Your Name _____ Score _____

Group Members _____

_____ Minutes _____

Performance Indicator 2.1

Standard 4
Key Idea 2

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

Major Understanding:

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.

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

2.1l 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 Earth is a dynamic geologic system.

- These plate boundaries are the sites of most earthquakes, volcanoes, and young mountain ranges.
- Compared to continental crust, ocean crust is thinner and denser. New ocean crust continues to form at mid-ocean ridges.
- Earthquakes and volcanoes present geologic hazards to humans. Loss of property, personal injury, and loss of life can be reduced by effective emergency preparedness.

2.1m Many processes of the rock cycle are consequences of plate dynamics. These include the production of magma (and subsequent igneous rock formation and contact metamorphism) at both subduction and rifting regions, regional metamorphism within subduction zones, and the creation of major depositional basins through down-warping of the crust.

2.1n Many of Earth's surface features such as mid-ocean ridges/rifts, trenches/subduction zones/island arcs, mountain ranges (folded, faulted, and volcanic), hot spots, and the magnetic and age patterns in surface bedrock are a consequence of forces associated with plate motion and interaction.

2.1o Plate motions have resulted in global changes in geography, climate, and the patterns of organic evolution.

Mini Lesson 1: Earth's Interior

Earth's interior has a layered structure because it is composed of materials with different densities. As Earthquake waves pass through these layers they bend (refract) and sometimes are stalled or stopped. Scientists analyze earthquake and meteorite impact data to study the behavior of waves in order to infer what each layer is composed of. The more scientists learn about Earth's interior, the better prepared they will be to minimize the effects of earthquakes on buildings, roads and human life.

The lithosphere is the outermost layer of Earth. It includes the crust and rigid mantle. Don't forget that the crust is also the solid bottom under the ocean. Beneath the crust is the asthenosphere, also known as the Plastic Mantle, followed by the Stiffer Mantle. The Outer Core, which is liquid, moves around the solid Inner Core and creates a magnetic field. The Inner Core is solid and is considered to be Earth's magnet.

Need to know:

1. Why does Earth's interior have a layered structure? _____

2. What happens to earthquake waves as they pass through the different layers of Earth's interior?

3. What two things do scientists use to infer the composition of Earth's interior?

4. Why is it important that scientists learn about Earth's interior? _____

5. What is the outermost layer of Earth? _____
6. What does the lithosphere include? _____ and _____
7. What layer is located under the lithosphere? _____
8. What is another name for the asthenosphere? _____
9. Describe how the Outer Core creates a magnetic field. _____

"Inferred Properties of Earth's Interior" Earth Science Reference Tables Page 10

Materials
- ✓ ESRT's
- ✓ Highlighter
- ✓ Color pencils

1. Look at the information above the chart. Highlight each of the following labels that indicate the location on Earth's surface:

   Pacific Ocean, North America, and Atlantic Ocean

2. Find and highlight the "Cascades" and complete the sentence below:

   The Cascades are located at the boundary of the _____ and _____

3. What is located next to the Cascades but in the Pacific Ocean? _____

4. Highlight the word Trench.

5. What is located on Earth's crust, in the Atlantic Ocean? _____

6. Highlight "Mid-Atlantic Ridge"

7. Highlight the following Labels on the chart:
   Density, Lithosphere, Pressure, Temperature and Depth

8. Referring to the top of the chart, what two layers does the lithosphere include? _____ and _____

9. What is the density of the continental crust? _____ g/cm^3

10. What is the name of the rock that makes up most of the continental crust? _____

11. What is the density of the oceanic crust? _____ g/cm^3

12. What is the name of the rock that makes up most of the oceanic crust? _____

13. Write the density range in each of the following layers.

    (a) Asthenosphere from _____ to _____ g/cm^3

    (b) Stiffer Mantle from _____ to _____ g/cm^3

    (c) Outer Core from _____ to _____ g/cm^3

    (d) Inner Core from _____ to _____ g/cm^3

14. Using a red color pencil <u>lightly</u> shade in the Asthenosphere section in the chart. Start at the top right side (under density) and follow the dotted lines all the way down to the bottom of the graph. Under the density section, color ONLY the top section next to the Asthenosphere section.

    - Answer the following questions by looking at the boundary between the asthenosphere and the stiffer mantle.

    (a) What is the pressure at this boundary? (estimate) _____ millions of atmospheres

    (b) What is the temperature at this boundary? (estimate) _____ °C

    (c) What is the depth at this boundary? (estimate) _____ km

15. Using a brown color pencil lightly shade in the Stiffer Mantle section in the chart. Start at the top right side and follow the dotted lines all the way down to the bottom of the graph. Under the density section, color ONLY the section next to the Stiffer Mantle section.

- Answer the following questions by looking at the boundary between the Stiffer Mantle and the Outer Core.

(a) What is the pressure at this boundary? (estimate) _____ millions of atmospheres

(b) What is the temperature at this boundary? (estimate) _____ °C

(c) What is the depth at this boundary? (estimate) _____ km

16. Using a orange color pencil lightly shade in the Outer Core section in the chart. Start at the top right side and follow the dotted lines all the way down to the bottom of the graph. Under the density section, color ONLY section next to the Outer Core section.

(a) What is the composition of the Outer Core? _____ & _____

- Answer the following questions by looking at the boundary between the Outer Core and the Inner Core.

(b) What is the pressure at this boundary? (estimate) _____ millions of atmospheres

(c) What is the temperature at this boundary? (estimate) _____ °C

(d) What is the depth at this boundary? (estimate) _____ km

17. Using a purple color pencil lightly shade in the Inner Core section in the chart. Start at the top right side and follow the dotted lines all the way down to the bottom of the graph. Under the density section, color ONLY the section next to the Inner Core section.

(a) What is the composition of the Inner Core? _____ & _____

- Answer the following questions by looking at the far right side of the chart.

(b) What is the pressure at this point? (estimate) _____ millions of atmospheres

(c) What is the temperature at this point? (estimate) _____ °C

(d) What is the depth at this point? (estimate) _____ km

18. Refer to the temperature section of the chart for the following questions.

(a) What layer of Earth's interior is partially melted? _____

(b) Is the melting point [higher or lower] than the interior temperature in the outer core?

This means that the Outer Core must be a [solid or liquid] .

Introduction:

Earth's interior is divided into layers due to the different densities of materials of which each layer is made. The atmosphere is also divided into layers based on temperature changes and composition. The Earth Science Reference Table shows the approximate depth of each layer within Earth and the height of each layer in our atmosphere.

Materials
- ✓ pencil
- ✓ ESRT's
- ✓ Ruler
- ✓ Colored pencils
- ✓ Adding machine tape

Objective:

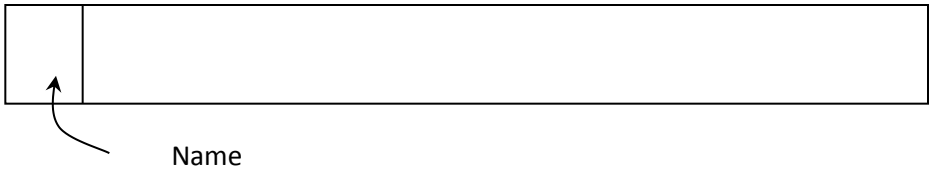
- To observe the relative depth of each layer of Earth

Procedure:

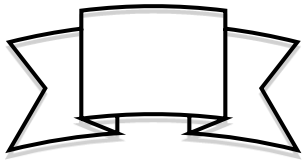
1. In the table below, the actual thickness of each layer is given. Determine the thickness needed for your scale model by dividing each of those values by 50. (50 km = 1 cm). Place your results in the table in the column labeled "Scale Model".

Layer	Thickness of Each Layer		Color
	Actual (km)	Scale Model (cm)	
Inner Core	1300		Yellow
Outer Core	2200		Blue
Mantle	2300		Green
Asthenosphere	500		Purple
Lithosphere	100		Brown
Hydrosphere	2	Use a Thick Line	Dark Blue
Troposphere	12		Light Blue
Stratosphere	38		White
Mesosphere	32		Yellow
Thermosphere	200		Orange

2. Obtain a piece of adding machine tape and a ruler.
3. Draw a vertical line 4 cm from the end of the tape as shown in the diagram below. Place your name to the left of that line.



