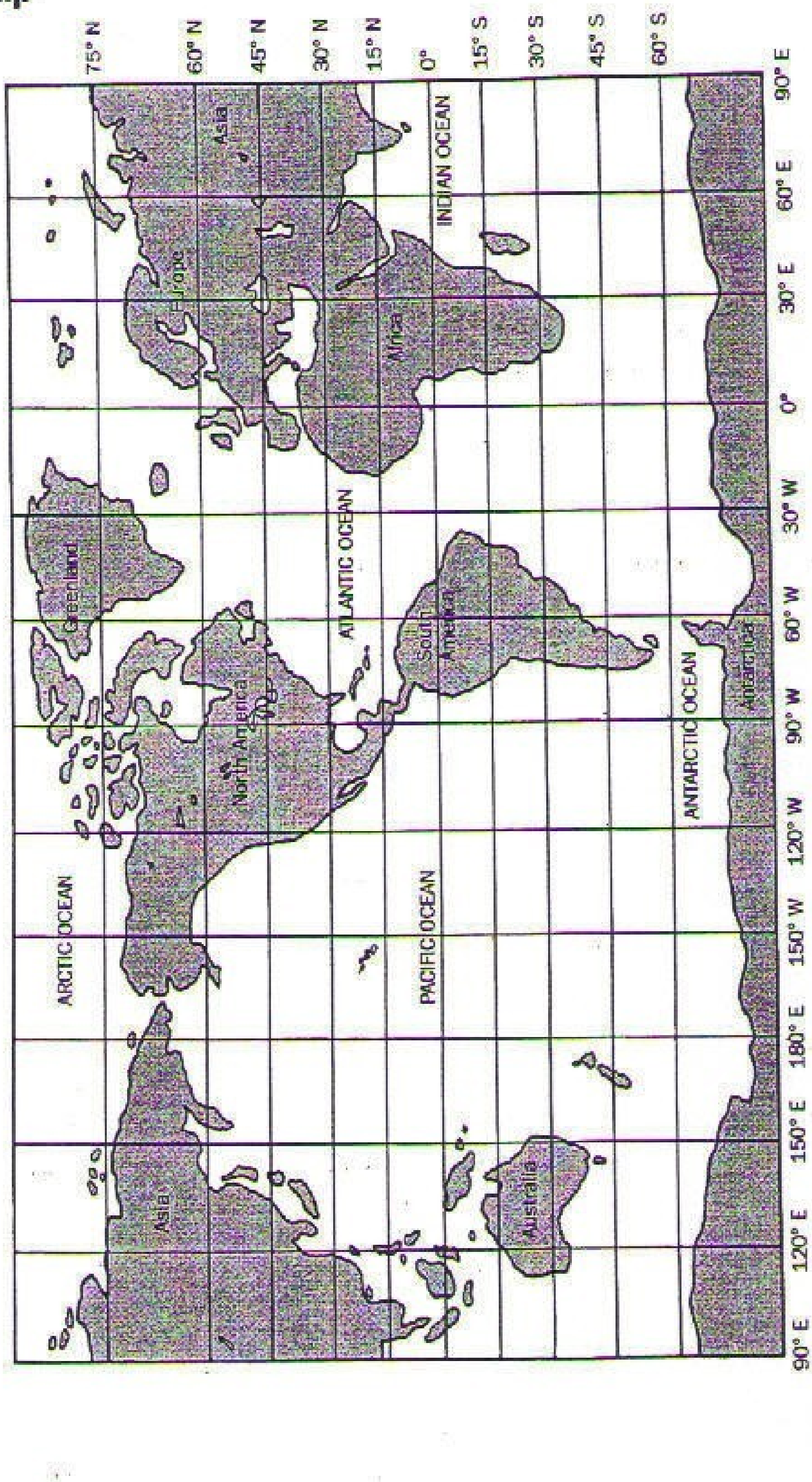
____

9. A seismograph station is 3000 kilometers away from the epicenter of an earthquake. How many seconds after the arrival of the P-wave would the S-wave arrive?

____

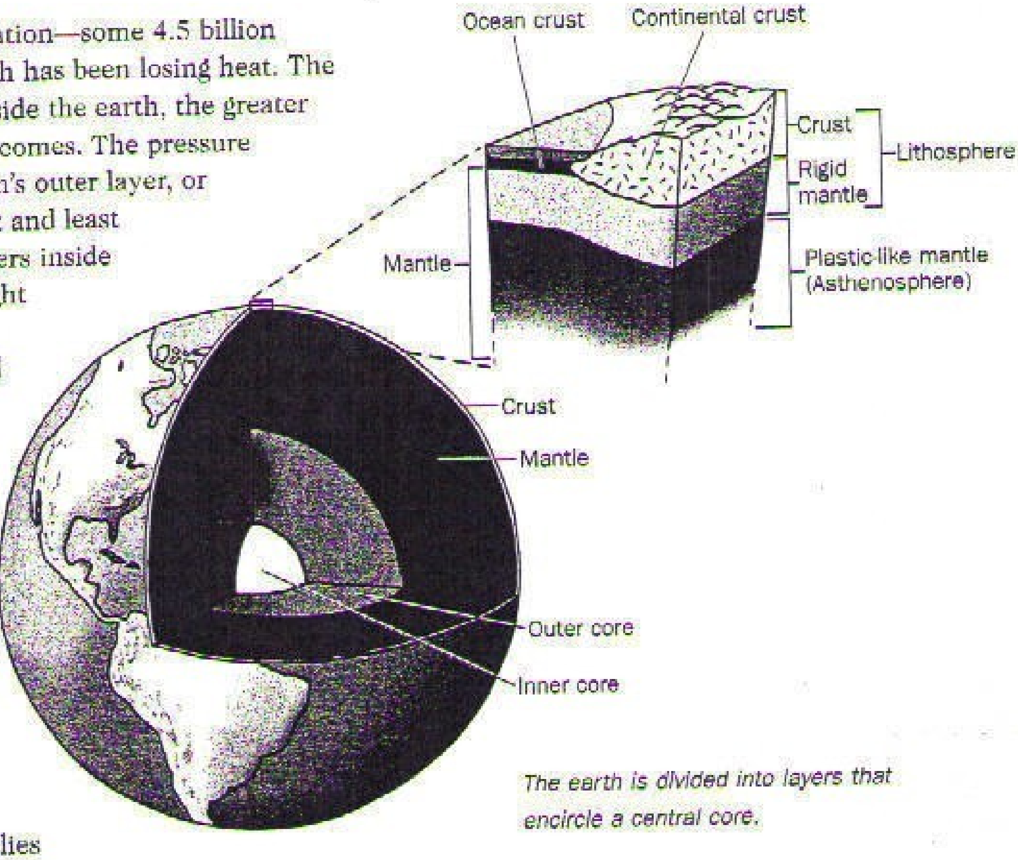
Lesson 13: Plotting Earthquakes

World Map


75° N
60° N
45° N
30° N
15° N
0°
15° S
30° S
45° S
60° S
90° E
60° E
30° E
0°
30° W
60° W
90° W
120° W
150° W
180° E
150° E
120° E
90° E
ARCTIC OCEAN
ATLANTIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
ANTARCTIC OCEAN
Asia
Europe
Africa
Greenland
North America
South America
Antarctica
Australia

Lesson 14:
Earth's Interior

THE EARTH'S INTERIOR



The earth is divided into layers that encircle a central core.

Ever since its formation—some 4.5 billion years ago—the earth has been losing heat. The deeper one goes inside the earth, the greater the temperature becomes. The pressure rises, too. The earth's outer layer, or crust, is the coolest and least dense of all the layers inside the earth. (You might compare the earth with a loaf of bread that is cooling on a shelf. The crust cools first; the soft inner part of the loaf remains warm much longer.)

There are two kinds of crust: oceanic and continental. The oceanic crust lies beneath the ocean. It is approximately 5 to 10 kilometers thick. The continental crust contains mostly land. It ranges from 15 to 70 kilometers thick and is thickest under high mountain areas. Both types of crust are made up of rock.

Directly under the crust is the mantle. Like the crust, the mantle is composed of rock; however, the rock in the mantle is much denser than that in the crust. The mantle is about 2900 kilometers thick, and it makes up about 83 percent of the earth's interior. The top layer of the mantle is rigid. It is cooler than the lower part of the mantle. Geologists call this rigid part of the mantle, together with the crust, the lithosphere. The lithosphere is broken into pieces, called "plates." (To visualize these plates, think about how an egg looks when its shell is cracked.)

The plates of the lithosphere "float" on the part of the mantle directly below it. This part of the mantle is called the asthenosphere. The consistency of the asthenosphere is like taffy. The asthenosphere is hot, and, like warm taffy, it can flow. The movement of the plates of the lithosphere on top of the slowly moving asthenosphere accounts for the formation of many mountains and volcanoes, as well as for earthquakes.

Beneath the mantle is the earth's innermost layer, the core. (Think of the center of an apple, which is also called the core.) The earth's core is divided into two parts: a liquid outer core, made of iron, and a solid inner core, made of iron and nickel. □

Name ______________________ Date ________ Class ____________

SECTION 1-1 **SECTION SUMMARY**

Earth's Interior

1

Guide for Reading

- What does a geologist do?
- What are the characteristics of Earth's crust, mantle, and core?

The modern science of **geology,** the study of planet Earth, began in the late 1700s. **Geologists** are scientists who study the forces that make and shape planet Earth. They study the chemical and physical characteristics of **rock,** the material that forms Earth's hard surface. They map where different types of rocks are found and describe landforms, the features sculptured in rock and soil by water, wind, and waves. **Geologists study the processes that create Earth's features and search for clues about Earth's history.**

Once geologists knew only a few facts about Earth. They knew it was a sphere with seven great landmasses, or **continents.** Now they know that Earth looks different today than it did millions of years ago. Geologists divide the forces that change the surface of Earth into two groups. **Constructive forces** shape the surface by building up mountains and landmasses. **Destructive forces** are those that slowly wear away mountains and, eventually, every other feature on the surface.

One of the most difficult questions that geologists face is, What's inside Earth? They must rely on indirect evidence to answer this question, such as by studying the paths of **seismic waves** produced by earthquakes. Using such data, geologists have learned that Earth's interior is made up of several layers. **Three main layers make up Earth's interior: the crust, the mantle, and the core. Each layer has its own conditions and materials.** The **crust** is the layer of rock that forms Earth's outer skin. It includes both dry land and the ocean floor. The crust beneath the ocean, called oceanic crust, consists mostly of **basalt,** a dark, dense rock with a fine texture. The crust that forms continents, called continental crust, consists mostly of **granite,** a rock that has larger crystals than basalt and is not as dense.

Below the crust is the **mantle,** a layer of hot rock. The crust and the uppermost part of the mantle together form a rigid layer called the **lithosphere.** In general, temperature and pressure in the mantle increase with depth. **Pressure** is the force pushing on a surface or area. The increased heat and pressure make the part of the mantle just beneath the lithosphere somewhat soft. This soft layer is called the **asthenosphere.** The lithosphere floats on top of the asthenosphere. The rest of the mantle down to the core is solid.

Earth's core consists of two parts. Both parts of the core are made of the metals iron and nickel. The **outer core** is a layer of molten metal that surrounds the inner core. The **inner core** is a dense ball of solid metal.

Currents in the liquid outer core force the solid inner core to spin at a slightly faster rate than the spinning of the whole Earth. This movement creates Earth's magnetic field, which causes the planet to act like a giant bar magnet.

Name ______________________ Date __________ Class __________

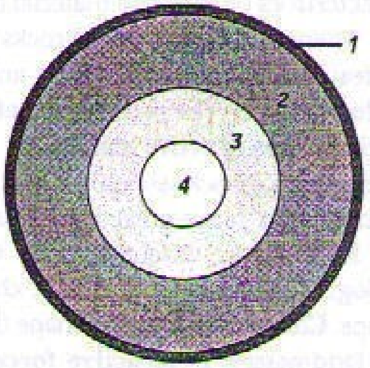
SECTION 1-1 **REVIEW AND REINFORCE**

Earth's Interior

◆ Understanding Main Ideas

Label the layers of Earth by writing the name of the layer in the blank.

1. ______________
2. ______________
3. ______________
4. ______________



Earth's layers

Answer the following questions on a separate sheet of paper.

