Your Name _____ Score _____

Group Members _____ _____ Minutes _____

Standard 4
Key Idea 1

Performance Indicator 1.2

Describe current theories about the origin of the universe and solar system.

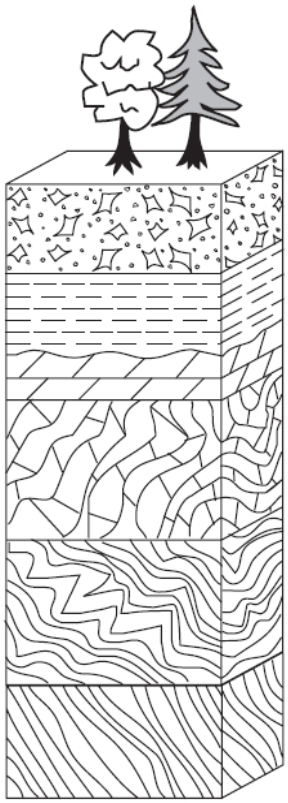
Major Understanding:

1.2h1j 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).

1.2h The evolution of life caused dramatic changes in the composition of Earth's atmosphere. Free oxygen did not form in the atmosphere until oxygen-producing organisms evolved.

1.2i The pattern of evolution of life-forms on Earth is at least partially preserved in the rock record.

- Fossil evidence indicates that a wide variety of life-forms has existed in the past and that most of these forms have become extinct.
- Human existence has been very brief compared to the expanse of geologic time.



1.2j Geologic history can be reconstructed by observing sequences of rock types and fossils to correlate bedrock at various locations.

- The characteristics of rocks indicate the processes by which they formed and the environments in which these processes took place.
- Fossils preserved in rocks provide information about past environmental conditions.
- Geologists have divided Earth history into time units based upon the fossil record.
- Age relationships among bodies of rocks can be determined using principles of original horizontality, superposition, inclusions, cross-cutting relationships, contact metamorphism, and unconformities. The presence of volcanic ash layers, index fossils, and meteoritic debris can provide additional information.
- The regular rate of nuclear decay (half-life time period) of radioactive isotopes allows geologists to determine the absolute age of materials found in some rocks.

Mini Lesson 1: Relative Time

It is beneficial to determine what has happened in the past so that we can make better decisions when dealing with things to come. The forces that exist on Earth today have always been in place. Earthquakes, volcanic eruptions, climate changes and even storms have played an important part in Earth's history. These forces shaped our planet long-ago and what we see today is the result. The law of uniformitarianism states that the present is the key to the past. Perhaps by studying the past we can protect our future. There are two main categories for geologic time, relative time and absolute time. Relative time places events in sequence of occurrence focusing on what happened first, second and so on. Absolute time puts an approximate age of a rock, fossil or even how long ago an event took place.

Keeping in mind that sedimentary rocks form in horizontal layers, the law of superposition states that the oldest layers in an undisturbed set of rock strata (layers) are on the bottom. When folding, faulting or tilting occur, it is important to remember that the rocks needed to be there in order for them to have been displaced. This means the faults, folds and tiling is younger than the rocks that have moved. It does not lead to an exact date of the event but is essential in determining which rock layer is older and which is younger.

Need to know:

1. Why is it important to understand what happened in the past? _____

2. What law states "the present is the key to the past? _____

3. Describe what the law in question 2 is referring to. _____

4. What is the difference between relative time and actual time? _____

5. According to the law of superposition, where are the oldest layers in a undisturbed set of rock strata located? _____

6. Explain why events such as folding, faulting and tilting of rocks are younger than the rocks the move. _____

1. Using the map symbols on page 7 of the Earth Science Reference Tables, name each of the following rock layers as indicated by the numbers below.

   Rock layer 1 _____

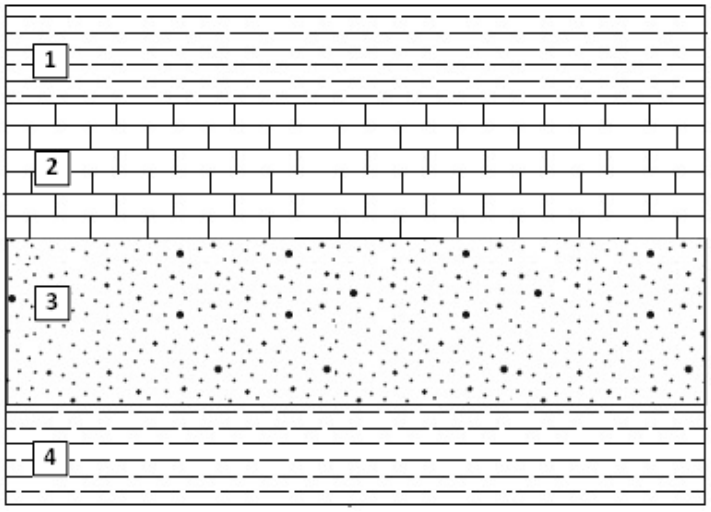
   Rock layer 2 _____

   Rock layer 3 _____

   Rock layer 4 _____

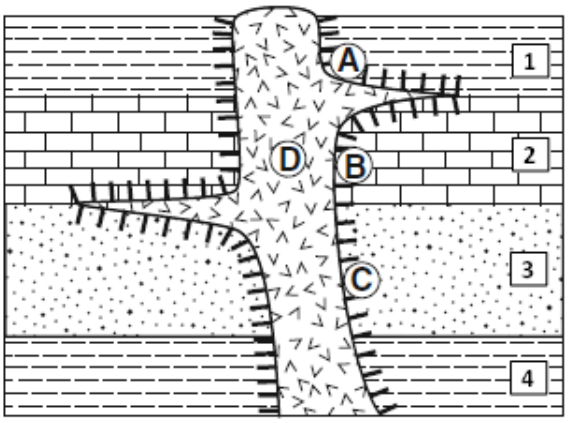
   Which rock layer is the oldest? _____

   Which rock layer is the youngest? _____



An **<u>intrusion</u>** occurs when magma moves up through the rock layers but does not reach the surface. Once solidified, the magma forms an **intrusive** igneous rock. The principle of cross-cutting states that the intrusion is always **<u>younger</u>** than the rock it cuts across.

Use the cross section below to answer questions 1 – 8. The cross section represents a portion of Earth's crust. Letters *A* through *D* are **<u>locations</u>** within the rock units. Numbers *1* through *4* indicate specific rock layers.



1. What does the  symbol indicate on the diagram?

   _____

2. At which location is quartzite most likely found? _____
3. At which location is slate most likely found? _____
4. At which location is marble most likely found? _____
5. What rock type does ***D*** represent? _____

6. Write the numbers from each rock layer in the order in which they occurred from oldest to youngest.

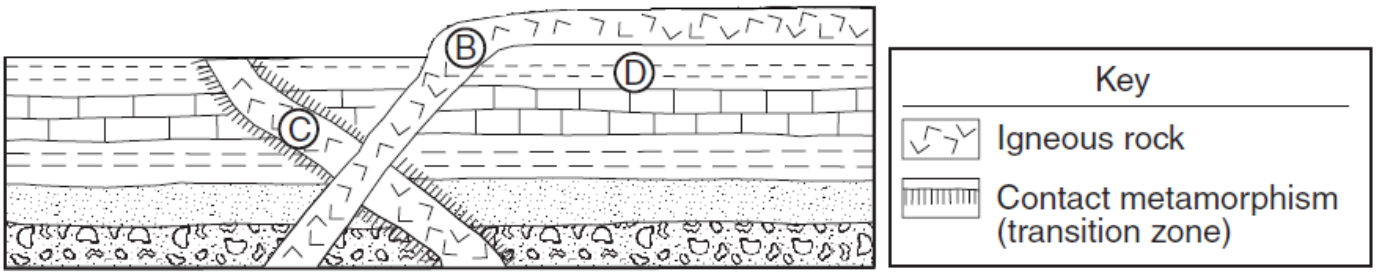
   _____ , _____ , _____ , _____

7. Which rock layers have evidence of contact metamorphism? _____ , _____ , _____ , _____

8. Which is the youngest event?
   (a) The intrusion of rock layers
   (b) The formation of rock layers

An **extrusion** occurs when magma moves up through the rock layers and **reaches the surface**. Once solidified, the magma forms an **extrusive** igneous rock. The principle of cross-cutting states that the intrusion is always **younger** than the rock it cuts across BUT older than the rock layers on top. If there is NO contact metamorphism between the igneous rock and the rock layers on top, it is an **extrusion**.