4. The line drawn would be the center of Earth. Measure the distance for the Inner Core and draw a vertical line. USING PENCIL, very lightly and small label it "Inner Core". This will be erased before you color it.
5. From the line drawn for the Inner Core, measure the distance for the Outer Core Draw a vertical line. USING PENCIL, very lightly and small label it "Inner Core". This will be erased before you color it.
6. Continue to measure the remaining layers and drawing the corresponding lines.
7. BEFORE you color it in, check your accuracy with your teacher! Once checked –color it according to the chart.
8. Once completed have the teacher sign here:
9. Complete the chart below using your Earth Science Reference tables.



Layer	Temperature Range (°C)	Pressure Range (millions of atm)	Composition	Density (g/cm^3)
	From - To	From - To		
Inner Core	-	-		
Outer Core	-	-		
Mantle	-	-	Mg, Fe, Al, Si, O	
Asthenosphere	-	-		
Lithosphere	-	-		
Continental crust			Rock name	
Oceanic crust			Rock name	
Hydrosphere	-	Sea level: 1 atm		
Troposphere	-	-		Less than 1
Stratosphere	-	-	Ozone	
Mesosphere	-		Ionosphere	
Thermosphere	-		N_2 and 0_1	

Answer the following questions:

a) Number the following from 1 – 3, in the order of increasing density. (least to most)

_____ hydrosphere _____ lithosphere _____ atmosphere

b) What happens to density as you go from the surface to the center of Earth?

_____

c) What happens to pressure as you go from the surface to the center of Earth?

_____

d) What happens to temperature as you go from the surface to the center of Earth? _____

Mini Lesson 2: Continental Drift

Continental Drift is the theory that Earth's crust is resting on a fluid which allows it to move. The crust is broken up into pieces called plates that move relative to each other. These plates are sitting on the asthenosphere (plastic mantle). The transfer of Earth's internal heat drives convection currents within the mantle that causes these plates to move. When hot rising currents reach the bottom of the plates, it causes them to move apart. When convection currents are sinking it causes plates to move towards each other.

Pangaea is the name that was given to the supercontinent that existed approximately 200 million years ago. There are four main pieces of evidence that support the idea that the continents of today were once part of this single super continent.

1. <u>Shape of the coastlines</u>
   - continents fit together like a jigsaw puzzle

2. <u>Fossil correlation</u> across ocean basins
   - some fossils found on the east coast of South America are found only on the west coast of Africa

3. <u>Rock correlations</u> across ocean basins
   - the rocks on the east coast of South and North America match the same rocks found on the west coast of Africa and Europe.

4. <u>Climate changes</u>
   - coal has been found in Antarctica
   - evidence of glaciation in Australia and Africa

Reading Review:

1. What is the theory of Continental Drift? _____

   _____

2. What layer of Earth are the plates resting on? _____
3. What causes the plates to move? _____
4. What direction do plates move when there is a hot rising current? _____
5. What direction do plates move when currents are falling? _____

6. What is the name of the supercontinent that once existed? _____

7. List the four pieces of evidence that the continents were once connected.

   a) _____

   b) _____

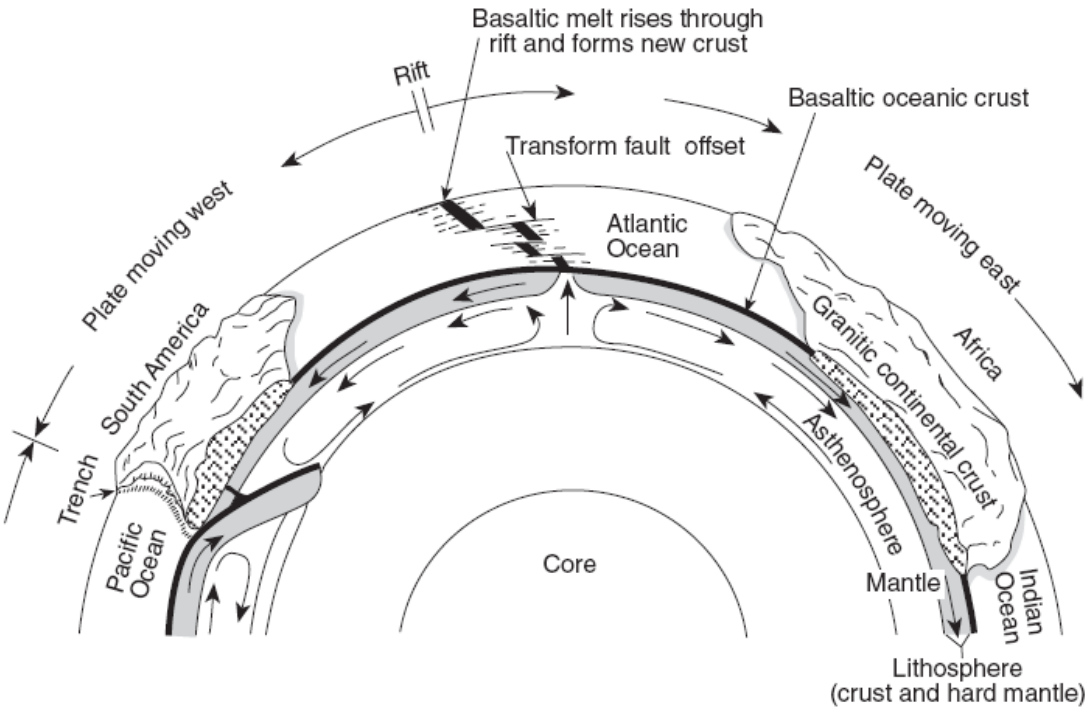
   c) _____

   d) _____

Show what you know: **Continental Drift**

Materials
- ✓ ESRT's
- ✓ Highlighter
- ✓ Color pencils

1. Using a red color pencil shade in the area labeled Asthenosphere on the diagram below.
2. Find the arrow in the asthenosphere near the center of the diagram that is pointing up. Trace over this arrow with a purple color pencil.
3. In the space under the arrow, write "rising currents". _____



4. Trace the arrow on either side of the, near the top of the asthenosphere purple as well.

   These arrows pointing [toward or away from] the rising current.

5. What is located on Earth's surface, directly above the rising current? _____

6. Color the Atlantic Ocean, Indian Ocean, and Pacific Ocean blue.

7. The rigid (hard) mantle is the shaded portion of the diagram, directly above the asthenosphere. Look at the arrow under the Pacific Ocean, and the arrow under South America and western portion of the Atlantic Ocean

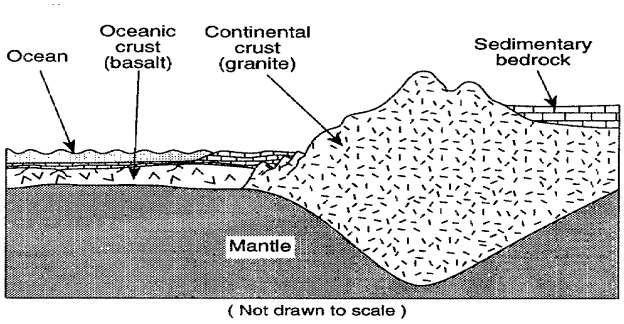
   These arrows are pointing [toward or away from] the sinking current.

8. Color South America and Africa green.

✓ **Check Point (refer to the diagram on page 8)**

1. What feature forms when plates are moving toward each other? _____
2. What two layers are included in the lithosphere? _____ and _____
3. What is the composition of the oceanic crust? _____
4. What is the composition of the continental crust? _____
5. What does the basaltic melt rising through the rift form? _____
6. What does the word rift mean? _____
7. In which compass direction is South American moving? _____
8. In which compass direction is Africa moving? _____
9. Using the diagram below and the ESRTs page 10, fill in the chart.