5. What does a geologist do?
6. Compare and contrast the asthenosphere with the lithosphere.

◆ Building Vocabulary

Match each term with its definition by writing the letter of the correct definition on the line beside the term in the left column.

______ 7. basalt
______ 8. constructive force
______ 9. continent
______ 10. destructive force
______ 11. geology
______ 12. granite
______ 13. pressure
______ 14. rock
______ 15. seismic wave

a. the material that forms Earth's hard surface
b. the force pushing on a surface or area
c. a force that slowly wears away features of Earth's surface
d. the study of planet Earth
e. a rock that makes up the core of the continents
f. one of Earth's great landmasses
g. a wave produced by an earthquake
h. a force that builds up features of Earth's surface
i. a rock that makes up much of the ocean floor

Lesson 15:
Plate Movement & Faults

Earth's Moving Plates: **A Look Back**

You've observed that Africa and South America seem to fit together like pieces of a puzzle. Scientists now believe that all the continents were once a single landmass. Earth's hot mantle separated these continents over time, and oceans formed between them. How did scientists long ago explain these changes? Let's take a look.

Looking for Evidence

For centuries, some scholars hypothesized that continents move. For example, in 1620, Sir Francis Bacon, an English philosopher, noticed that continental margins looked as if they would fit together.

In the mid-1800s, Antonio Pellegrini, a geologist, noticed that identical fossils were found on continents separated by wide oceans. He thought a great flood caused these oceans to form, separating the continents and their fossils.

Edward Suess, an Austrian geologist in the middle to late 1800s, claimed that the scratches and gouges from glaciers line up along the boundaries of separated continents. He also noted similarities among plant fossils on different continents. He hypothesized that these fossil similarities were evidence that long land bridges had once connected the landmasses. He believed that the bridges later sank beneath the ocean.

In 1910, American geologist Frank B. Taylor explained that mountain ranges on distant continents line up. He theorized that large polar continents had broken apart, drifted toward the equator, and stayed there as a result of gigantic tidal forces. These forces, according to Taylor, were generated by the pull of gravity when the earth "captured" the moon.


CORBIS/MICHAEL NICHOLSON

Sir Francis Bacon, English statesman and philosopher


CORBIS/HULTON-DEUTSCH COLLECTION

Edward Suess, Austrian geologist and president of the Vienna Academy of Sciences

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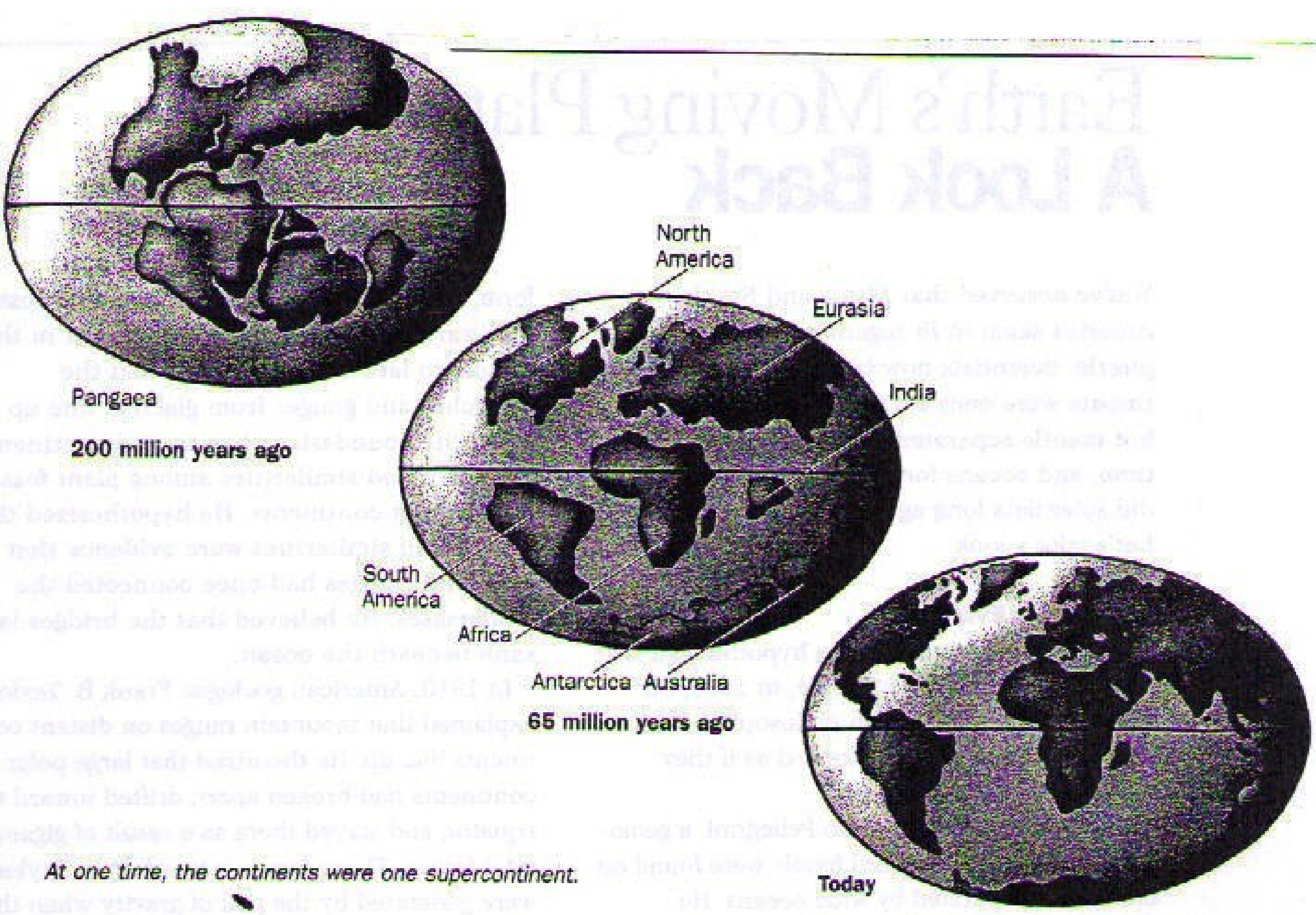
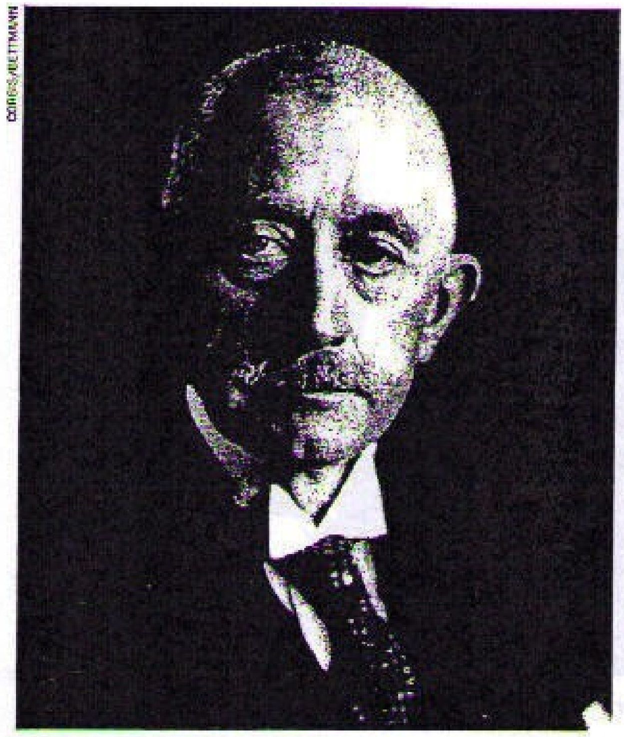


At one time, the continents were one supercontinent.

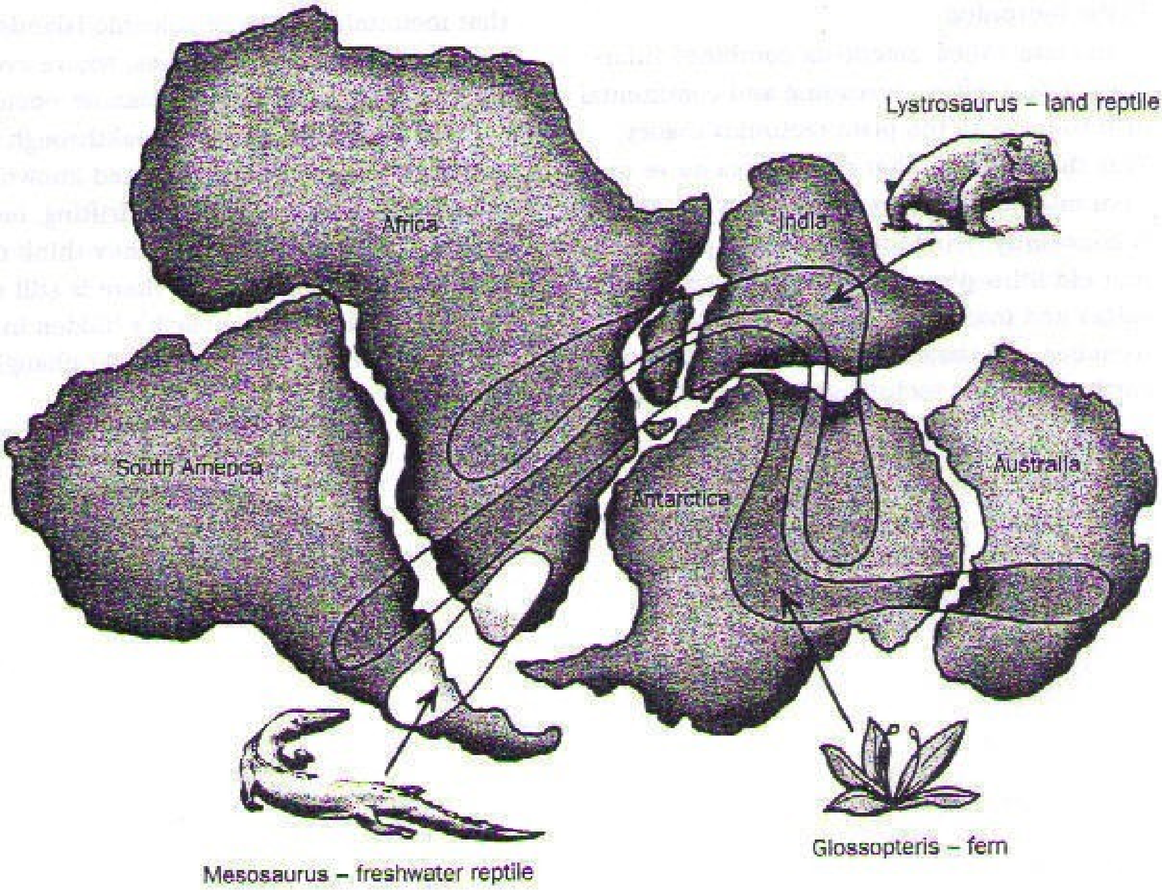


Alfred Wegener, German meteorologist

The Breakup of a Supercontinent

After many scientists had gathered evidence, Alfred Wegener, a German meteorologist, proposed in 1912 the theory of continental drift. According to this theory, the continents were once united in one "supercontinent." Wegener named this continent Pangaea. He claimed that, over time, Pangaea had broken into pieces that drifted apart. South America and Africa had moved away from each other. North America and Europe had separated. His theory was supported by evidence from many different fields of science.

Wegener explained why the shorelines of different continents seem to match. He noted that mountain ranges of similar age and structure were now located on separated continents. Fossil animals, such as Mesosaurus (a fresh water reptile about 1 meter long), were found in countries on two different continents, South Africa and South America. Because Mesosaurus



Wegener found that evidence from fossils, for example, supported his theory that plates move.

could not swim, Wegener surmised that the continents at one time were connected. Finally, Wegener found evidence that continents currently in the Tropics were once covered with glaciers. This means the continents must have "drifted" or moved somehow.

Wegener proved that continents appeared to move over time, but he could not prove *why* these events took place. What caused the continents to drift? Wegener thought he had answers. He argued that both gravitational tidal forces and the earth's rotation were responsible for continental drift. However, it was fairly easy for scientists to prove that these forces were much too weak. His explanations were not accepted.