Base your answers to questions 1 through 3 on the cross section provided below. The cross section represents a portion of Earth's crust. Letters *B*, *C*, and *D* are rock units.



1. List the names of the rock layers in the order in which they were formed.

Oldest _____

_____

_____

_____

Youngest _____

2. Which intrusion (B or C) came after the five rock layers were formed? _____

3. What was the next event that took place? _____

4. Draw the symbol for contact metamorphism on rock unit B, wherever it is in contact with the rock layers. (not on top)

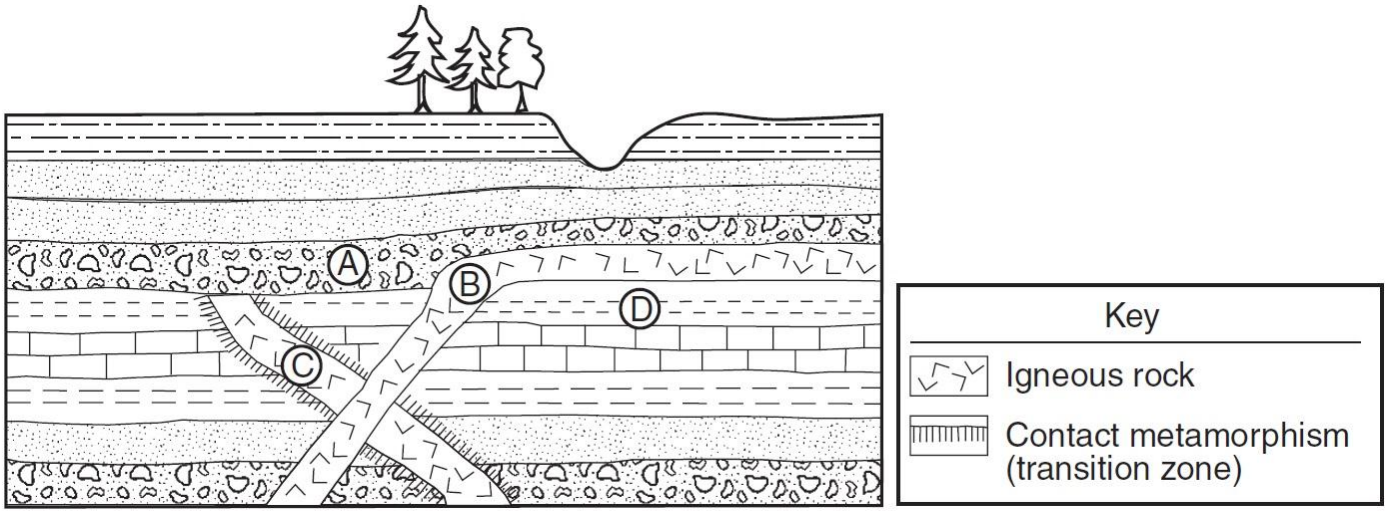
➢ **FLASHBACK: Describe how each rock type is formed:**

Igneous _____

Sedimentary _____

Metamorphic _____

Base your answers to questions 1 through 5 on the cross section provided below. The cross section represents a portion of Earth's crust. Letters *A*, *B*, *C*, and *D* are rock units.



1. Igneous rock *B* was formed after rock layer *D* was deposited but before rock layer *A* was deposited. Using the contact metamorphism symbol shown in the key, draw that symbol in the proper locations on the cross section provided to indicate those rocks that underwent contact metamorphism when igneous rock *B* was molten.

2. List the formation of rock layers in the order in which they occurred after the extrusion (B). Notice that there are two of the same layers on the diagram. You must list it twice.

   _____

   _____

   _____

   _____

3. What caused the "dip" in the cross-section to the right of the trees? _____

4. In relation to rock units A and B in the cross section, when was igneous rock C formed?

   After . . . _____

   _____

   Before . . . . _____

   _____

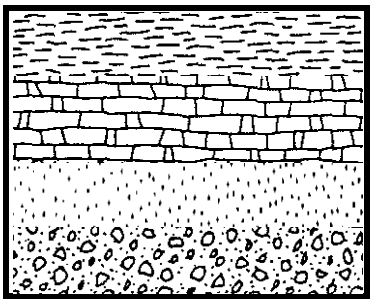
5. Describe one observable characteristic of rock A that indicates it is sedimentary.

   _____

6. Why is there no contact metamorphism location on rock layer A? _____

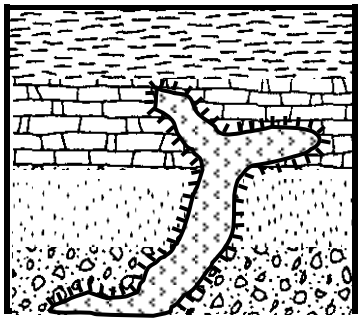
   _____

1. **Writing the sequence of event**: Using the sedimentary rock map symbols on page 7 of the Earth Science Reference Tables write the sequence of events for the rock strata (layers) below. Remember to include how the rock layer was formed as well as the rock name. The first one has been done for you.



1. *Deposition of mixed particles, compaction and cementation, formation of conglomerate.*
2. _____
3. _____
4. _____

2. The diagram to the right is the same as the diagram on page 4, except an inclusion was added. Color the intrusion red. **Step 5** in this formation would read as follows:



5. *Magma intrusion, solidification of magma, formation of igneous rock, contact metamorphism*

3. Drawing a sequence of events: Using the sedimentary rock map symbols on page 7 of the Earth Science Reference Tables draw the following sequence of events in the diagram box below. Remember in a sequence of events the formations that happened first are at the bottom.

a) deposition of mixed size particles, compaction and cementation, formation of conglomerate - on the bottom layer, *draw the symbol for conglomerate*

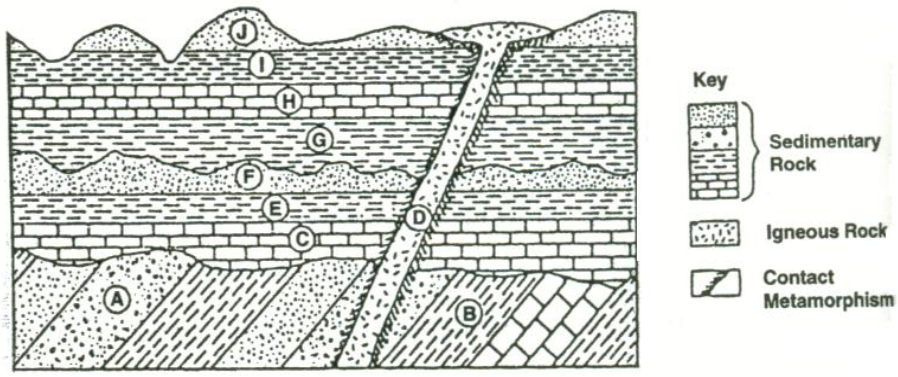
b) deposition of calcite, compaction and cementation, formation of limestone

c) deposition of clay, compaction and cementation, formation of shale

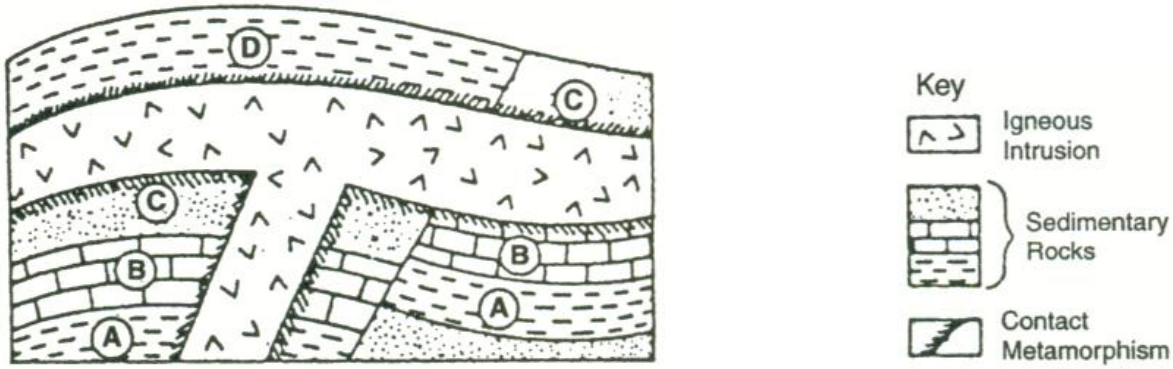
d) deposition of sand, compaction and cementation, formation of sandstone - *this should be the top layer*