	Continental Crust	Oceanic Crust
Composition		
Density		
Thickness		



10. Rising currents cause the plates to move _____ each other.
11. Sinking currents cause the plate to move _____ each other.
12. Convection currents are caused by differences in density. Rising currents are *[more / less]* dense than sinking currents because they are *[warmer / cooler]*
13. Open your reference table to page 5, Tectonic Plates. Highlight the name of the three boundaries listed at the bottom of the page.

    Place the names of these boundaries and the information in (parenthesis) in the chart below.

Name of Boundary	(description)

Introduction:

Pangaea is the name given to the supercontinent that existed over 200 million years ago. There are several pieces of evidence that support this theory. This activity is designed to help you better understand how this was first thought of by using a simple child's puzzle.

Objective:

- To recognize how scientists eventually found evidence of Pangaea (by looking below the surface)

Procedure:

1) Pick up a puzzle from your instructor.
2) Place the puzzle pieces upside down on your desk. Put the puzzle together without turning it over.
3) How did you know how to put the puzzle together correctly?

_____

_____

4) Take the puzzle apart, mix up the pieces and place them face up on the desk.
5) Before you put the puzzle together again write down the first thing you will be <u>matching</u> up. It's a simple question – you do it automatically.

_____

6) Put the puzzle together. By looking at the puzzle, how do you know that it is put together correctly?

_____

7) Using complete sentences, in a well written paragraph, compare the puzzle and its pieces with the evidence for continental drift.

_____

_____

_____

_____

_____

_____

Mini Lesson 3: Sea Floor Spreading

Divergent boundaries occur along spreading centers where plates are moving apart. New crust is created by magma pushing up from the mantle. Picture two giant conveyor belts facing each other slowly moving in opposite directions as they transport newly formed oceanic crust away from the ridge crest. As the plates separate, water fills the low areas. Crust continues to separate allowing more magma to emerge making small underwater "hills" at the point of separation. Eventually a mid-ocean ridge will form. The youngest rocks are located at the center of the ridge because they are still being formed. The oldest are located the farthest from the ridge.

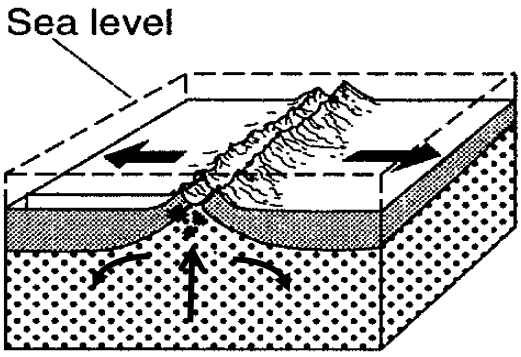
Need to know:

1. Which directions do plates move at a divergent boundary? _____
2. What is created as magma moves to the surface? _____
3. What happens as the plates separate? _____
4. What will eventually form at a divergent boundary? _____
5. Where are the youngest rocks found in the ocean? _____
6. Where are the oldest rocks found? _____

Show what you know: **Sea Floor Spreading**

Materials
- ✓ Pencil
- ✓ Construction paper
- ✓ Plain paper
- ✓ ruler
- ✓ color pencils
- ✓ tape
- ✓ cardboard cutout

1. Using a red color pencil, trace the arrows in the diagram below. As covered before, this is called a rising current.
2. Color the section directly above the rising current to illustrate where magma would be escaping.



3. Using a blue color pencil, color in both sides on the top of the diagram to illustrate water has filled in the lower areas. (Go up to the dotted line)

Introduction:

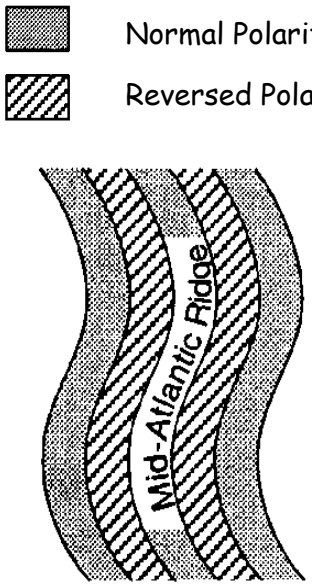
Materials
- ✓ Cardboard with a cut in the middle
- ✓ Copy paper
- ✓ Color pencils
- ✓ Masking tape

Some Igneous rocks contain minerals that are magnetic. Instruments measure small changes in magnetism. Bands of igneous rock on the ocean floor show that earth's magnetic orientation has been reversed in the past. This leads to the inference that crust must have shifted. Magnetic reversal supports the theory of sea floor spreading. "Normal Polarity" indicates that these areas have the magnetic alignment that is the same as it is today. "Reversed Polarity" indicates it is opposite.

Objective:

- To illustrate normal and reverse polarity

Procedure:



1. Color the Mid-Atlantic Ridge red. Label it "youngest".
2. Since the sea floor is spreading, the areas indicated by the striped lines not only have the same polarity, but they are the same age. Place an "X" at the top of each shaded area and label it "same age".
3. The outermost shaded areas on the diagram are also the same age. Place a "Y" under the two outside shaded areas and label them "same age"
4. Pick up a plain piece of paper from your teacher.
5. Turn your plain paper so that the short distance is top to bottom ("landscape" on a computer).
6. Using a ruler, measure the following distances on the top and the bottom of your plain piece of paper (use centimeters).

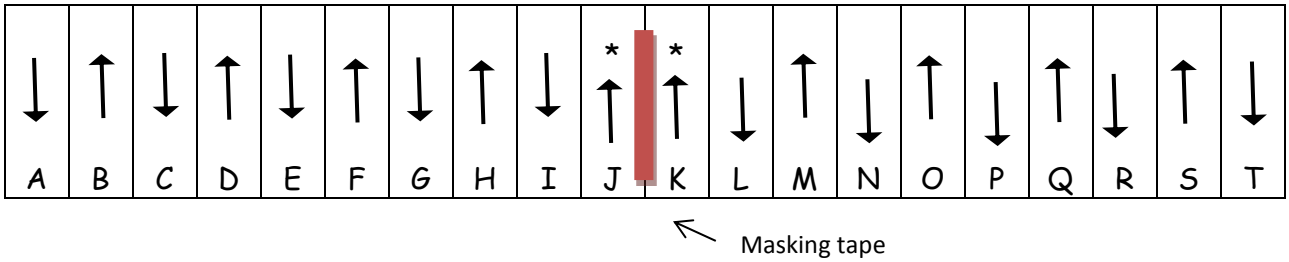
* 2	4	2	2.5	1.5	2.5	1.5	2	1.5	3	3
*										

7. Draw lines connecting those points.
8. Fold the paper in half (the long way – hotdog) and then open it up.

9. Place "*" on the bottom of the top and top of the bottom of the first column as shown in the diagram above.

10. Refold along the same crease and then carefully tear the paper in half

11. Lay the two halves next to each other and match the "*" on the left of one and the right of the other.



12. Using masking tape, tape the two halves together.

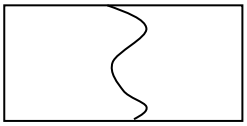
13. Color the masking tape red and label it "Mid Ocean Ridge"

14. Starting at the masking tape and using a red color pencil, place a large arrow, pointing upward in the first section, and in every other section to the right. Repeat for the opposite side with the first section's arrow again pointing up. (See diagram above)

15. Starting at the far left side of your model, label each section with letters starting with A, as seen in the diagram above.

16. Starting at the masking tape and using a blue color pencil, place a large arrow, pointing down in the sections between each of the other arrow. Repeat for the opposite side with the first section's arrow again pointing down. (See diagram above)

17. Using half a sheet of construction paper, draw a landmass.



18. Rip the construction paper in about half so that the tear is NOT even.

19. Put glue on the last two "sections" of your "arrowed" paper.

20. Place the $\frac{1}{2}$ piece of construction paper (landmass) so that the inside edge is located in the third from last section but it is glued to the last two.

21. Repeat for the other side. Make sure the torn parts of the construction paper face each other so that they would complete the landmass design if pushed together

22. Put materials away and then pick up a cardboard cutout.

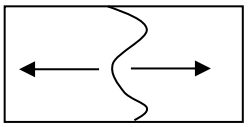
23. Fold the paper at the tape so that the lines and arrows are on the inside facing each other.