Seafloor Spreading and the Drifting Continents

In the late 1950s and early 1960s, years after Wegener's death, new data about the seafloor emerged that enabled geologists to suggest why continents appear to drift. Evidence from seafloor fossils and magnetic data suggested that younger parts of the floor were located closer to the mid-ocean ridge, while older parts of the seafloor were farther from the mid-ocean ridge, near the trenches. These data prompted the theory of seafloor spreading, which states that a force within the earth drives the ocean floor apart and allows new oceanic crust to form.

Plate Tectonics

In the late 1960s, scientists combined information on seafloor spreading and continental drift to propose the plate tectonics theory. This theory states that rigid plates move away from mid-ocean ridges, where new lithosphere is constantly being formed. It also proposed that old lithosphere moves away from these ridges and toward ocean trenches. At the trenches, old ocean lithosphere sinks into the earth. The plate tectonics theory also states that mountain chains of volcanic islands, such as Japan, form along trenches, where events such as earthquakes and volcanoes occur.

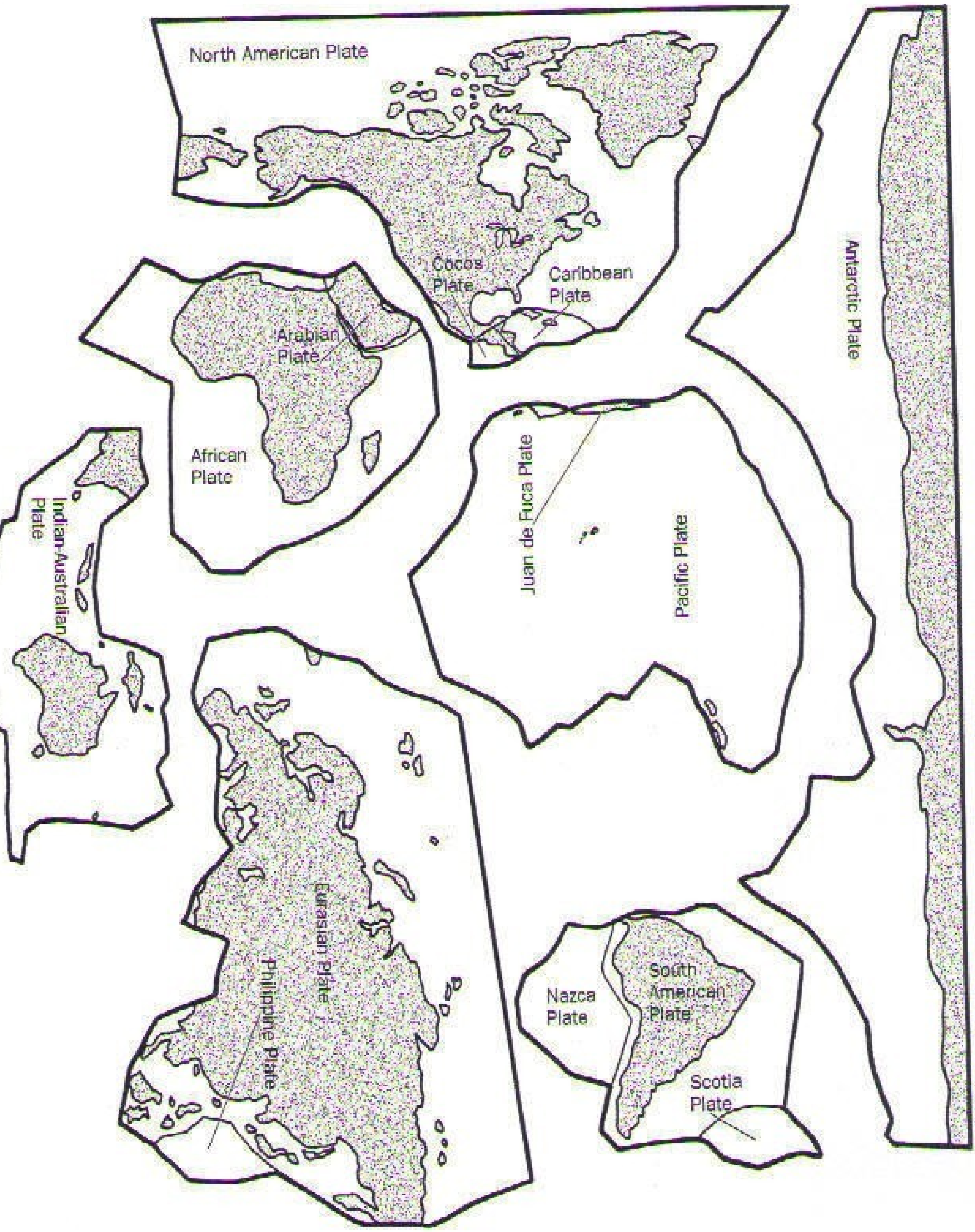
This theory was a major breakthrough for scientists. For many years, they had known that the earth's surface was slowly drifting, but they couldn't explain why. Today, they think they have found the answer. But there is still much to be learned about the earth's hidden interior and its effects on the planet's ever-changing surface. □

Name: ______________________

Class: __________ Date: __________

Student Sheet 15.3c
Making a Plate Model

Directions Cut out the lithospheric plates shown on this map. Then put the plates back together.



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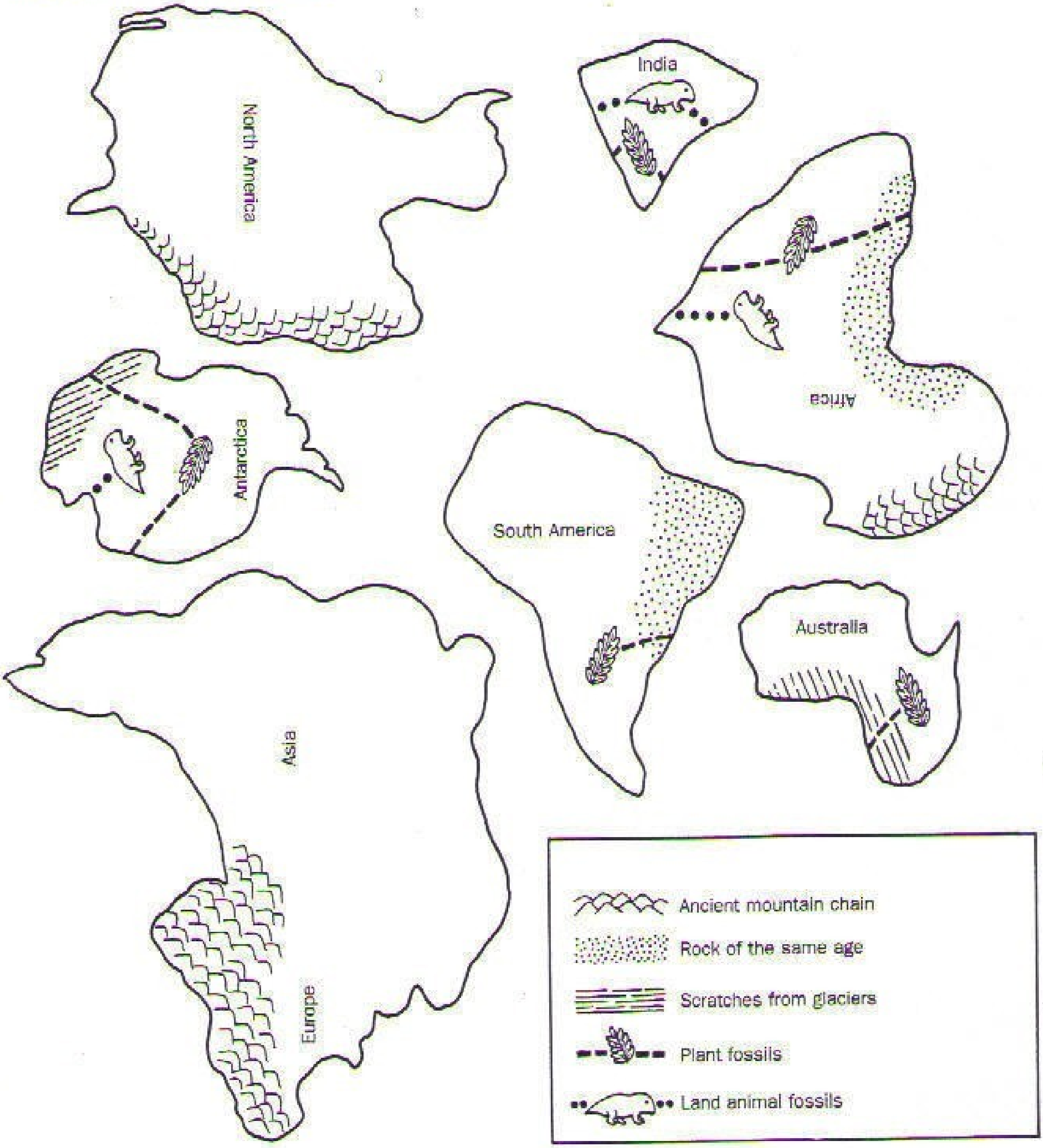
Name: ______________________________

Class: ______________ Date: ______________

Student Sheet 15.3d
Putting It All Together

Directions After reading "Earth's Moving Plates: A Look Back" in the Student Guide, cut out the continents below. Use the legend to match the continents. On another sheet of paper, glue the continents into one large landmass.



Name: ____________________
Date: ____________________ **Period:** ________

PANGAEA & WORLD PLATES ACTIVITY

Pangaea Map Rubric

	Poor **0 points**	**Fair** **2 points**	**Good** **4 points**	**Excellent** **6 points**
Coloring the Landmasses	Directions were not followed; landmasses were not colored	70-80% of the directions were followed; coloring was sloppy	80-99% of the directions were followed; landmasses were neatly colored	All directions were followed; landmasses were neatly colored
Piecing the Land Together	The landmasses were not pieced together	Many of the landmasses were not pieced together	Most of the landmasses were correctly pieced together	All landmasses were correctly pieced together
Classroom Performance	Participated less than 70% of the time	Participated 70-80% of the time	Participated 80-90% of the time	Participated 100% of the time
Key/Legend	The key/legend is missing	The key/legend is on the final product		

Comments: ______________________________________ Total Points: ________

____

World Plate Map

	Poor **0 points**	**Fair** **2 points**	**Good** **4 points**	**Excellent** **6 points**
Piecing the Land Together	The landmasses were not pieced together	Many of the landmasses were not pieced together	Most of the landmasses were correctly pieced together	All landmasses were correctly pieced together

Comments: ______________________________________ Total Points: ________

____

Please answer the following questions using complete sentences.

1. Take a look at your map of Pangaea. How was fossil evidence used in the development of the idea/theory of Pangaea? Explain.

2. Coal deposits have also been found beneath the ice of Antarctica, but coal only forms in warm swamps. Explain how coal could be found so near the poles.

3. Look at your map of the world plates. How many major world plates are labeled on this map? ______

4. What is the smallest world plate? ______

5. Which plate contains Europe? ______

6. Which plate contains India? ______

7. Explain how the world plates and the asthenosphere are connected to the theory/idea of Pangaea.

SECTION 1-3 **SECTION SUMMARY**

Drifting Continents

1

Guide for Reading

- What is continental drift?
- Why was Alfred Wegener's theory rejected by most scientists of his day?

In 1910, a young German scientist named Alfred Wegener became curious about why the coasts of several continents matched so well, like the pieces of a jigsaw puzzle. He formed a hypothesis that Earth's continents had moved! **Wegener's hypothesis was that all the continents had once been joined together in a single landmass and have since drifted apart.** He named this supercontinent **Pangaea,** meaning "all lands." According to Wegener, Pangaea existed about 300 million years ago. Over tens of millions of years, Pangaea began to break apart. The pieces of Pangaea slowly moved toward their present-day locations, becoming the continents of today. The idea that the continents slowly moved over Earth's surface became known as **continental drift.** In a book called *The Origin of Continents and Oceans,* Wegener presented evidence to support his theory.

Mountain ranges and other landforms provided evidence for continental drift. For example, Wegener noticed that when he pieced together maps of Africa and South America, a mountain range running from east to west in South Africa lines up with a range in Argentina. Also, European coal fields match up with coal fields in North America.

Fossils also provided evidence to support Wegener's theory. A fossil is any trace of an ancient organism preserved in rock. The fossils of a fernlike plant called *Glossopteris* have been found in Africa, South America, Australia, India, and Antarctica. Their occurrence on widely separated landmasses convinced Wegener that the continents had once been united.