4. Each box has a set of letters that are represented rock layers in the diagram below. Circle the letter that represents the <u>oldest</u> rock layer in the set. The first one has been done for you.

H (G)	E C
A B	J F
E D	D H
D J	A D
I C	I J
B C	B I
A F	E F



5. Use the diagram to the right and write the sequence of events. Use the ROCK NAMES not the letters in the diagram. Hint: the shale is NOT the oldest rock layer.



1) Deposition of _____, burial, compaction and cementation, _____
formation of _____
2) Deposition of _____, burial, compaction and cementation, _____
formation of _____
3) Deposition of _____, burial, _____,
formation of _____
4) Deposition of _____, burial, _____,
formation of _____
5) Deposition of _____, burial, _____,
formation of
6) _____ of rock layers
7) Intrusion of _____, solidification of _____,
formation of _____, _____ metamorphism
6) _____ of rock layers

Introduction:

In order for geologists to piece together past environments they need to determine how rock layers have formed. They use several methods such as the principle of superposition and law of uniformitarianism.

Objective:

- To draw two sequence of events

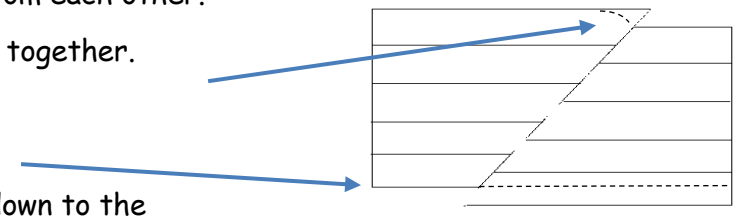
Procedure:

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

1. Use the map symbols in the Earth Science Reference tables when drawing the sedimentary rocks.
2. Use these symbols when drawing Granite:  or Basalt: 
3. Carefully remove the last page of this packet. It contains two separate sequence boxes.
4. Draw the following rock symbols to represent the layers on the first sequence diagram. Start drawing at the top of the diagram sequence box.

Sandstone, Limestone, Conglomerate, Shale, Granite

5. Color the granite layers *gray*, the shale layer *green*, the conglomerate *orange*, the limestone *blue*, the sandstone *purple.*
6. Completely cut out Sequence Box 1.
7. Turn the cut out Sequence Box over and cut carefully cut the diagonal.
8. Slide the right of the Sequence Box up along the cut out diagonal until the arrows are across from each other.
9. Along the diagonal, tape the two halves together.
10. Turn the taped Sequence Box over.
11. The top right has a point on it. Cut off the point so that it is diagonally down to the right.



12. Cut the bottom (Granite) of the sequence box straight across so that it is even.
13. Write the sequence of events in the space below. Remember to include how each layer formed, and the name of the layer. The fault was listed for you.

1) *Solidification of magma, formation of* _____

2) *Deposition of* _____ *, compaction and cementation, formation of* _____

3) _____

_____

4) _____

_____

5) _____

_____

6) _____ *of rock layers.*

14. Draw the following rock symbols to represent the layers on the second sequence diagram. Start drawing at the top of the diagram sequence box.

    Limestone, Siltstone, Dolostone, Shale, Conglomerate

15. Color the limestone layer *blue, s*iltstone *brown,* dolostone *gray*, the shale *green*, the conglomerate *orange*.
16. Completely cut out Sequence Box 2. Be careful not to cut the diagram below the box.
17. Turn the cut out Sequence Box over and cut carefully cut the diagonal.
18. Slide the right of the Sequence Box up along the cut out diagonal until the arrows are across from each other.
19. Along the diagonal, tape the two halves together.
20. Turn the taped Sequence Box over.
21. The top right has a point on it. Cut off the point so that it is diagonally down to the right.
22. Cut the bottom (conglomerate) of the sequence box straight across so that it is even.
23. The diagram at the bottom of the back of the page is an intrusion. Draw in the symbol for basalt throughout the diagram.
24. Color the intrusion red and then cut the diagram out.
25. Glue the intrusion onto the bottom center of the second sequence box.
26. With a black pen, draw in contact metamorphism.
27. Write the sequence of events in the space below. Remember to include how each layer formed, and the name of the layer.

1) _____

_____

2) _____

_____

3) _____

_____

4) _____

_____

5) _____

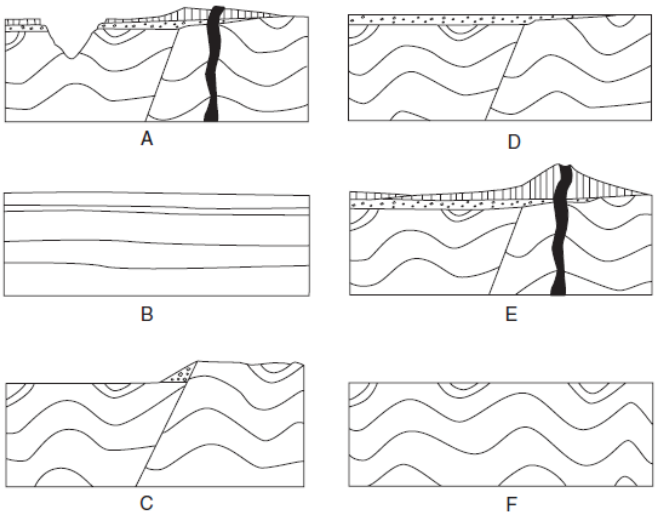
_____

6)

7)

Regents questions:

____1. Geologic cross sections *A* through *F* shown below represent different stages in the development of one part of Earth's crust over a long period of geologic time.



What is the correct order of development from the original (oldest) stage to the most recent (youngest) stage?

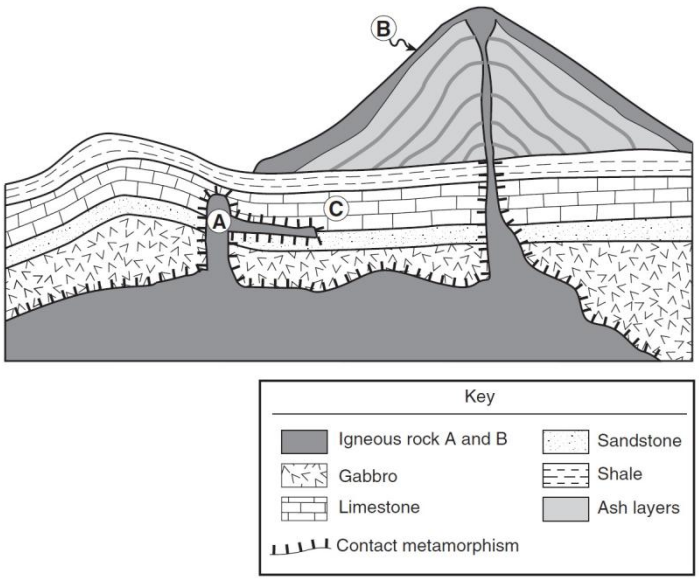
(1) *B* → *D* → *C* → *F* → *A* → *E*

(2) *B* → *F* → *C* → *D* → *E* → *A*

(3) *E* → *A* → *D* → *F* → *C* → *B*

(4) *E* → *A* → *F* → *C* → *D* → *B*

Base your answers to questions 2 and 3 on the geologic cross section to the right. The large cone-shaped mountain on Earth's surface is a volcano. Letters *A, B,* and *C* represent certain rocks.