24. Starting with the fold, slide folded paper into the cut out portion of the cardboard until the two halves of your landmass meet.

25. Lay the landmass so that it is flat.

26. Place an arrow on each half of the landmass to demonstrate the motions of the plates.

27. Slowly pull the landmass apart to demonstrate sea-floor spreading.



✓ **Check Point**

1. What type of boundary is being illustrated by this activity? _____
2. What feature would be forming where the masking tape is? _____
3. What do the arrows on either side of the masking tape represent? _____
4. Where are the youngest rocks located in your diagram? _____
5. Looking at your "sea-floor", write down the matching letters that represent the same age of bedrock.

   J and _____ H and _____ F and _____ L and _____ N and _____

6. Where are the oldest rocks located in your diagram? _____
7. If this were the ocean floor, where would the heat flow be the greatest?

   _____

8. Evidence that the plates are moving apart include the following:
   a) The ocean floor is generally _____ than the continents.
   b) Rocks continually form at the _____
   c) Heat flow is the highest at the _____ because magma / lava is leaking out
   d) Change in _____ orientation, also known as magnetic reversal.

(younger / older)

Regents Questions:

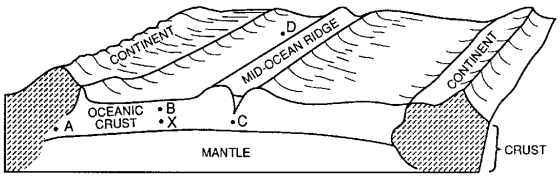
____1. Igneous rocks on the ocean floor that have an alternating pattern of magnetic orientation provide evidence that
   (1) mountains are rising
   (2) the seafloor is spreading
   (3) the Earth was struck by meteorites
   (4) ocean tides are cyclic

____2. Which statement best supports the theory of continental drift?
   (1) Basaltic rock is found to be progressively younger at increasing distances from a mid-ocean ridge.
   (2) Marine fossils are often found in deep-well drill cores.
   (3) The present continents appear to fit together as pieces of a larger landmass
   (4) Areas of shallow-water seas tend to accumulate sediment, which gradually sinks.

____3. Igneous materials found along oceanic ridges contain magnetic iron particles that show reversal of magnetic orientation. This is evidence that
   (1) volcanic activity has occurred constantly throughout history
   (2) the Earth's magnetic poles have exchanged their positions
   (3) igneous materials are always formed beneath oceans
   (4) the Earth's crust does not move

____4. Which is the best evidence supporting the concept of ocean floor spreading?
(1) Earthquakes occur at greater depths beneath continents than beneath oceans.
(2) Sandstones and limestones can be found both in North America and Europe.
(3) Volcanoes appear at random within the oceanic crust.
(4) Igneous rocks along the mid-oceanic ridges are younger than those farther from the ridges.

____5. The diagram to the right represents a cross of a section portion of the Earth's crust and mantle. Letters A, B, C, D and X identify locations within the crust. The age of oceanic crust increases along a line between X and location
(1) A (2) B (3) C (4) D



____6. The theory of continental drift does not explain the
(1) matching of rock features on continents thousands of kilometers apart
(2) melting of glacial ice at the close of the Pleistocene Epic
(3) apparent fitting together of many continental boundaries
(4) fossils of tropical plants in Antarctica

____7. Two samples of ocean floor basaltic bedrock are found at equal distances from, and on opposite sides of, a mid-ocean ridge. The best evidence that both samples were formed at the ridge during the same time period would be that both samples also
(1) have the same density
(2) contain different crystal sizes
(3) are located at different depths below sea level
(4) have the same magnetic field orientation

____8. As evidence accumulates the support for the theory that the present continents were at one time a single, large landmass
(1) increases (2) deceases (3) remains the same

____9. Which statement best supports the theory that all the continents were once a single landmass?
(1) Rocks of the ocean ridges are older than those of the adjacent sea floor
(2) Rock and fossil correlation can be made where the continents appear to fit together.
(3) Marine fossils can be found at high elevations above sea level on all continents.
(4) Great thickness of shallow water sediments are found at interior locations on some continents.

____10. For the last 200 million years, continents on opposite sides of the Atlantic ocean have generally
(1) been drifting apart
(2) been drifting closer together
(3) remained the same distance apart

Mini Lesson 4: Convergent & Transform Boundaries

A convergent boundary is where two plates move toward each other. There are two basic types of convergent boundaries. Collision boundaries involve two continental plates and lead to mountain building. Subduction boundaries involve two ocean crusts or an ocean and continental crust. It is called a subduction boundary because one plate is subducted (goes under) the other plate. A transform boundary occurs when two plates slide past each other. Each boundary is pictured below with specific descriptions.

Need to know:

1. Which directions do plates move at a convergent boundary? _____
2. What land feature is created as the plates collide? _____
3. What happens at a subduction boundary? _____

_____

4. Which way do the plates move relative to each other at a transform boundary? _____

_____

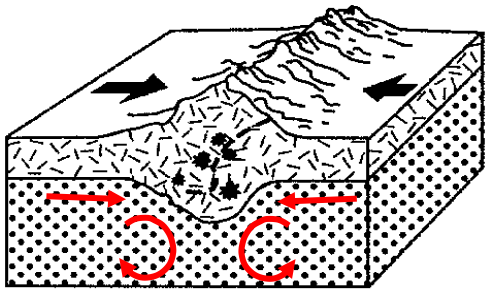
Materials
- ✓ color pencils
- ✓ ESRTs

Collision Boundary

Occurs when two continental plate collide. The collision causes crust to be pushed upward, forming mountain ranges.

Example: Himalayan, Ural, Appalachian

Evidence: Bench marks – changes in elevation

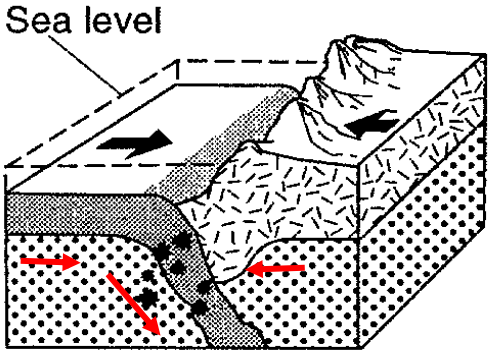


1. Color the mountains brown
2. The arrows beneath the mountains illustrate plate movement. Trace the arrows red.

Subduction Boundary

Ocean Plate / Continental Plate

Ocean plate is thinner and more dense than the continental plate and is subducted. Formation of deep sea trenches bordered by a mountain chain and volcanoes on the continental plate.



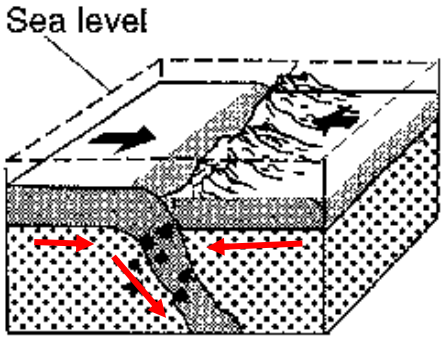
Example: Mt. St Helens

Evidence: Uplift of fossils
- marine fossils found on mountain tops

3. Color the ocean water blue (up to the dotted line)
4. Label the trench
5. Color the volcanic mountains brown
6. Place a couple red dots on the top of the mountains to show volcanoes

Ocean Plate / Ocean Plate

One ocean plate is subducted under the other. Formation of deep sea trenches and volcanic islands.

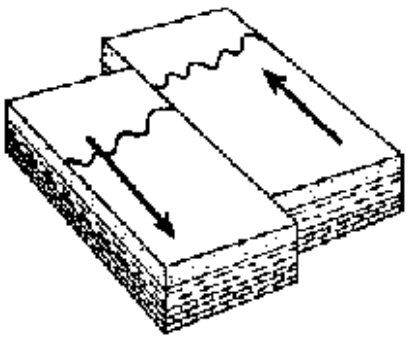


Examples: Aleutian islands, Japan and the Eastern Caribbean islands of Martinique, St. Lucia and St. Vincent and the Grenadines

Evidence: Subsidence of fossils
- shallow water fish buried deep in the ocean floor

7. Color the ocean water blue (both sides of diagram)
8. Label the trench
9. Place red dots on top of volcanoes (above water)

Transform Boundary



Occurs when any two plates move past each other.