Wegener used evidence from climate change to further support his theory. For example, an island in the Arctic Ocean contains fossils of tropical plants. According to Wegener, the island once must have been located close to the equator. Wegener also pointed to scratches on rocks made by glaciers. These scratches show that places with mild climates today once had climates cold enough for glaciers to form. According to Wegener's theory, Earth's climate has not changed. Instead, the positions of the continents have changed.

Wegener also attempted to explain how the drift of continents took place. **Unfortunately, Wegener could not provide a satisfactory explanation for the force that pushes or pulls the continents.** Because he could not identify the cause of continental drift, most geologists rejected his theory. For nearly half a century, from the 1920s to the 1960s, most scientists paid little attention to the idea of continental drift. Then new evidence about Earth's structure led scientists to reconsider Wegener's bold theory.

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Name ______________________ Date __________ Class ______________

SECTION 1-3 REVIEW AND REINFORCE

Drifting Continents

◆ Understanding Main Ideas

Fill in the blanks in the table below.

Evidence for Continental Drift

Type of Evidence	Example of Evidence
Evidence from 1. ______________	**a.** Mountain ranges in South America and **2.** ______________ line up **b.** European coal fields match with similar coal fields in North America
Evidence from Fossils	**a.** Fossils of the plant **3.** ______________ found in rocks on widely separated landmasses
Evidence from 4. ______________	**a.** Fossils of tropical plants found near Arctic Ocean **b.** Scratches in rocks made by **5.** ______________ found in South Africa

Answer the following questions on a separate sheet of paper.

6. State the hypothesis of continental drift.

7. Why did most scientists reject Wegener's theory for nearly a half century?

◆ Building Vocabulary

Fill in the blank to complete each statement.

8. All the continents were once joined together in a supercontinent called ______________, meaning "all lands."

9. A(n) ______________ is any trace of an ancient organism preserved in rock.

10. Wegener's theory that the continents slowly moved over Earth's surface became known as ______________.

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Name ______________________ Date __________ Class ______________

SECTION 1-5 SECTION SUMMARY

The Theory of Plate Tectonics

1

Guide for Reading

- What is the theory of plate tectonics?
- What are three types of plate boundaries?

Earth's lithosphere is broken into separate sections called **plates.** The plates fit closely together along cracks in the crust. They carry the continents, or parts of the ocean floor, or both. **Plate tectonics** is the geological theory that states that pieces of Earth's lithosphere are in constant, slow motion, driven by convection currents in the mantle. A **scientific theory** is a well-tested concept that explains a wide range of observations. **The theory of plate tectonics explains the formation, movement, and subduction of Earth's plates.**

The plates float on top of the asthenosphere. Convection currents rise in the asthenosphere and spread out beneath the lithosphere, causing the movement of Earth's plates. As the plates move, they produce changes in Earth's surface, including volcanoes, mountain ranges, and deep-ocean trenches. The edges of different pieces of the lithosphere meet at lines called plate boundaries. **Faults**—breaks in Earth's crust where rocks have slipped past each other—form along these boundaries.

There are three types of plate boundaries: transform boundaries, divergent boundaries, and convergent boundaries. A **transform boundary** is a place where two plates slip past each other, moving in opposite directions. Earthquakes occur frequently along these boundaries. The place where two plates move apart, or diverge, is called a **divergent boundary.** Most divergent boundaries occur at the mid-ocean ridge. When a divergent boundary develops on land, two slabs of Earth's crust slide apart. A deep valley called a **rift valley** forms along the divergent boundary. The place where two plates come together, or converge, is a **convergent boundary.** When two plates converge, the result is called a collision. When two plates collide, the density of the plates determines which one comes out on top. Oceanic crust is more dense than continental crust.

When two plates carrying oceanic crust meet at a trench, the plate that is less dense dives under the other plate and returns to the mantle. This is the process of subduction. When a plate carrying oceanic crust collides with a plate carrying continental crust, the more dense oceanic plate plunges beneath the continental plate through the process of subduction. When two plates carrying continental crust collide, subduction does not take place because both plates are mostly low-density granite rock. Instead, the plates crash head-on. The collision squeezes the crust into mighty mountain ranges.

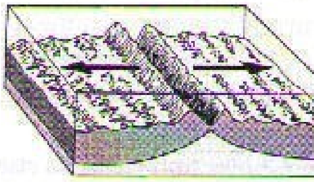
The plates move at amazingly slow rates, from about 1 to 10 centimeters per year. They have been moving for tens of millions of years. About 260 million years ago, the continents were joined together in the supercontinent Pangaea. About 225 million years ago, Pangaea began to break apart. Since then, the continents have moved to their present locations.

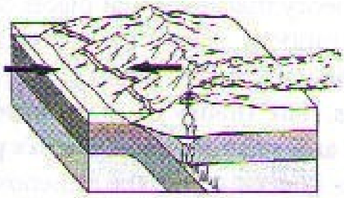
Name ____________________ Date __________ Class ____________

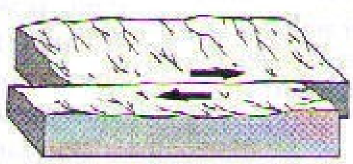
The Theory of Plate Tectonics

◆ Understanding Main Ideas

Label each figure by writing the type of plate boundary it shows.







1. ______________ **2.** ______________ **3.** ______________

Answer the following questions on a separate sheet of paper.

4. Describe what happens when **a.** two plates carrying oceanic crust collide, **b.** two plates carrying continental crust collide, and **c.** a plate made of oceanic crust collides with a plate carrying continental crust.

5. Explain what force caused the movement of the continents from one supercontinent to their present positions.

◆ Building Vocabulary

Fill in the blank to complete each statement.

6. A scientific ______________ is a well-tested concept that explains a wide range of observations.

7. Breaks in Earth's crust where rocks have slipped past each other are called ______________.

8. The lithosphere is broken into separate sections called ______________.

9. A(n) ______________ is a deep valley on land that forms along a divergent boundary.

10. The geological theory that states that pieces of Earth's crust are in constant, slow motion is called ______________.

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Name: ____________________

Date: ________________ Period: ___

TITLE: Plate Movement Activity (Inquiry 15.1)

PROBLEM: How do plates move at various types of plate boundaries?

BACKGROUND:

- ______________________________
- ______________________________
- ______________________________

HYPOTHESIS: Predict how you think each pad would respond in the following situations:

A. Pull on the pad from opposite ends

____

____

B. Push on the pad at opposite ends toward the center

____

____

C. Slide two pads past one another

____

____

D. Collide two pads by pushing them together

____

____

EXPERIMENT:

MATERIALS NEEDED:

- 2 thick foam pads
- 2 thin foam pads
- 2 desks/tables
- 1 relief globe

PROCEDURE:

1. Examine the foam pads. Describe their properties. Consider their density, appearance, thickness, weight, and size. Record these observations in the Data/Observations section of the lab.
2. Test your above predictions (hypothesis).

Part A

3. Pull the black pad. Record the following in the Data/Observations section of the lab: What happens to its appearance? What happens to its size? Draw a picture and explain what happens to the pad.
4. Hold the black foam pad by its opposite ends (figure 15.1). Compress the pad by pushing your hands toward each other. Record the following in the Data/Observations section of the lab: Draw a picture and explain what happens to the pad. Repeat the above with the blue foam pad.

Part B

5. Stack the blue pad on top of the black pad. Compress them. Draw a picture and explain what happens to the pad. Record this information in the Data/Observations sections of the lab.

Part C

6. Place two black pads side by side on the table. Slide them past one another (figure 15.2). Draw a picture and explain what happens to the pad. Record this information in the Data/Observations sections of the lab.
7. Repeat step 6 with one blue pad and one black pad. Did your results change? Draw a picture and explain what happens to the pad. Record this information in the Data/Observations sections of the lab.

Part D

8. Separate the two lab tables by 10-cm. Place two black pads side by side (figure 15.3A). Make the pads collide (push them together). What happens? Draw a picture and explain what happens to the pad. Record this information in the Data/Observations sections of the lab.
9. Repeat the above step with one black and one blue pad (figure 15.3B) how does the behavior differ from step 8? Why do you think this happens? Draw a picture and explain what happens to the pad. Record this information in the Data/Observations sections of the lab.
10. Repeat the above step with two blue pads. Record your information in the Data/Observations sections of the lab.
11. Answer all conclusion questions.

DATA/OBSERVATIONS:

Foam Pad General Observations

Foam Pad Properties	Black Foam Pad	Blue Foam Pad
Density		
Appearance		
Thickness		
Weight		
Size		

Part A Observations

Foam Pad Properties	Pulling the Black Foam Pad	Compressing the Black Foam Pad
Appearance		
Size		
Picture of what Happened		

Foam Pad Properties	Pulling the Blue Foam Pad	Compressing the Blue Foam Pad
Appearance		
Size		
Picture of what Happened		

Part B Observations

Observation Drawing	Explanation

Part C Observations

Foam Pad Observations	Two Black Pads	One Black and One Blue Pad
Explanation of what Happened		
Picture of what Happened		

Part D Observations

Foam Pad Observations	Two Black Pads	One Black Pad and One Blue Pad	Two Blue Pads
Explanation of what Happened			
Picture of what Happened			

CONCLUSION:

1. How did the pads behave when pulled from opposite ends?

2. How did the pads behave when compressed?

3. If oceanic plates are colder, denser, and thinner than continental plates are, which pad do you think represented oceanic plates? Which pad represented continental plates? Explain why.

4. How did the density of the pads affect the way they behaved when you made them collide?

5. When do colliding plates on earth form mountains? When do colliding plates form trenches? Explain.

6. Can plates ever move without forming new land? If so, when?

7. How do you think colliding plates on earth cause earthquakes? Explain your thoughts.

Lesson 16: Convection in the Mantle

Name: ______________________

Date: ______________ Period: ____

TITLE: Modeling Convection in the Mantle

PROBLEM: What causes Earth's crust to move?

BACKGROUND:

- ______________________
- ______________________
- ______________________

HYPOTHESIS: (Give a possible explanation to the above problem.)

____

____

____

____

EXPERIMENT:

MATERIALS NEEDED:

- 1 copy of the lab
- 1 jar of convection fluid
- 1 tea candle
- 2 wooden blocks
- 1 flashlight
- 1 paper towel

SAFETY TIPS:

The fluid in the jar is nontoxic, but DO NOT loosen or remove the cap. Be careful when working with an open flame. If you have long sleeves, push them up. NEVER reach across an open flame. If your hair is long, tie it back. Be very careful when working with the heated jar.

PROCEDURE:

1. Obtain your group's materials.
2. Observe the fluid in the jar. Record your observations of the fluid in the data table.
3. Review all the above safety tips.
4. Shake the jar with the convection fluid. Set up your equipment as indicated in the picture in your data/observation section. Your teacher will light the candle.
5. Place the lit candle under the jar.

PART A

6. Shine the flashlight on the fluid to observe its movement. You will want to shine the flashlight on one of the sides of the jar. Observe the various movements of the fluid from the different angles.
7. Record your observations in both words and pictures in your data/observation section. This information is recorded in part A. Use arrows to depict the direction in which the fluid moves.

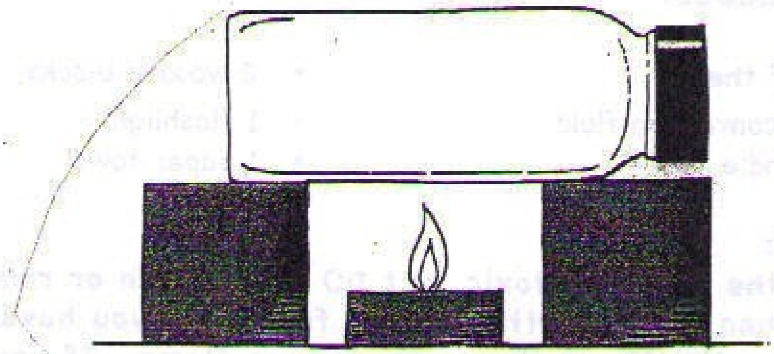
PART B

8. Shine the flashlight down on the jar.
9. Record your observations in both words and pictures in your data/observation section. This information is recorded in part B. Use arrows to depict the direction in which the fluid moves.
10. Clean up your workspace and return all equipment.
11. Answer all conclusion questions.