____2. Rock *B* is most likely which type of igneous rock?

(1) granite (3) peridotite

(2) pegmatite (4) basalt

____3. Which statement correctly describes the relative ages of rocks *A* and *C* and gives the best supporting evidence from the cross section?

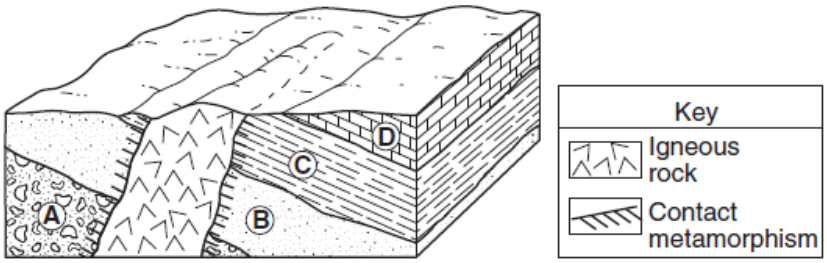
(1) *A* is younger than *C,* because *A* is a lower sedimentary rock layer.

(2) *A* is younger than *C,* because the intrusion of *A* metamorphosed part of rock layer *C.*

(3) *A* is older than *C,* because *A* has older index fossils.

(4) *A* is older than *C,* because the intrusion of *A* cuts across rock layer *C.*

Base your answers to questions 4 through 6 on the block diagram to the right, which shows a portion of Earth's crust. Letters *A, B, C,* and *D* indicate sedimentary layers.

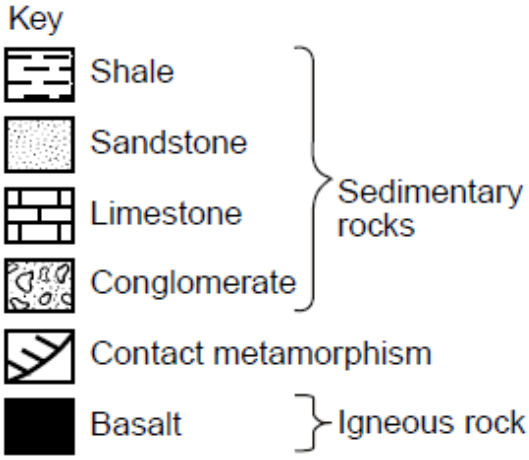


____4. Which event occurred most recently?
(1) formation of layer *A*
(2) formation of layer *D*
(3) tilting of all four sedimentary rock layers
(4) erosion of the igneous rock exposed at the surface

____5. The igneous rock is mostly composed of potassium feldspar and quartz crystals that have an average grain size of 3 millimeters. The igneous rock is most likely
(1) granite (2) gabbro (3) pegmatite (4) pumice

____6. Which processes produced rock layer *B*?
(1) subduction and melting (3) heat and pressure
(2) uplift and solidification (4) compaction and cementation

Base your answers to questions 7 through 11 on the diagram and information below.
The diagram shows a cross section of a portion of Earth's crust that has undergone geological processes. Overturning of rock layers has not occurred. Point *A* represents one location of metamorphic rock.



7. State *one* piece of evidence that indicates basalt is the youngest rock unit in the cross section.

_____

8. As magma cools, what process changes it into basalt? _____

9. State the name of the inorganic sedimentary rock shown in the cross section that is composed of sediment with the greatest range in particle size. _____

10. State the name of the rock, formed by contact metamorphism, located at *A*. _____

11. State *one* piece of evidence that shows that crustal uplift has occurred in this region. _____

Mini Lesson 2: Rock Correlation & Unconformities

There are several ways to correlate (match) rock strata (layers). The easiest way is called walking the outcrop. This is when you can physically walk along on outcrop and follow the rock strata. *An outcrop is any rock strata that are exposed at Earth's surface.* Most times rock strata are not continuously exposed; it may be hidden underneath soil or simply missing due to extreme erosion. In order to have a complete sequence of events, many layers of rock strata from several outcrops are compared because sometimes there are unconformities (missing rock layers). Unconformities are caused by extreme weathering and erosion (breakdown and movement of the rock). When a rock layer is missing in a sequence it does not mean it was never there, it means that some agent of erosion removed it.

Index fossils in the rock is another way to correlate outcrops. Index fossils are considered geologic time markers. Three things that make a good index fossil are that they are easily recognized, the specimen lived for a short amount of geologic time and they were wide spread geographically. A third time marker is volcanic ash falls. They are also geographically wide spread and can be matched to specific volcanic events.

Need to know:

1. What does the word correlation mean? _____
2. What is another name for rock strata? _____
3. What is "walking the outcrop"? _____

_____

4. What is an outcrop? _____
5. Why is it important to look at several outcrops in order to have a complete sequence of events?

_____

_____

6. What two other methods are used to correlate rock outcrops?

_____ and _____

7. List the three things that make a good index fossil.

_____

_____

_____

Introduction:

One of the way in which scientists can place the continents together is that the rocks and fossils across the oceans match. In this lab you will be looking at both rock types and index fossils to see if you can create an entire sequence of events.

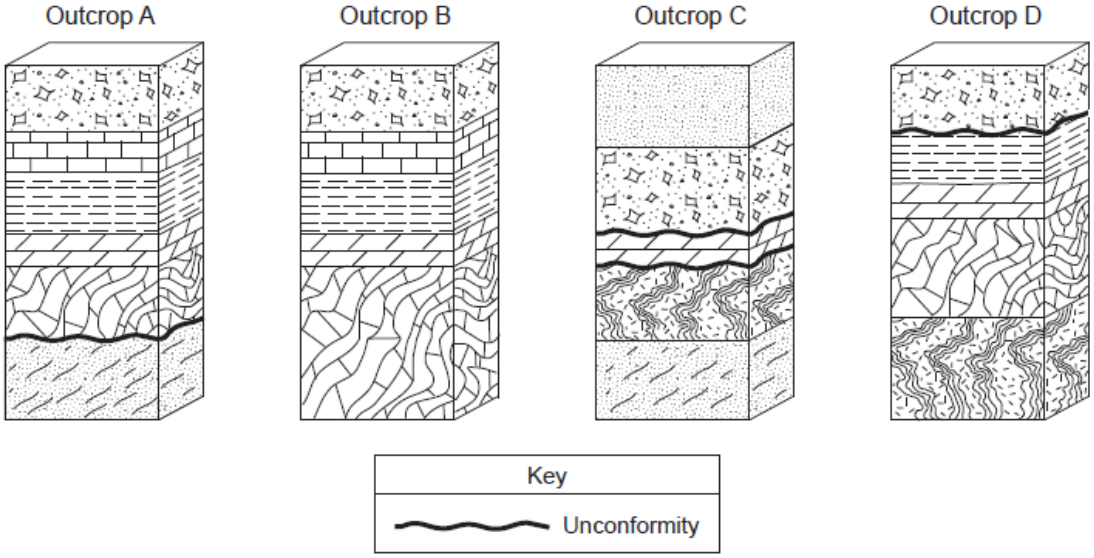
Materials
- ✓ ESRT's
- ✓ Scissors
- ✓ Glue stick

Objective:

- Construct a complete sequence of events by correlating rock outcrops

Procedure:

The diagrams below are of four rock outcrops, *A*, *B*, *C*, and *D,* located within 15 kilometers of each other. The rock layers have not been overturned,



1. Tear off the last page of this packet and carefully cut out each of the rock layers.
2. Find the rock layers that match Outcrop A in the diagram above.
3. Place the 6 cut out rock layers in order on your desk, according to Outcrop A. Leave a space to where the unconformity is. This indicates a rock layer is missing.
4. Look at Outcrop B. If there any layers that are in Outcrop B that are not in the sequence on your desk, add them to the sequence keeping the correct order. DO NOT take away any layers.
5. Look at Outcrop C. If there any layers that are in Outcrop C that are not in the sequence on your desk, add them to the sequence keeping the correct order. DO NOT take away any layers. *Hint: the layer that was missing in Outcrop A is located in Outcrop C.*
6. Look at Outcrop D. You have used all of your rock layers already. Make sure that if you go from top to bottom in the rock sequence for Outcrop D that they are in order. DO NOT take away any layers.
7. Glue the completed sequence in the space provided on page 13.
8. Using the rock symbols in the Earth Science Reference Tables on page 7, write the name of each rock layer to the right of each symbol.