Stress builds up between plates and eventually it is enough to cause an abrupt slippage.

10. Major earthquakes occur at transform boundaries
11. Example: San Andres Fault

✓ Check Point

1. How do mountain ranges form? _____
2. What causes the plates to move together? _____
3. What three features form when an ocean plate and a continental plate converge?
   a) _____
   b) _____
   c) _____
4. What evidence is there that Earth's surface has been uplifted? _____

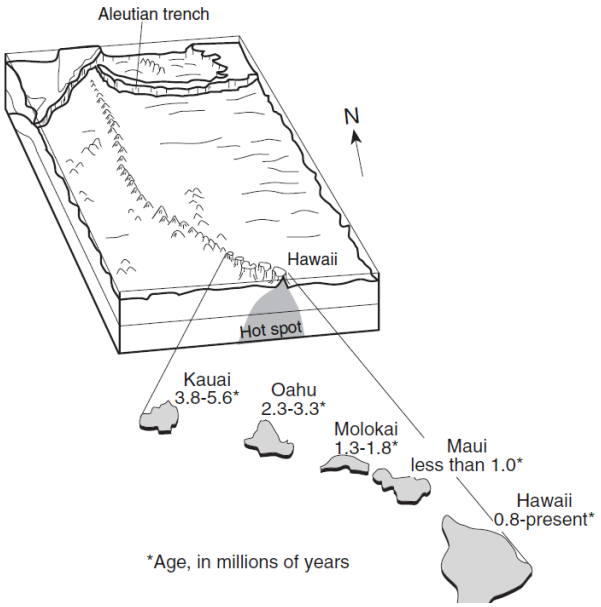
   _____
5. Give an example of a volcanic mountain. _____
6. What two features form when an ocean plate and an ocean plate collide?
   a) _____
   b) _____
7. What evidence is there that Earth's surface has been subducted? _____

   _____

Hot spots are places where magma is coming up through Earth's crust that are not necessarily located at a plate boundary. As the plates move over the hot spot volcanic islands can form. The block diagram below shows the bedrock age as measured by radioactive dating and the present location of part of the Hawaiian Island chain. These volcanic islands may have formed as the Pacific Plate moved over a mantle hot spot.

Use the diagram to the right to answer the following questions.

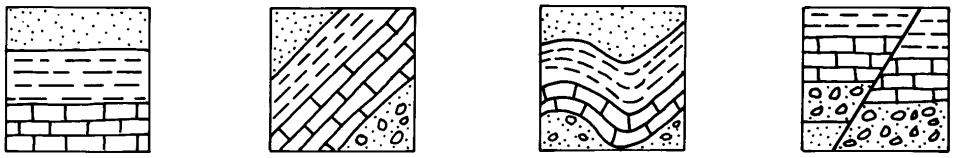
1. Which island is the youngest? _____
2. Which island is the oldest? _____
3. Which compass direction was the Pacific crust moving toward? _____
4. A new island is already forming off the coast of Hawaii named Loihi. By looking at the diagram to the right, what compass direction (from Hawaii) is Loihi forming? _____



5. You may recall from learning about the formation of sedimentary rocks that rocks are formed in horizontal layers. When the rock strata (layers) have not been deformed they are said to be "undisturbed".

   ❖ **Place the labels on the line provided <u>under</u> each diagram.**

   (a) Label the one that shows no evidence of movement, "undisturbed".
   (b) Find the diagram that shows that the layers are broken. Label this diagram faulting.
   (c) Look for the strata that is tipped and label it "tilted".
   (d) Label the remaining diagram "folded".



_____ _____ _____ _____

Regents Questions:

____1. Fossils of marine life can be found at locations higher than 200 meters above sea level in New York State. Which statement best explains this fact?
   (1) Much of New York State was once below sea level and has since been uplifted.
   (2) Much of New York State was once above sea level and has since subsided.
   (3) Sea level was once more than 200 meters lower than it is today.
   (4) Sea level was once more than 200 meters higher than it is today.

____2. Shallow-water fossils are found in rock layers that are deep beneath the ocean floor. This suggests that
   (1) shallow-water organisms always migrate to the deeper waters to die
   (2) parts of the ocean floor have been uplifted
   (3) parts of the ocean floor have subsided
   (4) the surface water cooled off, killing the organisms

____3. The best evidence of crustal movement would be provided by
   (1) dinosaur tracks found in the surface bedrock
   (2) marine fossils found on a mountaintop
   (3) weathered bedrock found at the bottom of a cliff
   (4) ripple marks found in sandy sediment

____4. The best evidence of crustal uplift is provided by
   (1) marine fossils found in the bedrock of some mountaintops
   (2) shallow-water marine fossils found in deep ocean water
   (3) horizontal sedimentary layers
   (4) thick layers of sediment on the ocean floor

____5. Evidence of crustal subsidence (sinking) is provided by
(1) zones of igneous activity at mid-ocean ridges
(2) heat-flow measurements on coastal plains
(3) marine fossils on mountaintops
(4) shallow-water fossils beneath the deep ocean

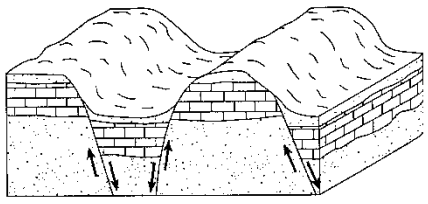
____6. A sandstone layer is tilted at a steep angle. What probably caused this tilting?
(1) nearly all sandstone layers are formed from wind deposited sands
(2) this sandstone layer has changed position due to crustal movement
(3) this sandstone layer has recrystallized due to contact metamorphism
(4) the sediments that formed this sandstone layer were originally deposited at a steep angle

____7. Which evidence suggests that sections of the Earth's crust have been uplifted in the past?
(1) Fossils of organisms that lived in shallow water are found at great ocean depths.
(2) Fossils of organisms that lived in the oceans are found in rocks above sea level.
(3) Sediments that were deposited in shallow water are found in great thicknesses.
(4) Large ocean basins containing accumulations of sediments show signs of subsidence (sinking)

____8. Which is the best evidence of crustal movement?
(1) molten rock in the Earth's outer core
(2) residual sediments on top of bedrock
(3) tilted sedimentary rock layers
(4) marine fossils found below sea level

____9. Folded sedimentary rock layers are usually caused by
(1) Deposition of sediments in folded layers
(2) Differences in sediment density during deposition
(3) A rise in sea level after deposition
(4) Crustal movement occurring after deposition

____10. The diagram to the right shows a portion of the Earth's crust. The movements indicated by the arrows represent the process of
(1) volcanism
(2) folding
(3) metamorphism
(4) faulting



____11. Which event provides direct evidence of crustal movement?
(1) the erosion of the outside of a river curve
(2) the deposition of sediments in the ocean
(3) the displacement of rock strata during an earthquake
(4) the weathering of rock to form a residual soil

Introduction:

Convection currents in the asthenosphere cause the lithospheric plates to move. If it is a rising current, plates move apart. If the currents are sinking they move toward each other.