DATA/OBSERVATIONS:

Part A:

Draw arrows on the diagram to show movement of the convection fluid within your jar. Then record your observations.



What observations did you make in Part A?

____

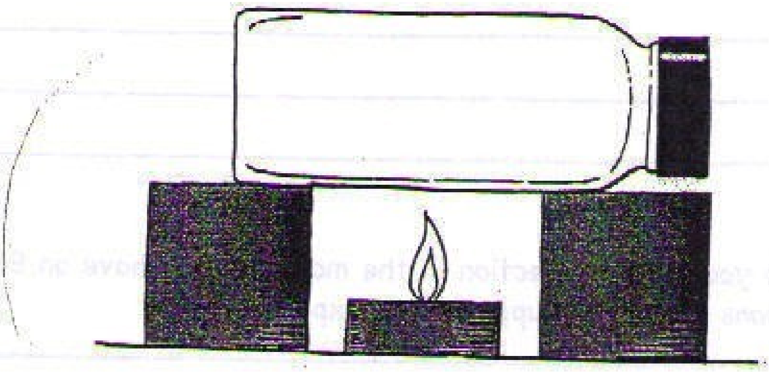
____

____

____

Part B:

Draw arrows on the diagram to show movement of the convection fluid within your jar. Then record your observations.



What observations did you make in Part B?

CONCLUSION:

1. What observations did you make of the heated fluid?

2. Compare the components of the experiment with the layers of the Earth. Which piece of equipment represented the core, which the mantle? Explain how they are a representation of each of these layers.

3. Use your textbook to help you answer the following question. Describe what a convection current is and how it is formed.

4. What effect do you think convection in the mantle might have on Earth's surface? What observations in the jar support your explanations?

5. What will happen to the flow of hot rock in Earth's mantle if the planet's core eventually cools down? How would this affect our planet?

Name ____________________ Date ________ Class ____________

SECTION 1-2 **SECTION SUMMARY**

Convection Currents and the Mantle

1

Guide for Reading

- How is heat transferred?
- What causes convection currents?

The movement of energy from a warmer object to a cooler object is called **heat transfer.** Heat is always transferred from a warmer substance to a cooler substance. **There are three types of heat transfer: radiation, conduction, and convection.**

The transfer of energy through empty space is called **radiation.** Heat transfer by radiation takes place with no direct contact between a heat source and an object. For example, radiation enables sunlight to warm Earth's surface.

Heat transfer by direct contact of particles of matter is called **conduction.** In conduction, the heated particles of a substance transfer heat to other particles through direct contact. An example is when a spoon heats up in a hot pot of soup.

The transfer of heat by the movement of a heated fluid is called **convection.** Fluids include liquids and gases. During convection, heated particles of a fluid begin to flow, transferring heat energy from one part of the fluid to another.

Heat transfer by convection is caused by differences in temperature and density within a fluid. **Density** is a measure of how much mass there is in a volume of a substance. When a liquid or gas is heated, the particles move faster. As they move faster, they spread apart. Because the particles of the heated fluid are farther apart, they occupy more space. The fluid's density decreases. But when a fluid cools, the particles move closer together and density increases.

An example of convection occurs in heating a pot of soup on a stove. As soup at the bottom of the pot gets hot, it expands and becomes less dense. The warm, less dense soup moves upward, floating over cooler, denser soup. At the surface, the warm soup spreads out and cools, becoming denser. Then gravity pulls this cooler, denser soup down to the bottom, where it is heated again and begins to rise. This flow that transfers heat within a fluid is called a **convection current. The heating and cooling of the fluid, changes in the fluid's density, and the force of gravity combine to set convection currents in motion.** Convection currents continue as long as heat is added to the fluid.

Convection currents flow in the asthenosphere. The heat source for these currents is heat from Earth's core and from the mantle itself. Hot columns of mantle material rise slowly. At the top of the asthenosphere, the hot material spreads out and pushes the cooler material out of the way. This cooler material sinks back into the asthenosphere. Convection currents like these have been moving inside Earth for more than four billion years!

17

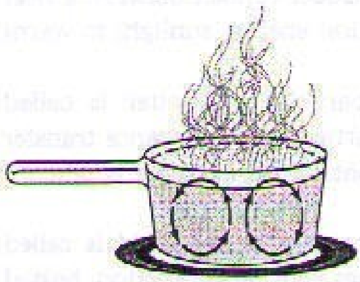
Name ____________________ Date __________ Class __________

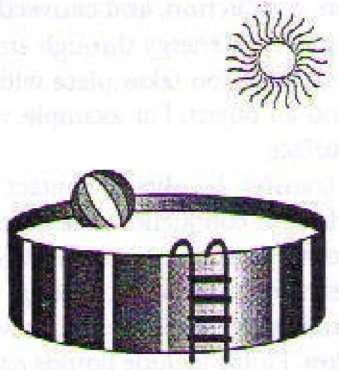
SECTION 1-2 **REVIEW AND REINFORCE**

Convection Currents and the Mantle

◆ Understanding Main Ideas

Label each figure by writing the type of heat transfer it shows.





1. ______________ 2. ______________ 3. ______________

Answer the following questions in the spaces provided.

4. What are convection currents and what causes them?

____

____

5. What causes convection currents in Earth's mantle?

____

____

◆ Building Vocabulary

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

______________ 6. The transfer of energy through empty space is called convection.

______________ 7. The movement of energy from a warmer object to a cooler object is called heat transfer.

______________ 8. Conduction is heat transfer by direct contact of particles of matter.

______________ 9. Radiation is the transfer of heat by the movement of a heated fluid.

______________ 10. Density is a measure of how much heat there is in a volume of a substance.

Lesson 18: Volcanoes

Name _______________ Date _________ Class _______________

SECTION 3-3 SECTION SUMMARY

Volcanic Landforms

Guide for Reading

- What landforms does lava create on Earth's surface?
- How does magma that hardens beneath the surface create landforms?

3

Some volcanic landforms are formed when lava flows build up mountains and plateaus on Earth's surface. **Rock and other materials formed from lava create a variety of landforms including shield volcanoes, composite volcanoes, cinder cone volcanoes, and lava plateaus.**

At some places on Earth's surface, thin layers of lava pour out of a vent. More layers of such lava harden on top of previous layers. The layers gradually build a wide, gently sloping mountain called a **shield volcano.** If a volcano's lava is thick and stiff, the lava may explode into the air and harden into ash, cinders, and bombs. These materials pile up around the vent, forming a steep, cone-shaped hill or mountain called a **cinder cone.** Sometimes lava flows alternate with explosive eruptions of ash, cinders, and bombs. The alternating layers form a tall, cone-shaped mountain called a **composite volcano.** Some eruptions of thin, runny lava flow out of cracks and travel a long distance before cooling and hardening. Over millions of years, these layers of lava build up over a large area to form a lava plateau.

An enormous eruption may empty a volcano's main vent and magma chamber. With nothing to support it, the top of the mountain collapses inward. The huge hole left by the collapse of a volcanic mountain is called a **caldera.**

Over time, the hard surface of a lava flow breaks down to form soil. Some volcanic soils are among the most fertile soils in the world. People have settled close to volcanoes to take advantage of the fertile soil.

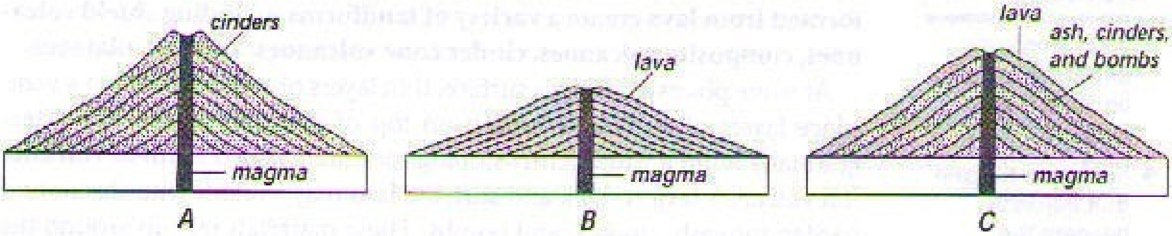
Sometimes magma rises upward through cracks in the crust but does not reach Earth's surface. The magma cools and hardens into rock beneath the surface. **Features formed by magma include volcanic necks, dikes, and sills, as well as batholiths and dome mountains.** A **volcanic neck** forms when magma hardens in a volcano's pipe. The softer rock around the pipe wears away, exposing the hard rock of the volcanic neck. A **dike** forms when magma forces itself across rock layers and hardens. A **sill** forms when magma squeezes between layers of rock and hardens. When a large body of magma cools inside the crust, a mass of rock called a **batholith** forms. Smaller bodies of hardened magma can form dome mountains.

Name ______________________ Date __________ Class ______________

SECTION 3-3 **REVIEW AND REINFORCE**

Volcanic Landforms

◆ Understanding Main Ideas



Answer the following questions on a separate sheet of paper.

1. Name each type of volcano shown in the diagrams. How is each formed?

2. How does a lava plateau form?

3. What happens to create a caldera?

4. Why is volcanic soil so fertile?

◆ Building Vocabulary

Define each of the following terms in the spaces provided.