✓ **Check Point**

Base your answers on the four outcrop diagrams on page 12

9. Find the unconformity in Outcrop A. Name the rock that is missing.

_____

10. There are two unconformities in Outcrop C. Name the two missing rock layers missing due to the erosion closest to the top of the outcrop.

_____

_____

Name the missing rock layer that is illustrated by the second unconfomity.

_____

11. Name the missing rock layer in Outcrop D.

_____

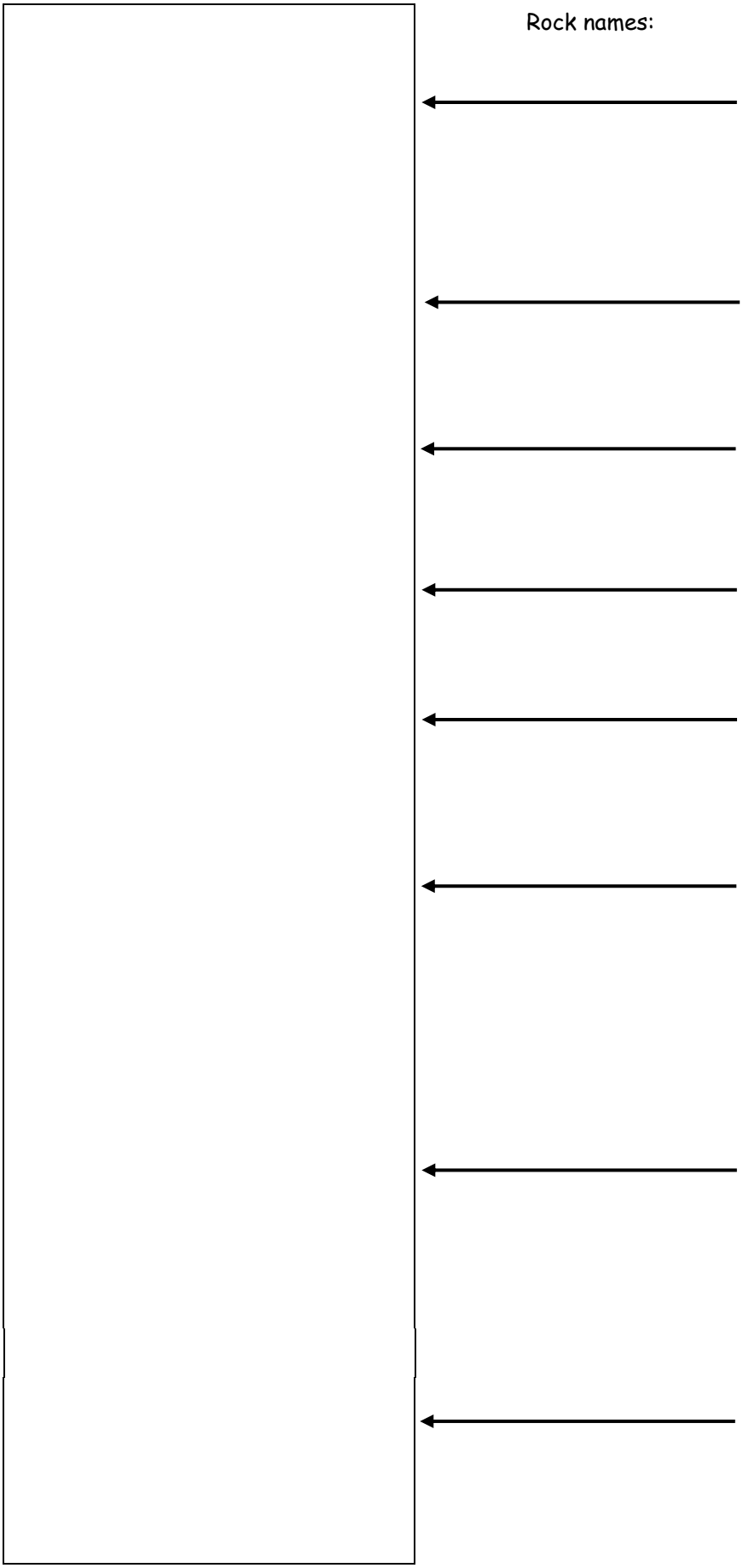
12. Explain why it is necessary to have more than one out-crop when determining the complete sequecnce of events.

_____

_____

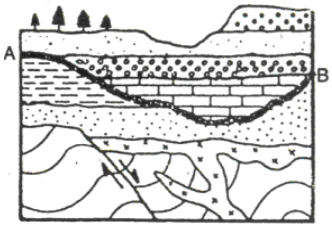
_____

_____



Regents Questions:

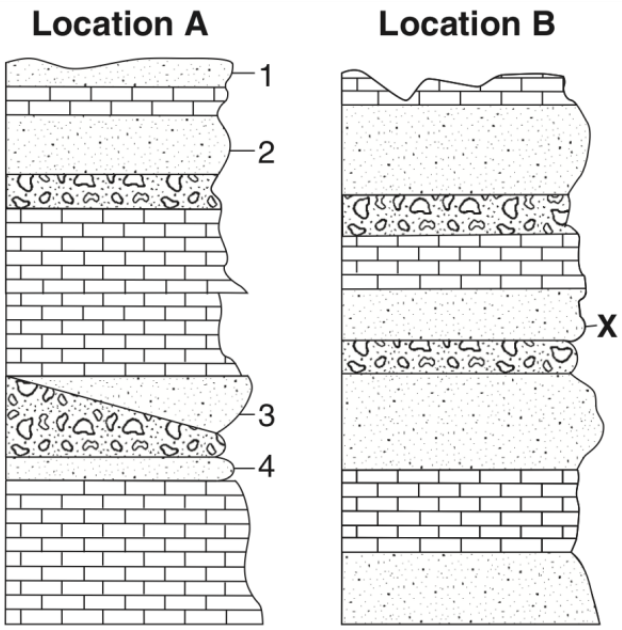
1. What **process** most directly caused the formation of the feature shown by line AB in the geologic cross section in the diagram to the right?



_____

What is the name given to this formation? _____

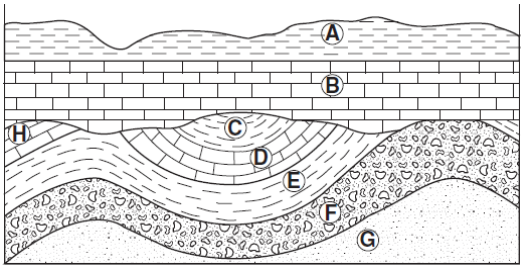
____2. The cross sections to the right show the surface bedrock in two different locations 20 miles apart. Rock layers are labeled 1, 2, 3, 4, and X. The rock layers have not been overturned. Rock layer X at location B is most likely the same relative age as which rock layer at location A?
(1) (2) (3) (4)



____3. Many parts of the rock record in New Your State are missing. These parts are most likely missing because of
(1) uplift and erosion
(2) subsidence and deposition
(3) earthquakes and volcanic activity
(4) folding and faulting

Base your answers to questions 4 through 6 on the geologic cross section below in which overturning has not occurred. Letters *A* through *H* represent rock layers.