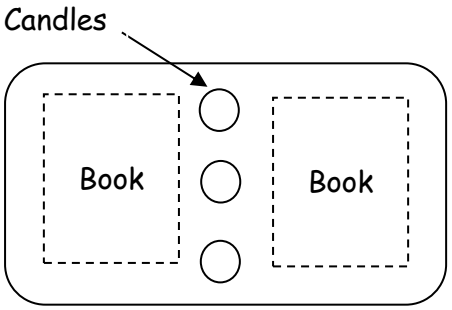
Materials
- ✓ 6 candles
- ✓ 2 sponges
- ✓ 11 x 14 baking pan
- ✓ Matches

Objective:

- To demonstrate how convection currents that cause lithospheric plates to move

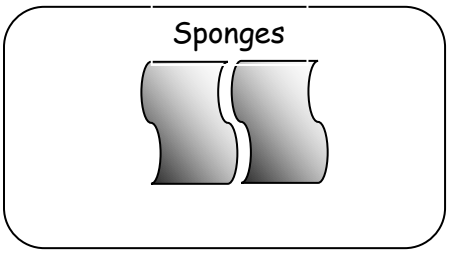
Procedure:

1. Get two books from your teacher and place them so that they will be at the outer edge of the pan that will rest on top of them.
2. Place three candles between the two books.
3. Fill the baking pan with water about half way. Make sure there is enough water to allow the sponges to float.
4. Light the candles and place the baking pan on top of the books as shown in the diagram to the right.
5. As soon as the water is almost still, place the two sponges in the middle of the pan directly over the burning candles with the scrubbing part down in the water.
6. Describe what happens to the sponges.

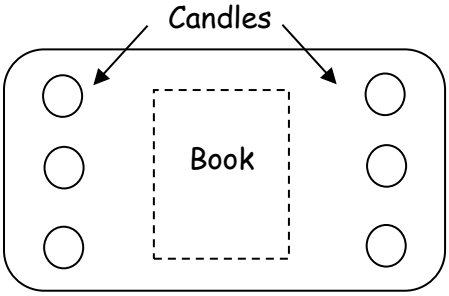


_____

_____



7. On the diagram to the right, draw arrows to show the general direction the sponges moved.
8. Blow out the candles and empty the pan of water into the sink.
9. Now, using only one book, place it below the center of the pan.
10. Place six candles on the outside of the book (three on each side, as shown in the diagram to the right).
11. Light the candles and place then place the baking pan on top of the book.

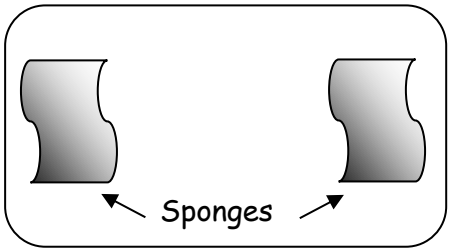


12. Wait until the water calms and place the two sponges in the water, one on the left and right one the right, directly above the candles, as shown in the diagram on page 22.
13. Describe what happens to the sponges. _____

_____

14. On the diagram to the right, draw in arrows to illustrate the general direction the sponges moved.

15. Blow out the candles and empty the pan of water into the sink and clean up your work area.



✓ **Check Point**

1. What layer of Earth's interior does the water represent? _____
2. What are the candles used for? _____
3. What happens to the water when it is heated by the candles? _____
4. What type of boundary is represented in step 7? _____
6. What feature forms at this type of boundary? _____
8. What type of boundary is represented in step 15? _____
9. What three feature forms at this type of boundary?

   _____

   _____

   _____
10. What drives the movements of plates in the asthenosphere? _____

Turn to page 10 of the Earth Science Reference Tables

11. Using a red color pencil, darken in the arrows at the top of the diagram in the asthenosphere layer.
12. Is the center arrow a rising current or a sinking current? _____
13. Are the arrows at the top moving together or apart? _____
14. What type of boundary is this? _____
15. What feature is formed above this boundary? _____
16. Using a red color pencil, darken in the arrows on the left side of the diagram in the asthenosphere layer.
17. Are the center arrows rising or sinking? _____
18. Are the arrows at the top moving together or apart? _____
19. What type of boundary is this? _____
20. What two features are formed above this boundary? _____

    _____

"Tectonic Plates: Earth Science Reference Tables Page 5

Materials
- ✓ ESRT's
- ✓ Highlighter
- ✓ Color pencils

1. Using a ruler, draw in the "Prime Meridian" from the zero (0°) degrees at the top of the map to the zero (0°) degrees at the bottom of the map. At the top of the map, label it "Prime Meridian".
2. Using a ruler, draw in the "International Date Line" from the 180° at the top of the map to the 180° degrees at the bottom of the map. At the top of the map, label it "International Date Line".
3. Using a yellow highlighter, highlight the **NAMES** of each of the following . . .
   - hot spots, ocean ridges, and trenches
4. Color each plate as indicated below. REMEMBER color very lightly so that you can read the map and know where the continents are.

- Eurasian Plate - dark green (both sides)
- North American Plate - dark blue
- African Plate - brown (both sides)
- Indian Australian Plate - light green
- Pacific Plate - blue
- Nazca Plate – purple
- South American Plate - light blue
- Antarctic Plate - orange
- Arabian Plate, Philippine Plate, Caribbean Plate – all three yellow

5. Using a red color pencil, color each of the hot spot locations.

6. Fill in the names of the Hot Spots at each of the following locations.

Location	Name of Hot spot
North American Plate	
Pacific Plate	
Nazca Plate	
Eurasian Plate	
NW African Plate	
SW African Plate	
Bottom of African Plate	
Indian Australian Plate	
Between Nazca and Pacific Plates	

7. Name the <u>two</u> plates located on either side of each of the following trenches.

Trench	Plate name	Plate name
Aleutian Trench		
Mariana Trench		
Tonga Trench		
Peru-Chile Trench		

8. Name the two plates located on either side of each of the following ridges.

Ridge	Plate name	Plate name
East Pacific Ridge		
Mid -Atlantic Ridge		
Southwest Indian Ridge		
Southeast Indian Ridge		
Mid-Indian Ridge		

9. In the boxes below, draw the symbols for each of the following boundaries:

Convergent Plate Boundary	Complex or Uncertain Boundary
Divergent Plate Boundary	Transform Plate Boundary

8. What do the arrows on the map indicate? _____

9. Look at the arrows along any of the trenches, on the two adjoining plates. Are the plates moving toward each other or away from each other? _____

10. What kind of boundary is located at a trench? _____

11. Look at the arrows along any of the ridges, on the two adjoining plates. Are the plates moving toward each other or away from each other? _____

12. What kind of boundary is located at a ridge? _____

13. Find the San Andres Fault. What type of boundary is this? _____

14. In the table below, state the direction of movement of the plates.

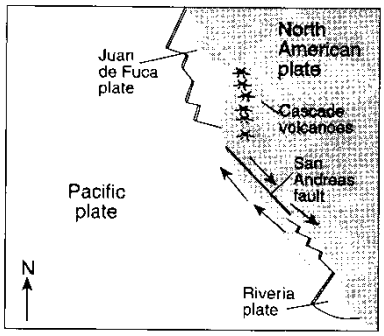
Name of Plate	Direction	Name of Plate	Direction
South American Plate	SW	Antarctic Plate - below Pacific Plate	
African Plate		Antarctic Plate - below African Plate	
Pacific Plate		North American Plate – west coast	
Nazca Plate		North American Plate – near Iceland	
Eurasian Plate		Indian - Australian Plate	

Regents Questions:

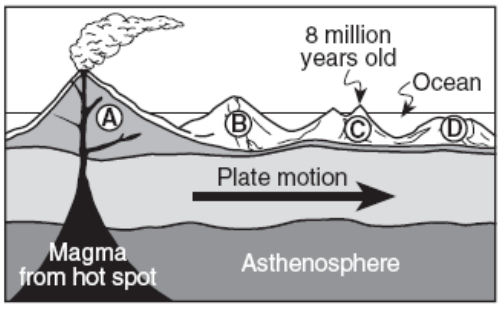
____1. Which of the following locations is the site of a convergent plate boundary?
(1) Mid-Atlantic ridge (3) Atlantic-Indian ridge
(2) Pacific/North American plate boundary (4) Aleutian Trench

____2. What is the direction of crustal movement of the Indian-Australian plate?
(1) northward (2) southward (3) northwestward (4) southwestward

____3. The map to the right shows continental and oceanic crustal plates along the west coast of North America. Which conclusion is best supported by the map?
(1) The boundary of the Pacific plate has very few faults.
(2) The Pacific plate has stopped moving
(3) The West Coast of North America is composed of the oldest rock on the continent
(4) The West Coast of North America is a zone of frequent crustal activity.