5. batholith ____

____

6. dike ____

____

7. volcanic neck ____

____

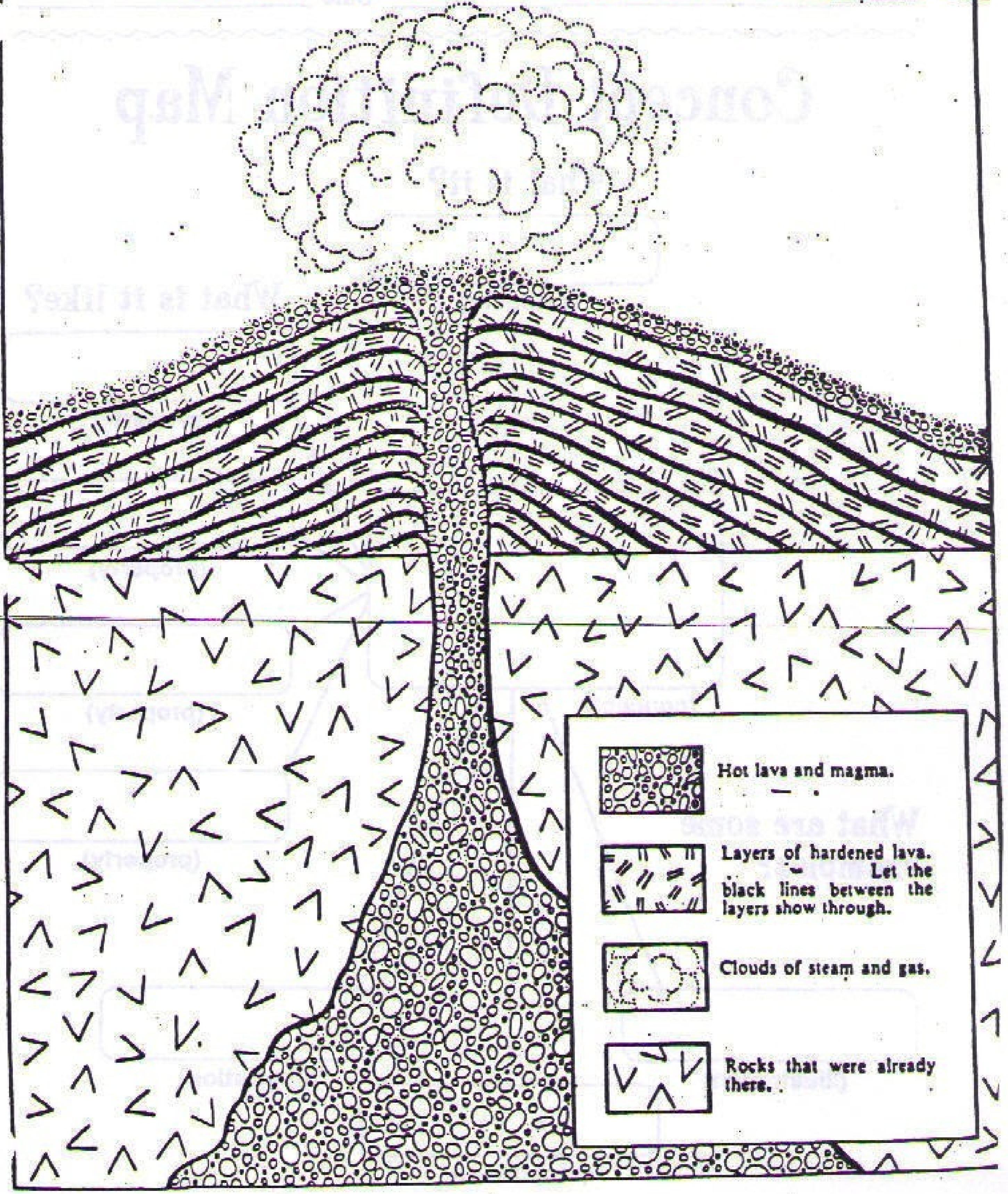
8. sill ____

____

3

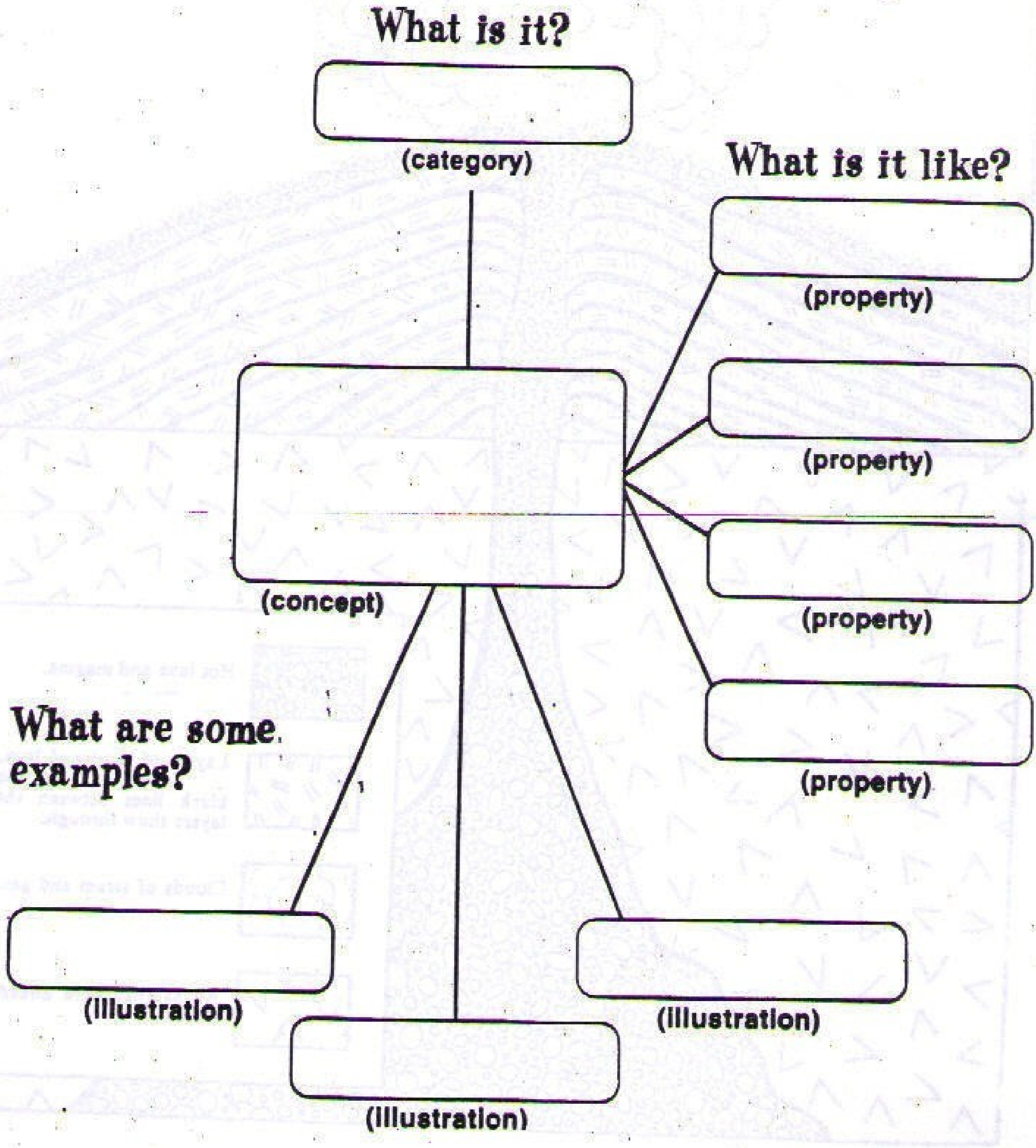
A SHIELD VOLCANO

The Hawiian volcanoes, Mt. Loa and Kilauea are some examples.