____4. Which sequence of events most likely caused the unconformity (erosion) shown at the bottom of rock layer *B*?
(1) folding → uplift → erosion → deposition
(2) intrusion → erosion → folding → uplift
(3) erosion → folding → deposition → intrusion
(4) deposition → uplift → erosion → folding



____5. The folding of rock layers *G* through *C* was most likely caused by
(1) erosion of overlying sediments
(2) contact metamorphism
(3) the collision of lithospheric plates
(4) the extrusion of igneous rock

____6. Which two letters represent bedrock of the same age?
(1) *A* and *E* (2) *F* and *G* (3) *B* and *D* (4) *D* and *H*

Mini Lesson 3: Geologic Time Scale

Time, such as day and night, hour, minute or month is all based on the motions of Earth relative to the Sun, Moon and stars. When looking into geologic history, events are used as time markers. The appearance or mass extinction of organisms is the bases of the Geologic time scale. It is broken up into Eon's, Era's, Periods and Epochs. Pages 8 and 9 of the Earth Science Reference Tables shows this division of time and the events that our associated with it. It is arranged with the oldest rock layers (and events) on the bottom, and the youngest on top.

Up until the Phanerozoic Eon, most organisms did not have hard body parts or shells, and thus there is a limited amount of evidence of their existence. Once more complex life began to appear the fossil record started showing a more complete record of Earth's history. It is inferred that more complex life-forms evolved from less complex life-forms and that most life-forms that existed on Earth have become extinct.

Need to Know:

1. What is "time" of day and night, hour, minute or month based on? _____

_____

2. What is used as time markers when studying geologic history? _____
3. What is the division of the geologic time scale based on? _____

_____

4. What are the divisions of the geologic time scale? _____

_____

5. Where are the oldest events located on the geologic time scale? _____
6. Why were fossils difficult to find before the Phanerozoic Eon? _____

_____

7. What appeared to give scientist a more complete record of Earth's history? _____

_____

8. Where did more complex life forms come from? _____

_____

9. What do scientists believe happened to most life forms that existed on Earth? _____

_____

"Interpreting the Geologic History of New York State Chart" ESRT pg 8 & 9

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

1. Division of time is based on major events such as mass extinctions and explosions of life. The longest division of time is an Eon. Highlight the word Eon at the top of the table on page 8.
2. Eons are divided into Era's that are further divided into periods. Highlight the words "Era" and "Period" at the top of the table on page 8.
3. Finally, each period is divided into "Epochs". Highlight the word "Epoch".
4. Much of the rock record during the Precambrian has either been destroyed by some type of geologic process (weathering, erosion, rock cycle, crustal movement) or it is buried too deep under the surface that it has not yet been found. Organisms from that time are believed to be soft bodied and therefore the remains were not fossilized, so much of the evidence is missing.
5. Notice that the Precambrian Eon column in your reference tables is sub-divided into three columns. Color ONLY the very slim column (up and down) with the word "Precambrian" in it blue. Underneath the column you have just colored blue, label it "EON".
6. Color the Proterozoic section orange and the Archean section purple. Underneath that column label it "ERA".
7. The Proterozoic and Archean Eras are each divided into three periods; Late, Middle and Early. Under that column label it "PERIODS".
8. There are two places on the chart that have the age of occurrence. It is located under the "Eon" column and the Epoch column. Highlight "Million years ago" located **under each location** on the chart. Highlight each of the **numbers** underneath.
9. Look at the column for Eon's. What is the name of the Eon near the top of the table?
   _____ Highlight the line on the bottom of the this Eon all the way to through page 9. How long ago did this Eon begin? _____ million years ago
10. The section below this Eon is divided into three columns of its own. This is because they have *condensed* this Eon's information. The name that appears on the very left in this column is the Eon. What is the name of this Eon? _____
    How long ago did this Eon begin? _____ million years ago
11. The Precambrian Eon ended when the Phanerozoic Eon began.
    How long ago did this Eon end? _____ million years ago
12. In order to determine how long the Precambrian lasted, subtract the time it ended from the time it began. How long ago did this Eon last? _____ million years
13. Name the two Era's in the Precambrian.
    _____ and _____
14. Name the three Era's in the Phanerozoic Eon _____
    _____ and _____

15. Please note that each of the Era's in the Precambrian are further divided into three "Periods". Name these three sections (periods) for each Era.

_____ , _____ , _____

16. Geologic Eras at a quick glance: * *Remember to use BOTH time scales.*

a) When was the beginning of the Archean era? _____ million years ago

b) When was the end of the Archean era? _____ million years ago

c) How long did the Archean era last? _____ million years

d) When was the beginning of the Proterozoic era? _____ million years ago

e) When was the end of the Proterozoic era? _____ million years ago

f) How long did the Proterozoic era last? _____ million years

g) When was the beginning of the Paleozoic era? _____ million years ago

h) When was the end of the Paleozoic era? _____ million years ago

i) How long did the Paleozoic era last? _____ million years

j) When was the beginning of the Mesozoic era? _____ million years ago

k) When was the end of the Mesozoic era? _____ million years ago

l) How long did the Mesozoic era last? _____ million years

m) When was the beginning of the Cenozoic era? _____ million years ago

n) When was the end of the Cenozoic era? _____ million years ago * *(present day)*

o) How long did the Cenozoic era last so far? _____ million years

j) How many years ago is the estimated origin of Earth? _____ million years ago

k) In order to determine the pecentage of geologic time for an era, divide the length of the Era by the estimated origin of Earth.

$$\boldsymbol{percent\ of\ time = \frac{Length\ of\ Era}{time\ of\ origin}\ x\ 100}$$

Use the information above to fill in the table below. The Archean has been done for you.

Era	Beginning of Era (mya)	End of the Era (mya)	Length of the Era (million years)	% of total time nearest whole number
Archean	4600	2500	2100	46 %
Proterozoic				
Paleozoic				
Mesozoic				
Cenozoic				

l) Using the Pie chart to the right, graph and LABEL the percentages of each Era in the table above. The Archean Era has already been done.

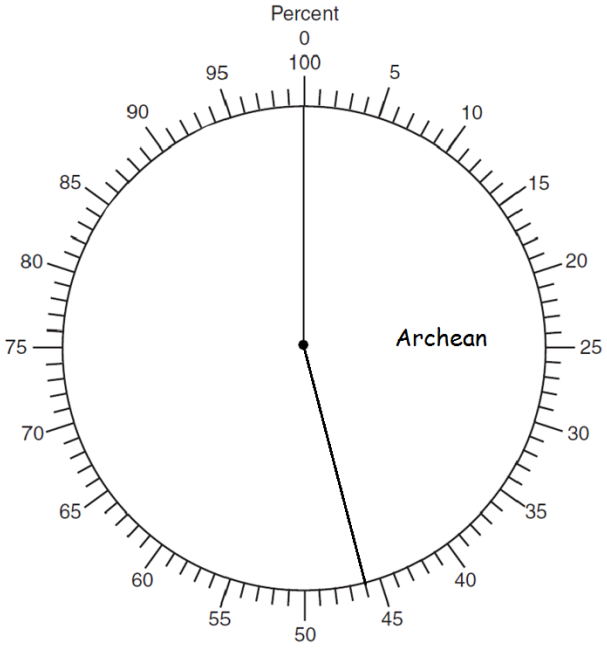
m) Shade in the entire Precambrian Eon in yellow.

n) Name the longest division on geologic time. Hint – its in yellow.

_____

o) How long did the Precambrian last?

_____ million years



17. The estimated time of origin of Earth and solar system occurred 4600 million years ago.
How many billion years ago is that? _____ billion years ago
Another way to say it is *Early Archean during the Precambrian Eon*.