____4. The cross section below shows the direction of movement of an oceanic plate over a mantle hot spot, resulting in the formation of a chain of volcanoes labeled *A*, *B*, *C*, and *D*. The geologic age of volcano *C* is shown. What are the most likely geologic ages of volcanoes *B* and *D*?



(1) *B* is 5 million years old and *D* is 12 million years old.

(2) *B* is 2 million years old and *D* is 6 million years old.

(3) *B* is 9 million years old and *D* is 9 million years old.

(4) *B* is 10 million years old and *D* is 4 million years old.

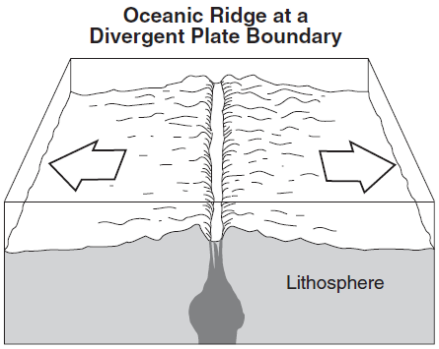
____5. Which two tectonic plates are separated by a mid-ocean ridge?
(1) Indian-Australian and Eurasian (3) North American and South American
(2) Indian-Australian and Pacific (4) North American and Eurasian

____6. The Mariana Trench was most likely created by the
(1) convergence of the Pacific and Philippine Plates
(2) divergence of the Eurasian and Philippine Plates
(3) sliding of the Pacific Plate past the North American Plate
(4) movement of the Pacific Plate over the Hawaii Hot Spot

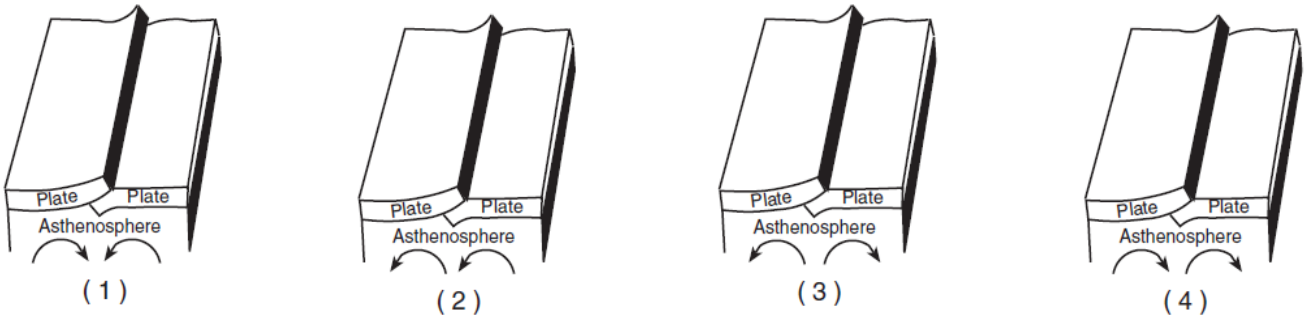
____7. The Himalayan Mountains are located along a portion of the southern boundary of the Eurasian Plate. At the top of Mt. Everest (29,028 feet) in the Himalayan Mountains, climbers have found fossilized marine shells in the surface bedrock. From this observation, which statement is the best inference about the origin of the Himalayan Mountains?
(1) The Himalayan Mountains were formed by volcanic activity.
(2) Sea level has been lowered more than 29,000 feet since the shells were fossilized.
(3) The bedrock containing the fossil shells is part of an uplifted seafloor.
(4) The Himalayan Mountains formed at a divergent plate boundary.

____8. The diagram to the right shows a tectonic plate boundary. Which mantle hot spot is at a plate boundary like the one shown in this diagram?

(1) Hawaii Hot Spot
(2) Yellowstone Hot Spot
(3) Galapagos Hot Spot
(4) Canary Hot Spot



____9. Which diagram correctly shows how mantle convection currents are most likely moving beneath colliding lithospheric plates?

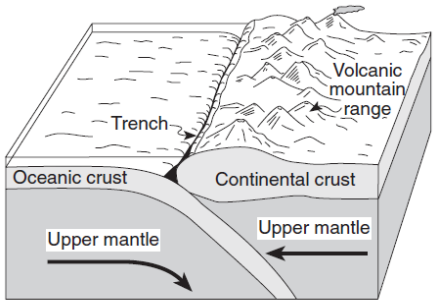


____10. Based on the theory of plate tectonics, it is inferred that over the past 250 million years North America has moved toward the
(1) northwest (2) southeast (3) southwest (4) northeast

____11. According to tectonic plate maps, New York State is presently located
(1) at a convergent plate boundary
(2) above a mantle hot spot
(3) above a mid-ocean ridge
(4) near the center of a large plate

____12. Convection currents in the plastic mantle are believed to cause divergence of lithospheric plates at the
(1) Peru-Chile Trench
(2) Mariana Trench
(3) Canary Islands Hot Spot
(4) Iceland Hot Spot

____13. The diagram to the right shows the interaction of two tectonic plates. The type of plate boundary represented in the diagram most likely exists between the
(1) Antarctic Plate and the African Plate
(2) Antarctic Plate and the Indian-Australian Plate
(3) South American Plate and the Nazca Plate
(4) South American Plate and the African Plate



(Not drawn to scale)

____14. The movement of tectonic plates is inferred by many scientists to be driven by
(1) tidal motions in the hydrosphere
(2) density differences in the troposphere
(3) convection currents in the asthenosphere
(4) solidification in the lithosphere

____15. At which plate boundary is one lithospheric plate sliding under another?
(1) Nazca Plate and Antarctic Plate
(2) Nazca Plate and Pacific Plate
(3) Indian-Australian Plate and Antarctic Plate
(4) Pacific Plate and Indian-Australian Plate

Base your answers to questions 15 through 17 on the information below and on your knowledge of Earth science.

In the 1930s, most scientists believed that Earth's crust and interior were solid and motionless. A small group of scientists were talking about "continental drift," which is the idea that Earth's crust is not stationary, but is constantly shifting and moving. From seismic data, geophysical evidence, and laboratory experiments, scientists now generally agree that lithospheric plates move at the surface. Both Earth's surface and interior are in motion. Solid rock in the mantle can be softened and shaped when subjected to the heat and pressure within Earth's interior over millions of years.

Subduction processes are believed by many scientists to be the driving force of plate tectonics. At present, this theory cannot be directly observed and confirmed. The lithospheric plates have moved in the past and are still moving today. The details of why and how they move will continue to challenge scientists.

16. Earth's crust is described as "constantly shifting and moving." Give two examples of geologic evidence that supports the conclusion that continents have drifted apart.

_____

_____

17. The information given suggests that "subduction processes are the driving force of plate tectonics." Identify a specific location of a subduction zone on Earth.

_____

18. According to the Earth Science Reference Tables, at what inferred depth is mantle rock partially melted and slowly moving below the lithospheric plates? _____

Mini Lesson 5: Landscape Regions and Drainage Patterns

Crustal movement, bedrock composition and climate conditions develop specific landscape regions. Two examples of tectonic forces that shape landscape regions are the formation of mountains when two plates collide and the development of plateaus when uplift and erosion occur.

Some bedrock may be more resistant to weathering (granite) while other, weaker rock (limestone) will wear away much faster. Finally, dry climates produce jagged, steep slopes (Grand Canyon) while wet climates tend to form rounded hills like the ones you see around New York State.

Drainage patterns are determined by the topographic structures and the underlying bedrock.