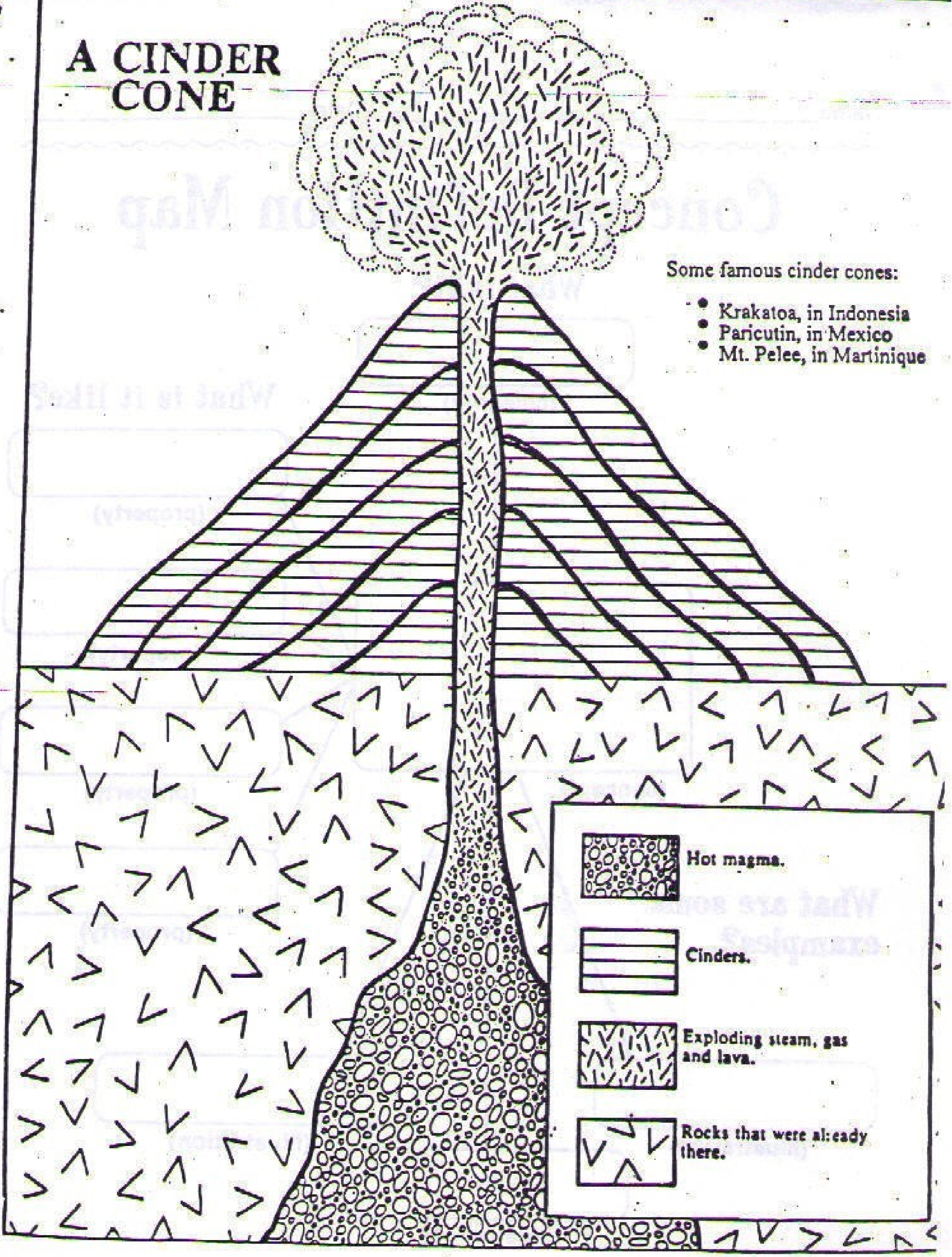


Name______________________________ Date ______________

Concept Definition Map

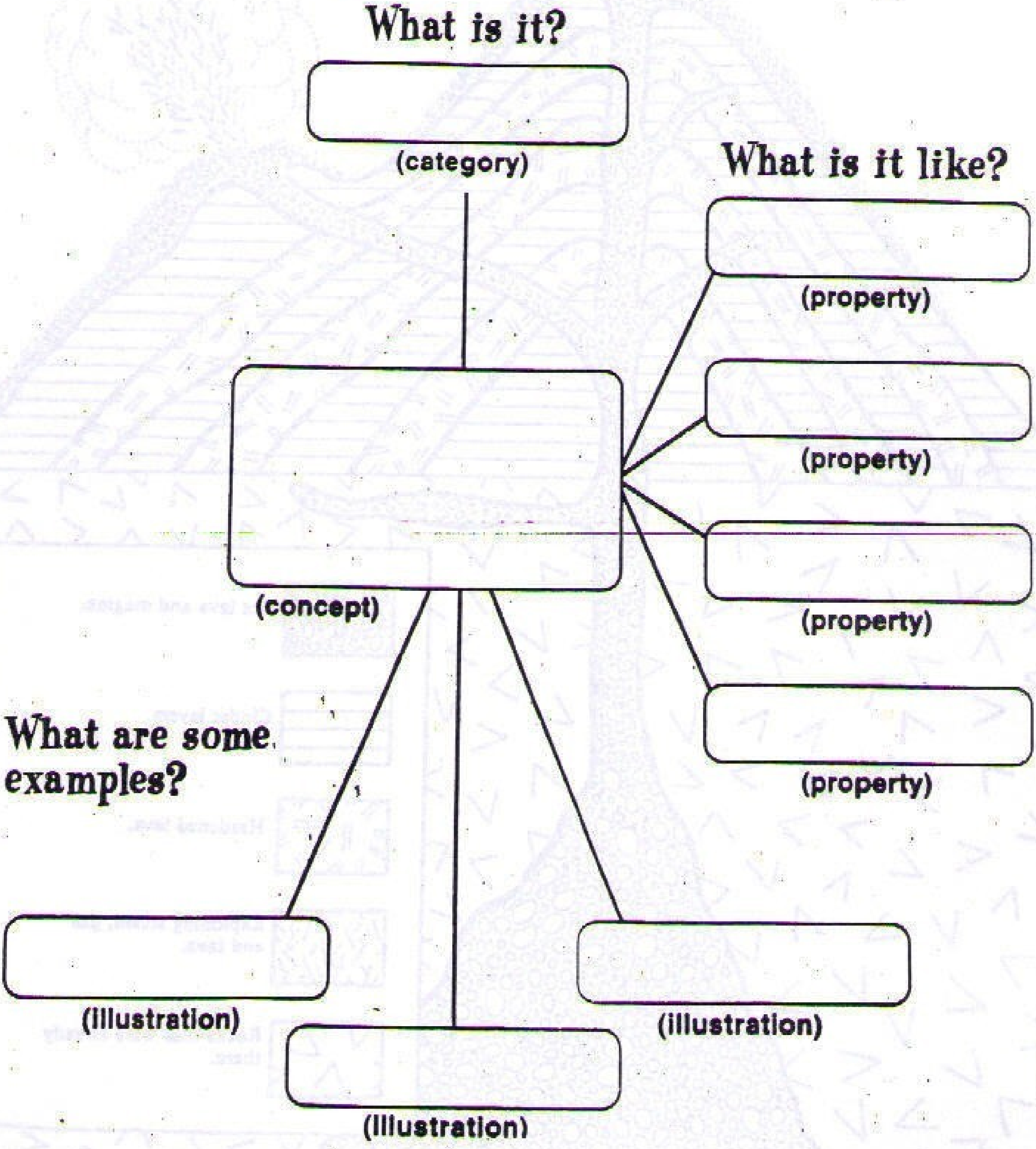


A CINDER CONE

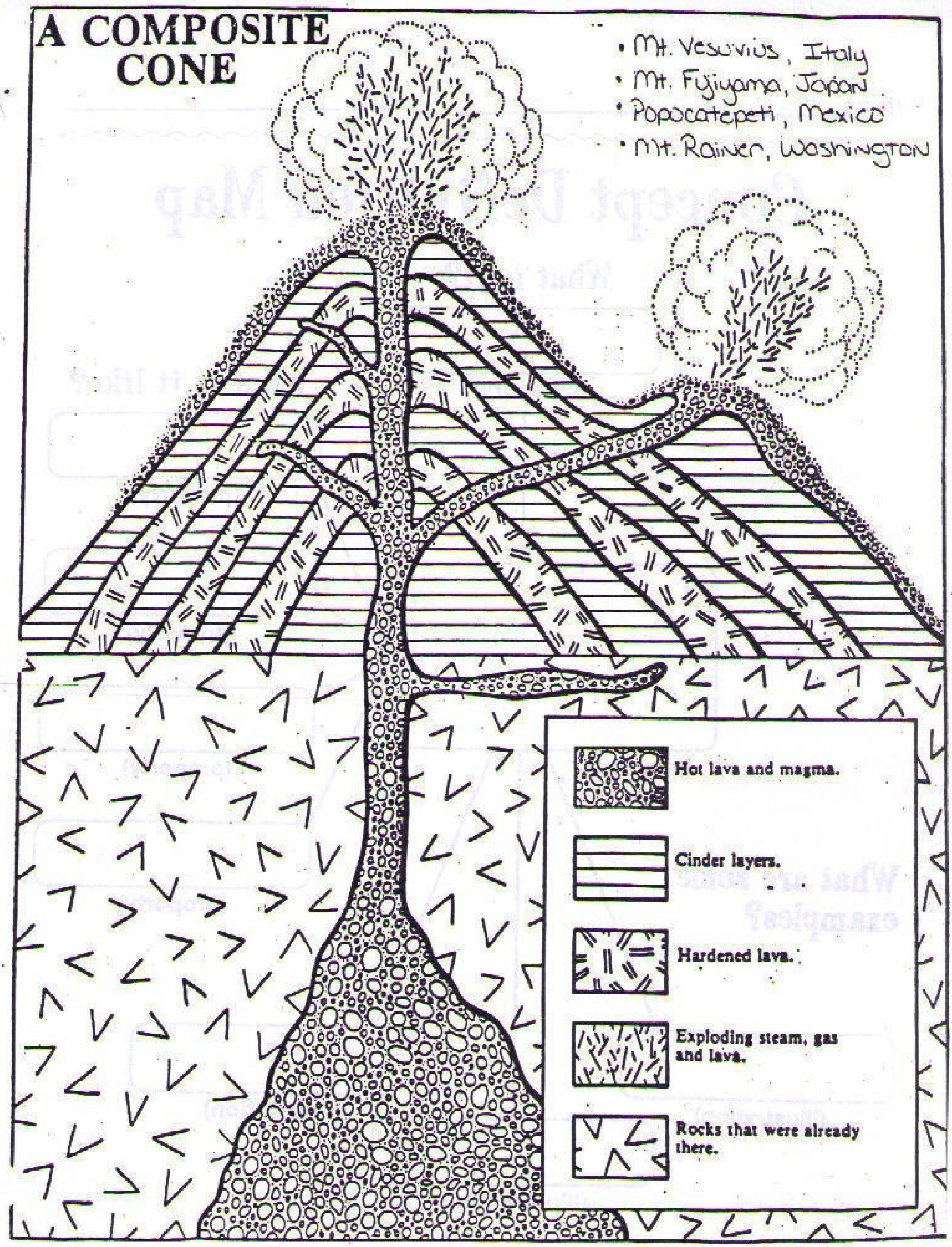


Name________________________ Date ____________

Concept Definition Map

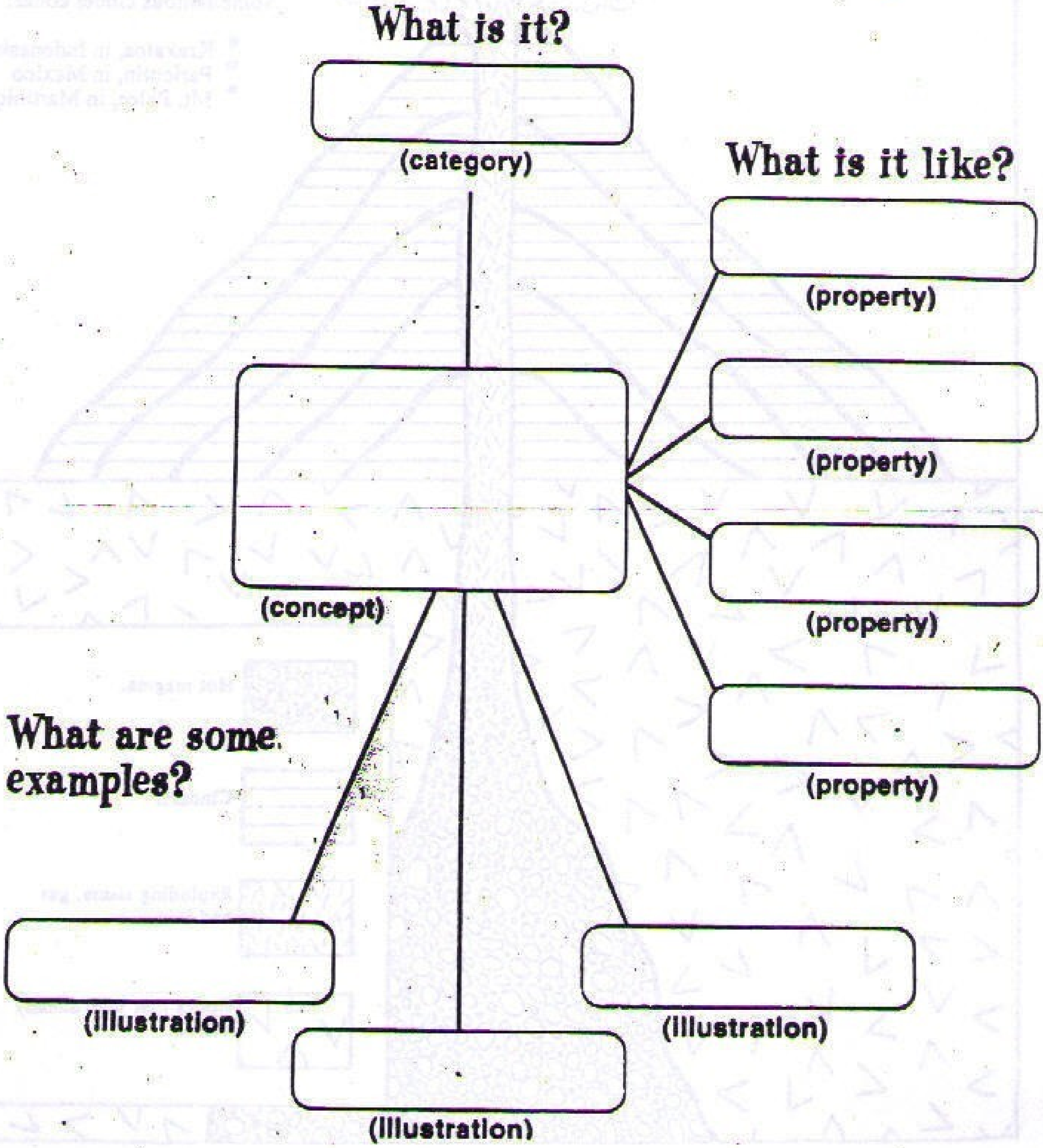


A COMPOSITE CONE



Name______________________________ Date ______________

Concept Definition Map



Lesson 19: Rocks

Name: ______________________________

Chapter 5: Rocks

Term/Concept	Definition or Information
Rock	• __________ mixture of __________ • made of __________ or more __________
Rock __________	• process where one __________ changes into another rock • process is like "__________"

Types of Rocks

Igneous	• forms from __________ magma or __________
__________	• forms when __________ are compacted or __________ together
Metamorphic	• forms when the __________ or __________ of a rock changes due to heat or __________

SECTION 5-1 **SECTION SUMMARY**

Classifying Rocks

Guide for Reading

- What characteristics are used to identify rocks?
- What are the three major groups of rocks?

Earth's crust is made of rock. Rocks are mixtures of minerals and other materials, although some rocks may contain only a single mineral. Geologists collect and study samples of rock in order to classify them. **When studying a rock sample, geologists observe the rock's color and texture and determine its mineral composition.** Using these characteristics, geologists can classify a rock according to its origin, or where and how it formed.

As with minerals, color alone does not provide enough information to identify a rock. Texture, however, is very useful. **Texture** is the look and feel of a rock's surface. Some rocks are smooth and glassy, while others are rough or chalky. Most rocks are made up of particles of minerals or other rocks, which geologists call **grains.** A rock's grains give the rock its texture.

To describe a rock's texture, geologists use a number of terms based on the size, shape, and pattern of the rock's grains. Often, the grains in a rock are large and easy to see. Such rocks are said to be coarse-grained. In other rocks, the grains are so small that they can be seen only with a microscope. These rocks are said to be fine-grained. Rock grains vary widely in shape. Some grains look like tiny particles of fine sand. Others look like small seeds or exploding stars. In some rocks, the grain shapes result from the shapes of the crystals that form the rock. In other rocks, the grain shapes result from fragments of other rock.

The grains in a rock often form patterns. Some grains lie in flat layers. Other grains form wavy, swirling patterns. Some rocks have grains that look like rows of beads, while other rocks have grains that occur randomly throughout the rock. Some rocks have no grain, either because they cooled quickly when they formed or because they are composed of tiny silica particles that have settled out of water.

Often, geologists must look closely at a rock to determine its mineral composition. By looking at a small sliver of a rock under a microscope, a geologist can observe the shape and size of crystals in the rock and identify the minerals it contains. In identifying rocks, geologists also use some of the tests used to identify minerals, such as the scratch test to determine hardness.

There are three major groups of rocks: igneous rock, sedimentary rock, and metamorphic rock. These terms refer to how the rocks in each group formed. **Igneous rock** forms from the cooling of molten rock. **Sedimentary rock** forms when particles of other rocks or the remains of plants and animals are pressed and cemented together. **Metamorphic rock** forms when an existing rock is changed by heat, pressure, or chemical reactions.

5

Name ______________________ Date __________ Class ______________

SECTION 5-1 REVIEW AND REINFORCE

Classifying Rocks

◆ Understanding Main Ideas

Fill in the blanks in the table below.

Grain Property	Description	Texture
Size	Large, easy to see	1. __________
Size	2. __________	Fine-grained
Shape	Mineral crystals	Crystalline
3. __________	Rock fragments	Rounded or jagged
4. __________	Layered or random grains	Banded or nonbanded
No visible grain	No crystal grains	5. __________

Answer the following questions on a separate sheet of paper.

6. What characteristics do geologists look for when observing a rock sample?
7. Name the three major groups of rocks and describe how each forms.
8. What tests do geologists use to identify minerals in rocks?

◆ Building Vocabulary

Fill in the blank to complete each statement.

9. The look and feel of a rock's surface is its __________ .
10. The particles of minerals or other rocks that make up a rock are called __________ .

5

Name: ________________

Class: __________ Date: __________

Student Sheet 21.1
Observing the Properties of Igneous Rock

Directions Look at the five rock samples carefully, using the tools you have been given. Then complete the table and explain your classification system in the space below.

Table Title: ____________________________

Rock No.	Colors of Minerals	Texture (large-grained, small-grained, mixed-grained, or glassy)	Other Observations
1			
2			
3			
4			
5			

This is how we would classify the rocks and why:

95

Conclusion Questions:

1. Do any of the rocks have similar properties? If so, explain those properties.

2. Describe any rocks that DO NOT share characteristics with the other rocks.

3. Examine the pictures of some common minerals found in your student guide on page 235. You may also examine the samples in the front of the class. Identify some of the minerals that make up the rocks you examined and explain why you think that. For example, rock #3 has mica because of how it shimmered.