18. What event occurred approximately 1000 million years ago? _____

_____

19. How many years ago did oceanic oxygen begin to enter the atmosphere? _____ mya
Another way to say it is _____ _____ _____
Epoch Period Era

20. What produced oceanic oxygen? _____

21. What did the combination of oceanic oxygen and iron form on the ocean floor?

_____

22. What was there evidence of 3750 million years ago? _____

23. What two things were found between Early and Middle Archean.

_____ & _____

24. Name the three Era's in the Phanerozoic Eon _____

_____ & _____

25. Using a highlighter, trace the line under the Cenozoic Era through each column. Line should end in the "Important Geologic Events in New York State" column on page 9.

26. How many million years ago did the Cenozoic begin? _____ million years ago

27. Write down the event that occurred at this division of time that is listed in the "Life on. Earth" column _____

_____

28. Using a highlighter, trace the line under the Mesozoic Era through each column. Line should end in the "Important Geologic Events in New York State" column on page 9.
29. How many million years ago did the Mesozoic begin? _____ million years ago
30. Write down the event that occurred at this division of time that is listed in the "Life on Earth" column. _____

_____

31. Using a highlighter, trace the line under the Paleozoic Era through each column. Line should end in the "Important Geologic Events in New York State" column on page 9.
32. How many million years ago did the Paleozoic begin? _____ million years ago
33. Write down the event that occurred at this division of time that is listed in the "Life on Earth" column. _____

_____

34. The division of Geologic time is primarily based on mass extinctions or new life forms. _____ provide evidence of this.
35. Name the three periods in the Cenozoic Era. _____

_____ & _____
36. Which period in the Cenozoic is the oldest? _____
37. Name the three periods in the Mesozoic Era. _____

_____ & _____
38. Which period in the Mesozoic is the youngest? _____
39. Name the six periods in the Paleozoic Era.

_____ & _____

_____ & _____

_____ & _____
40. Name the two divisions in the Carboniferous Period.

_____ & _____

41. The "Life on Earth" column lists the appearance and / or extinction of some of the organisms on Earth that existed at a particular time. Name the Epoch and Period for each of the following examples of Life on Earth.

	Period	Epoch
a) Earth's first forest		
b) earliest insects		
c) diverse bony fishes		
d) earliest fish		
e) mammal-like reptiles		
f) humans, mammoths		
g) earliest trilobites		
h) abundant eurypterids		
i) first coral reefs		

42. The "Important Geologic Events in New York" column gives some examples of events that have helped shape New York, oceans and landmasses. Name the Epoch and Period for each of the Important Geologic Events in New York.

	Period	Epoch
a) Catskill delta forms		
b) Uplift of Adirondack region begins		
c) Queenston delta forms		
d) Initial opening of the Atlantic Ocean		
e) Pangea begins to break up		
f) Alleghenian orgeny		
h) Erosion of Grenville Mountains		
g) Salt and Gypsum deposited in evaporite basins		

43. Find the four pictures of mountains in the Important Geologic Events in New York column. What is the **bolded** word next to each picture?

44. Name the word that is associated with mountain building. _____

Introduction:

The Phanerozoic Eon began approximately 542 million years ago. It is divided into three Eras and 13 Periods based on fossil evidence.

Materials
- ✓ ESRT's
- ✓ Scissors
- ✓ Glue stick

Objective:

- Graph the percentage of time for each Period in the Phanerozoic Eon.

Procedure:

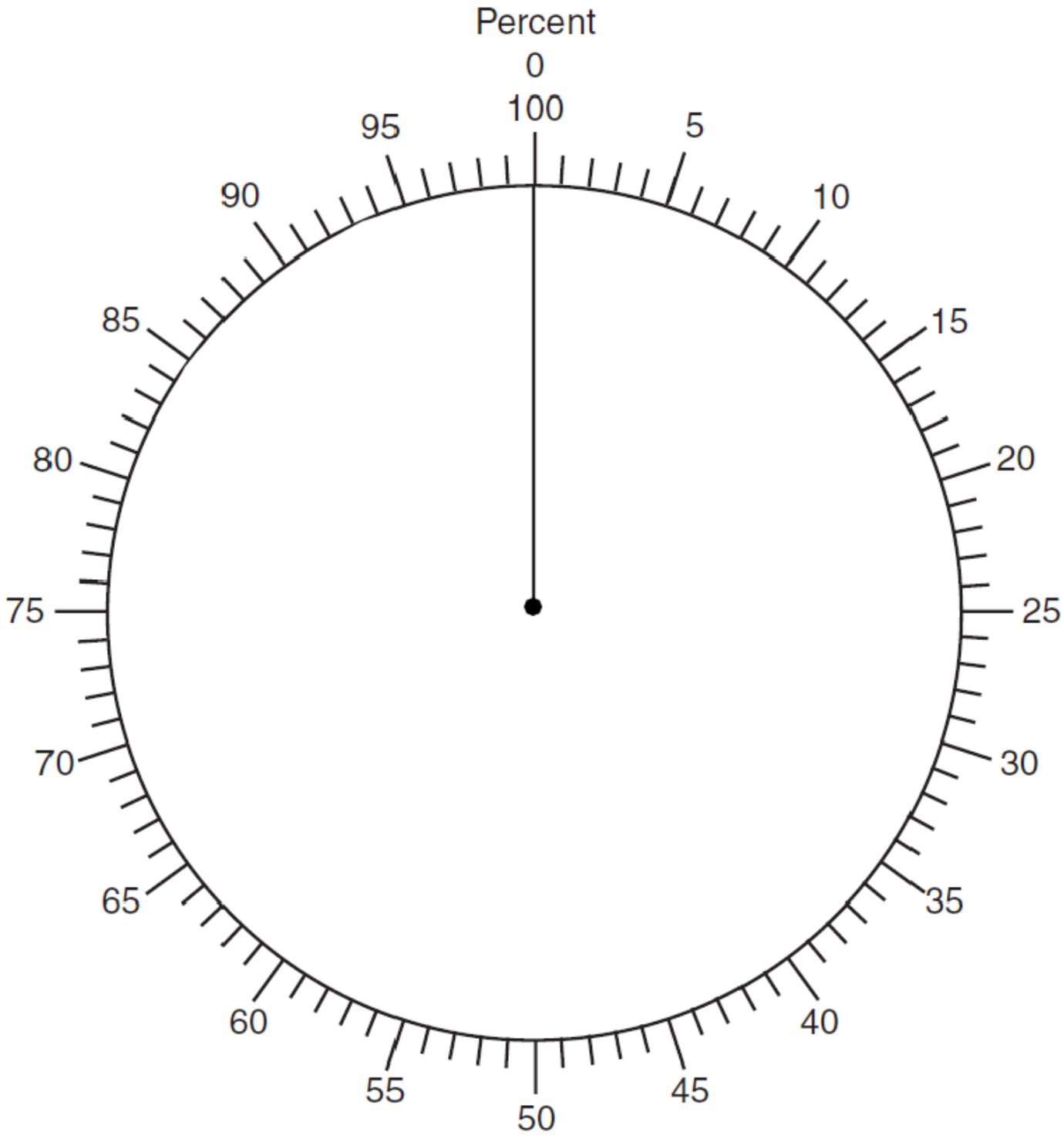
1. Use the information from page 8 of the Earth Science Reference Tables to determine the divisions of time in the table below. *REMEMBER*: In order to determine the pecentage of geologic time for an period, divide the length of the Period by the estimated lenth of time of the Phanerozoc.

$$percent\ of\ time = \frac{Length\ of\ Period}{Lengh\ of\ Phanerozoic}\ x\ 100$$