Landscape Region	Relief	Bedrock
Mountain	Great relief, high peaks, deep valleys	Faulted and tilted structure; many bedrock types, including igneous
Ridges	Moderate relief, rounded peaks, wide valleys	Folded sedimentary bedrock
Plateau	Moderate to high relief	Horizontal sedimentary bedrock layers
Plain	Very little relief, low elevations	Horizontal sedimentary bedrock layers
Valley	Low relief, located between ranges of hills or mountains	Any type of bedrock, area may have been eroded away by streams (V-shaped) or glaciers (U-shaped)
Escarpment	transition zone that involves a major elevation difference, often involving high cliffs	frequently formed by faults

Need to know:

1. List three factors that help shape landscape regions.

2. Describe how mountains are formed.

3. Describe how a plateau forms.

4. What rock type mentioned in the passage is resistant to weathering? _____

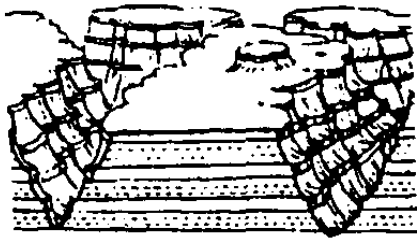
5. Explain why limestone weathers faster than granite? (Hint: composition) _____

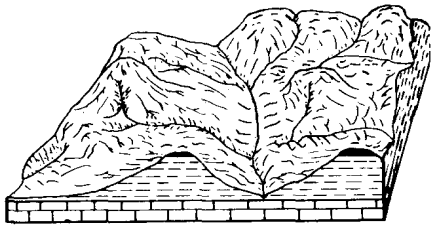
_____

6. What type of surface features are generally present in a dry climate? _____

7. What type of surface features are generally present in a wet climate? _____

8. The diagrams to the below show two different surface features affected by climate. On the line provided under each diagram, place the corresponding label that describes the climate it would be found in. (Dry Climate or Wet Climate)





_____ _____

9. Name three landscape features that form from crustal movement. (Hint: read the chart on page 28)

_____ _____ _____

10. Name three landscape features that form primarily from weathering and erosion

_____ _____ _____

11. What is the difference in bedrock structure between a plateau and a mountain?

_____

_____

12. What two things determine drainage patterns?

_____

_____

13. What is the difference between a valley and a plain? _____

_____

_____

Picture this: Most of Vermont's landscape regions consist of ancient, weathered mountains that were covered by several ice sheets during the last ice age. When the ice melted, sand, cobbles, and boulders were deposited throughout the state. Vermont is divided into six landscape regions.

(1) The Vermont Lowlands region has a mild climate, with Lake Champlain moderating its temperature.

(2) The Green Mountains run the length of Vermont and were formed over 400 million years ago. Most of the bedrock is metamorphic and the region is known for its deposits of talc and asbestos.

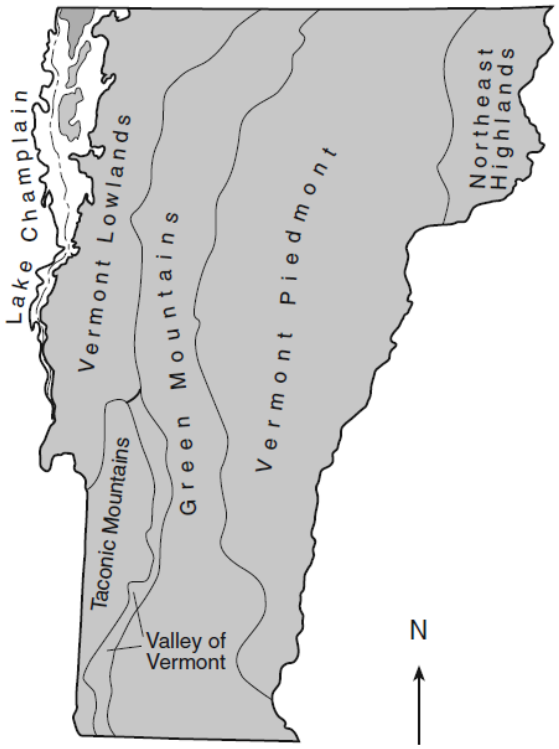
(3) The Taconic Mountains extend into New York State. Slate and marble are commonly mined in this region.

(4) The Valley of Vermont is a narrow valley between two mountain ranges. Most of the bedrock in the region is limestone and marble.

(5) The Vermont Piedmont covers the largest area of the state. This region consists of rolling hills and valleys. Granite mining is an important industry.

(6) The Northeast Highlands is a mountainous region composed of granite bedrock.

Generalized Landscape Regions of Vermont



____ 1. The classification of landscape regions is primarily based on which factors?
(1) climate, vegetation, and surface features (3) state boundaries, streams, and rivers
(2) bedrock type, structure, and elevation (4) nearness to mountains, lakes, and oceans

____ 2. Which Vermont landscape region is a continuation of New York State's Champlain Lowlands landscape?
(1) Vermont Lowlands (3) Taconic Mountains
(2) Valley of Vermont (4) Green Mountains

____ 3. During which geologic period did a major orogeny form the Taconic Mountains? (hint ESRT pg2/3)
(1) Cretaceous (2) Permian (3) Devonian (4) Ordovician

____ 4. Some of the bedrock in the Green Mountains is actually green in color because of the presence of the mineral chlorite. Which other mineral can cause rocks to appear green?
(1) sulfur (2) magnetite (3) olivine (4) halite

____ 5. Which processes formed the granite that is mined in Vermont?
(1) compaction and cementation of sediments (3) uplift and weathering of bedrock
(2) cooling and solidification of magma (4) application of heat and pressure to shale

Regents Questions:

____ 1. The major landscape regions of the United States are identified chiefly on the basis of
(1) similar surface characteristics
(2) similar climatic conditions
(3) nearness to major mountain regions
(4) nearness to continental boundaries

____ 2. Which city is located in a landscape region showing distorted and altered bedrock structure?
(1) Old Forge (2) Niagara Falls (3) Syracuse (4) Binghamton

____ 3. Which New York State landscape region has intensely metamorphosed surface bedrock?
(1) Appalachian Plateau
(2) Atlantic Coastal Plain
(3) Adirondacks Mountains
(4) Erie-Ontario Lowlands

____ 4. Which city is located in the St. Lawrence Lowlands?
(1) Kingston (2) Massena (3) Rochester (4) Albany

____ 5. Which characteristics of Earth's surface can be determined by using a topographic map?
(1) Hill slope and stream gradients
(2) Bedrock erosion and stream velocity
(3) Hilltop elevations and bedrock age
(4) Soil thickness and benchmark movement

____ 6. Which New York State landscape region contains the oldest surface bedrock?
(1) Erie- Ontario Lowlands
(2) Allegheny Plateau
(3) Adirondack Mountains
(4) Tug Hill Plateau

Base your answers to questions 7 and 8 on the photograph below, which shows an outcrop of sedimentary rock layers that have been tilted and slightly metamorphosed.

____ 7. The tilted rock structure shown in the photograph is most likely the result of the
(1) deposition of rock fragments on a mountain slope
(2) reversal of past magnetic poles
(3) passage of seismic waves
(4) collision of crustal plates

____ 8. Tilted, slightly metamorphosed rock layers such as these are typically found in which New York State landscape region?
(1) Taconic Mountains
(2) Atlantic Coastal Plain
(3) Tug Hill Plateau
(4) Erie-Ontario Lowlands

____ 9. Which location is on a plateau landscape?

(1) Rochester (2) Elmira (3) Old Forge (4) New York City

____ 10. The boundaries between landscape regions are usually determined by the location of

(1) plate boundaries
(2) major cities
(3) population density
(4) well-defined surface features

____ 11. The table below describes the characteristics of three landscape regions, *A, B,* and *C,* found in the United States.

Landscape	Bedrock	Elevation / Slopes	Streams
A	Faulted and folded gneiss and schist	High elevation Steep slopes	High velocity Rapids
B	Layers of sandstone and shale	Low elevation Gentle slopes	Low velocity Meanders
C	Thick horizontal layers of basalt	Medium elevation Steep to gentle slopes	High to low velocity Rapids and meanders

Which list best identifies landscapes *A, B,* and *C*?

(1) *A*—mountain, *B*—plain, *C*—plateau
(2) *A*—plain, *B*—plateau, *C*—mountain
(3) *A*—plateau, *B*—mountain, *C*—plain
(4) *A*—plain, *B*—mountain, *C*—plateau

12. New York State's Adirondacks are classified as a mountain landscape region. Describe one bedrock characteristic and one land surface characteristic that were used to classify the Adirondacks as a mountain landscape region.

Bedrock characteristic: _____

_____

_____

Surface characteristic: _____

_____

_____