4. Any of these rocks can change into another rock. Explain how this might this happen.

Identifying Types of Rocks

Rock Type	Origin	Diagnostic Properties: Possible Textures	Diagnostic Properties: Possible Shapes & Structures	Diagnostic Properties: Possible Chemistries
IGNEOUS	From molten rock or volcanic fragments	- Glassy - Full of bubble holes - No fossils or organic material - Random small or random large crystals	- Ropey streamlined lava flow shapes - Massive crystal shapes - Glass shards	- Dark colors (rich in Mg and Fe) - Multicolored (many minerals present) - Light colors (rich in quartz or feldspars)
SEDIMENTARY	From sediments or precipitation of crystals in water at or near earth's surface	- Clastic (made of rock fragments) - Layered - Fossils present - Usually one type of crystal	- Icicle shapes (stalactites) - Sand bar shapes - Extensive flat layers	- Often one color (fine grained) - Multicolored (if consists of large rock fragments) - Light colored (rich in calcite, halite, or gypsum)
METAMORPHIC	From physical or chemical alteration of other rocks by heating or intense pressure beneath earth's surface	- Foliated (minerals lie parallel) - Banded (wavy folds of color in rock) - Sometimes large crystals of equal size - No flat layers	- Can be fractured into pieces	- Contain "metamorphic minerals" (garnets-red, mica-shiny, epidote-light green)

Name ______________________ Date __________ Class ______________

SECTION 5-6 SECTION SUMMARY

The Rock Cycle

Guide for Reading

- What is the rock cycle?
- What is the role of plate tectonics in the rock cycle?

Earth's rocks are not as unchanging as they seem. **Forces inside Earth and at the surface produce a rock cycle that builds, destroys, and changes the rocks in the crust.** The **rock cycle** is a series of processes on Earth's surface and inside the planet that slowly change rocks from one kind to another. Earth's constructive and destructive forces move rocks through the rock cycle. Igneous, sedimentary, and metamorphic rocks change continuously through the rock cycle. Rocks can follow many different pathways through the cycle.

The rock of Stone Mountain in Georgia has followed one of the pathways of the rock cycle. First, millions of years ago the igneous rock granite formed beneath Earth's surface. Then the forces of mountain building slowly pushed the granite upwards to become the dome that forms Stone Mountain. Over millions of years, water and weather began to wear away the mountain's granite. Today, quartz particles of granite still break off the mountain and become sand. Streams carry the sand to the ocean. Over millions of years, layers of sand will build up. The processes of compaction and cementation will eventually form the quartz particles into sandstone, a sedimentary rock.

As more and more sediment piles up on the sandstone, pressure on the rock will increase. The rock will become hot. After millions of years, the heat and pressure will change the sandstone into the metamorphic rock quartzite. The quartzite will also eventually change as it moves through one of the many pathways that make up the rock cycle. Both igneous and sedimentary rock can change into metamorphic rock. Both igneous and metamorphic rock can change into sedimentary rock. And both sedimentary rock and metamorphic rock can change into igneous rock.

The changes in the rock cycle are closely related to plate tectonics. **Plate movements drive the rock cycle by pushing rocks back into the mantle, where they melt and become magma again. Plate movements also cause the folding, faulting, and uplift of the crust that move rocks through the rock cycle.** Subducting ocean plates advance the rock cycle by returning rock to the mantle. There, it melts and forms magma, which eventually becomes igneous rock.

Collisions between continental plates can also move rocks through the rock cycle. For example, such a collision between plates could change the sedimentary sandstone into the metamorphic quartzite. Eventually, the collision could form a mountain range or plateau. Then, as the mountains or plateaus containing quartzite are worn away, the rock cycle continues.

5

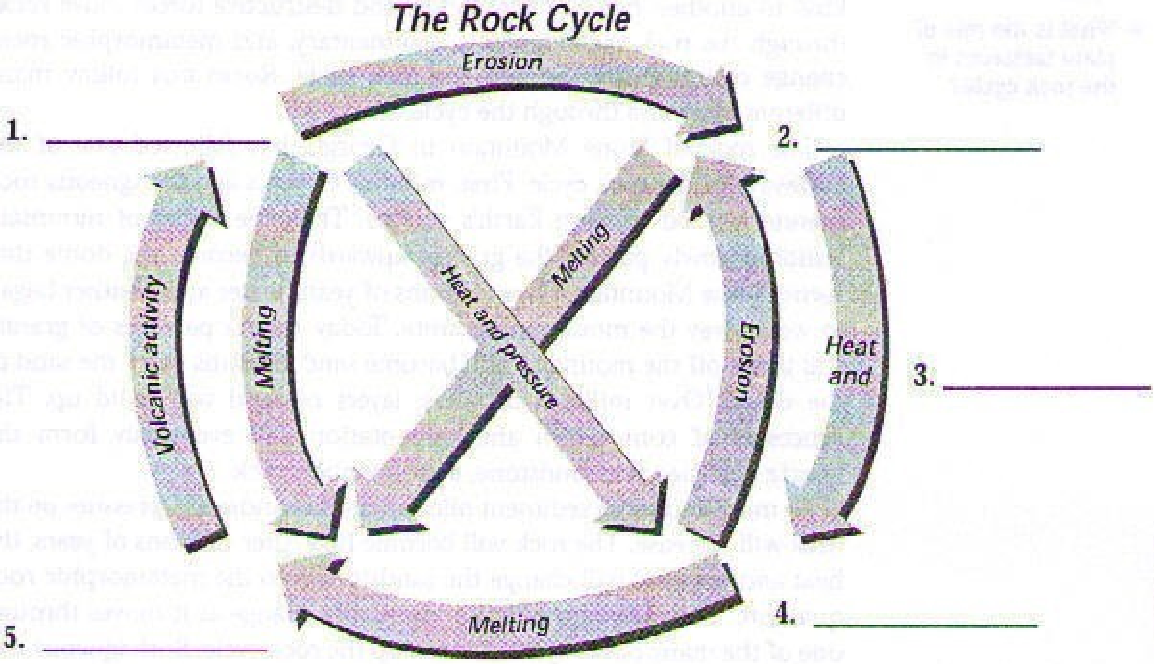
Name ______________________ Date __________ Class ______________

SECTION 5-6 **REVIEW AND REINFORCE**

The Rock Cycle

◆ Understanding Main Ideas

Use these terms to fill in the blanks in the figure below: metamorphic rock, sedimentary rock, magma, igneous rock, pressure.



Answer the following questions on a separate sheet of paper.

6. How do constructive and destructive forces contribute to the rock cycle?
7. Describe an alternate pathway within the rock cycle.
8. Describe how the granite of a mountain could change first into sandstone and then into quartzite.
9. What do plate movements cause that drives rocks through the rock cycle?

◆ Building Vocabulary

Using your own words, write a definition of the rock cycle on the lines below.

10. ____

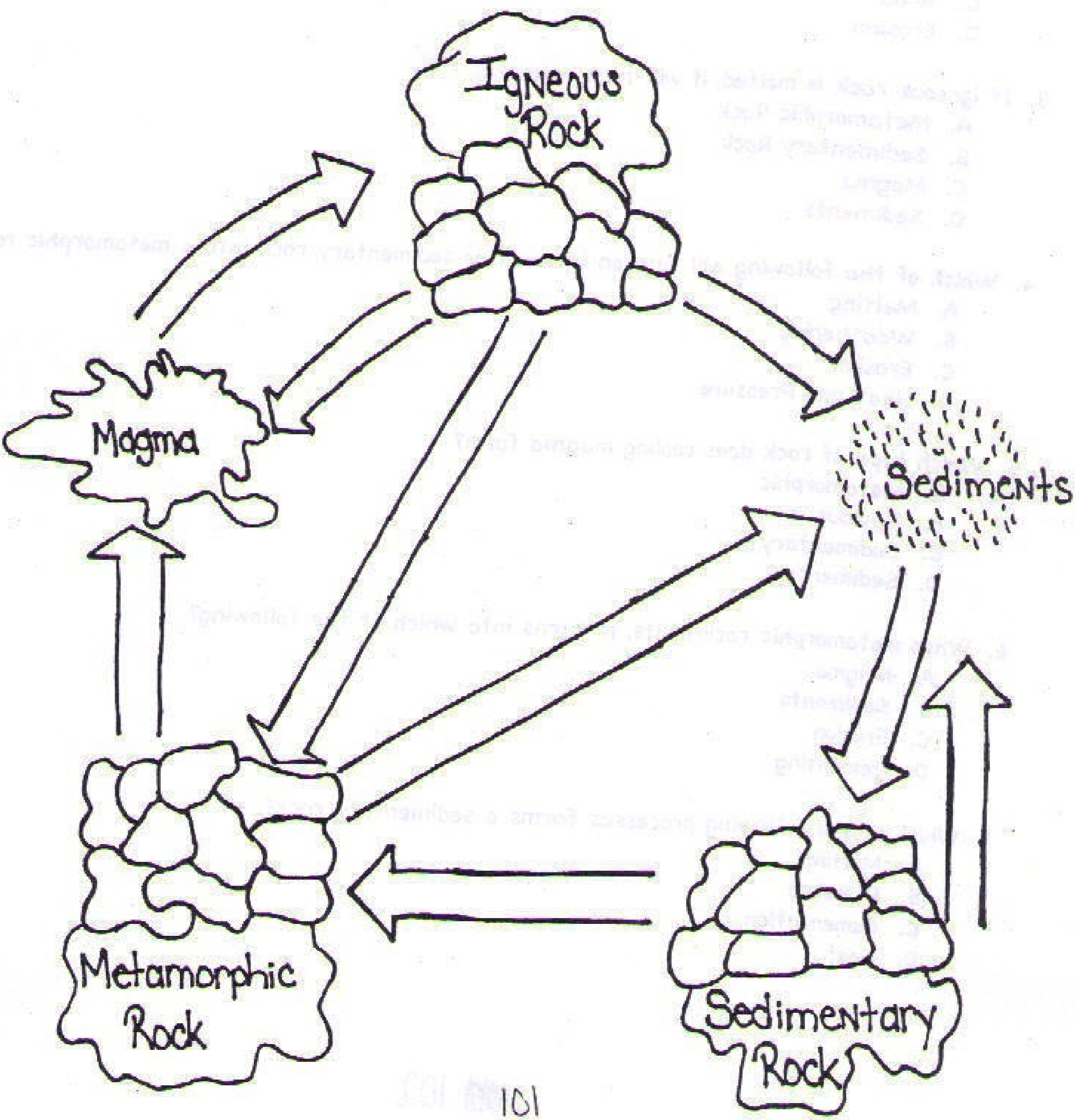
5

100

Name: ______________________________
Date: ________________ Period: ____ Score: ______

The Rock Cycle

The earth's crust is constantly changing. The Rock Cycle refers to the constant recycling of the materials in the crust. Throughout this cycle, various forces on the planet build, destroy, and change the rocks. These forces occur both inside the earth and on its surface.



Answer the following questions about the previous page's diagram.

1. What type of rock would be most likely to contain fossils?
   - A. Granite
   - B. Metamorphic
   - C. Igneous
   - D. Sedimentary

2. Which of the following would not break down a rock into sediments?
   - A. Water
   - B. Heat
   - C. Wind
   - D. Erosion

3. If igneous rock is melted, it will turn into this.
   - A. Metamorphic Rock
   - B. Sedimentary Rock
   - C. Magma
   - D. Sediments

4. Which of the following will turn an igneous or sedimentary rock into a metamorphic rock?
   - A. Melting
   - B. Weathering
   - C. Erosion
   - D. Heat and Pressure

5. Which type of rock does cooling magma form?
   - A. Metamorphic
   - B. Igneous
   - C. Sedimentary
   - D. Sediments

6. When metamorphic rock melts, it turns into which of the following?
   - A. Magma
   - B. Sediments
   - C. Erosion
   - D. Cementing

7. Which of the following processes forms a sedimentary rock?
   - A. Melting
   - B. Pressure
   - C. Cementation
   - D. Heat

Name: ______________________________
Date: _______________ Period: ______

THE ROCK CYCLE

Directions: The chart below shows how different kinds of rocks and rock materials are formed. Describe the rock or material within each box. Use the word bank to label each of the arrows (some of these words are used more than once). Color the arrows using the following information: cooling = blue; melting = red; weather and erosion = green; heat and pressure = yellow; compaction and cementation = gray. Take your time and think through this carefully. LOOK AT WHERE THE ARROWS ARE POINTING.

Word Bank: compaction and cementation, cooling, melting, weathering and erosion, heat and pressure