How long did the Phanerozoic last? _____ millions of years

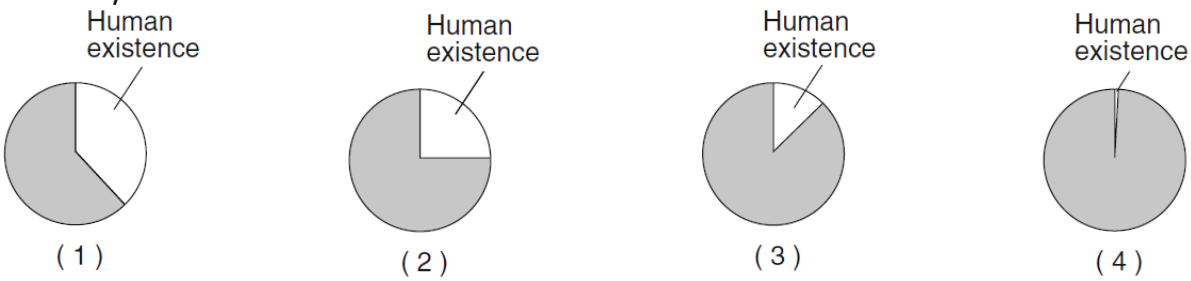
Era	Beginning of Period (mya)	End of Period (mya)	Length of Period (million years)	% of total time nearest tenth
Quarternary	1.8	0	1.8	.3 %
Neogene				
Paleogene				
Cretaceous				
Jurassic				
Triassic				
Permian				
Pennsylvanian				
Mississippian				
Devonian				
Silurian				
Ordovician				
Cambrian				

2. Using the pie chart provided on page 23 and graph the amount of time for each Period.
3. Label each of the periods from the table above.
4. Remove the last page of the packet and cut out each of the "Life events" on the page and glue the corresponding events onto the diagram.


Percent
0
100
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95

Regents Questions:

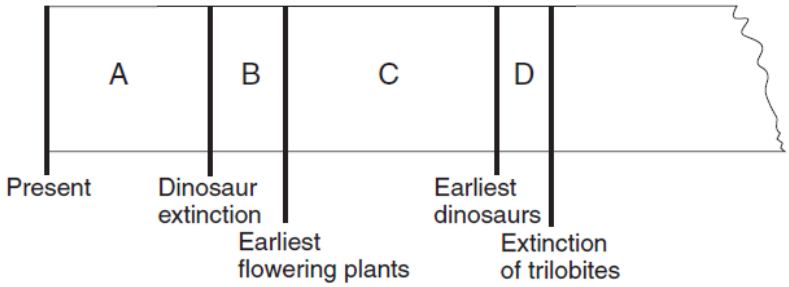
_____1. Which graph best represents human existence on Earth, compared with Earth's entire history?



_____2. The diagram below is a portion of a geologic time line. Letters *A* through *D* represent the time intervals between the labeled events, as estimated by some scientists

Fossil evidence indicates that the earliest birds developed during which time interval?

(1) A (3) C
(2) B (4) D



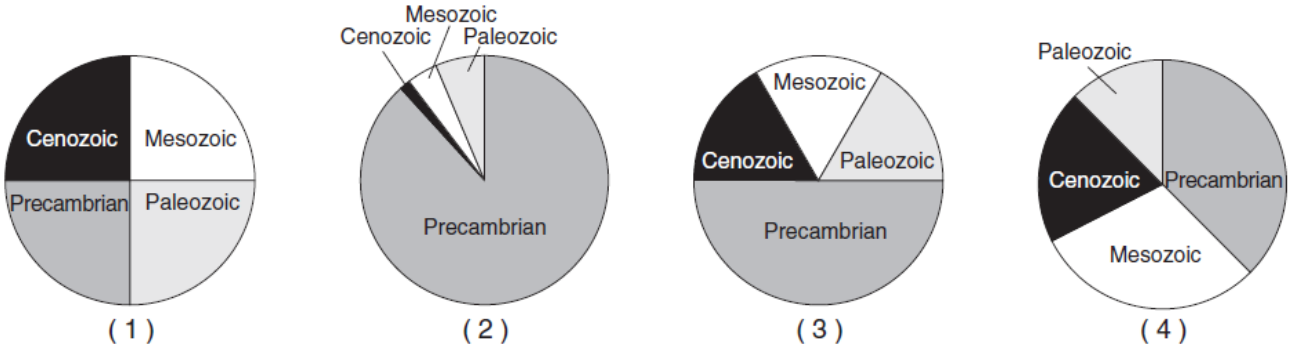
_____3. During which geologic time period did the earliest reptiles and great coal-forming forests exist?

(1) Devonian (2) Mississippian (3) Quaternary (4) Pennsylvanian

_____4. According to plate tectonic theory, during which geologic time interval did the continents of North America and Africa separate, resulting in the initial opening of the Atlantic Ocean?

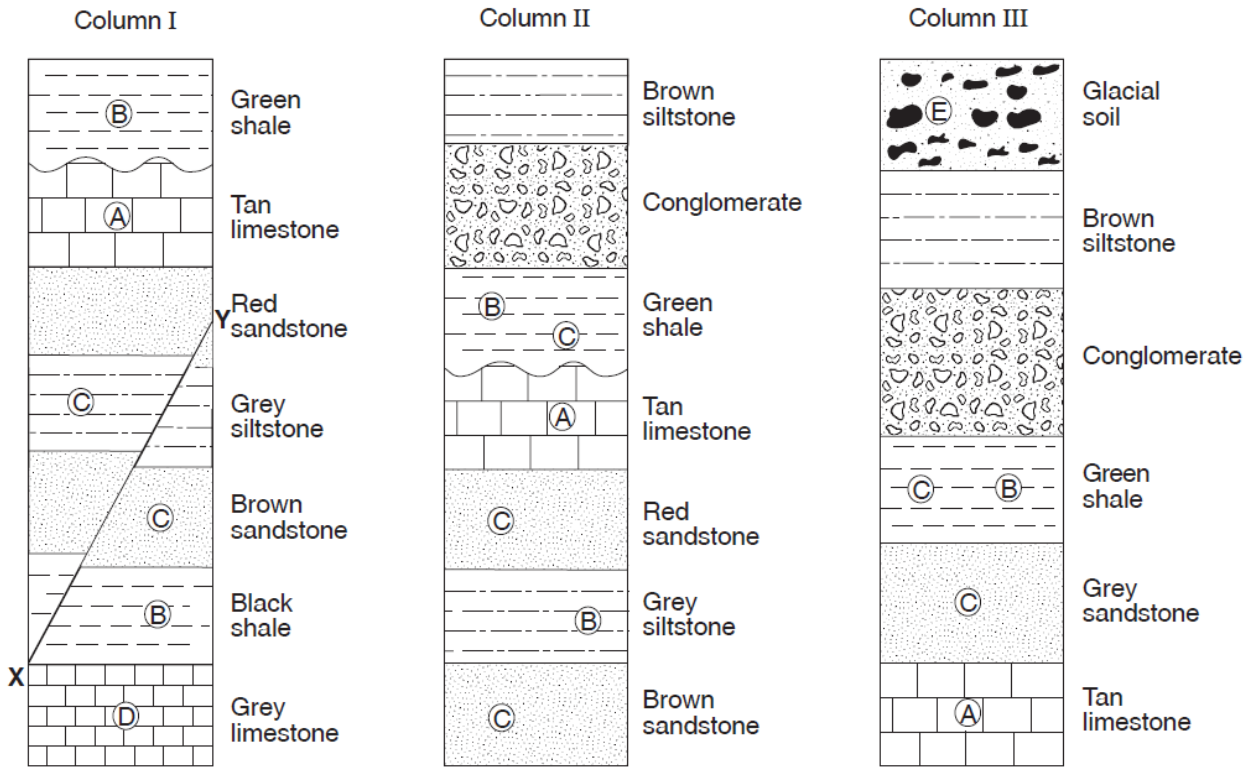
(1) Mesozoic Era
(2) Paleozoic Era
(3) Proterozoic Eon
(4) Archean Eon

_____5. Which graph shows the relative duration of geologic time for the Precambrian, Paleozoic, Mesozoic, and Cenozoic time intervals?



Base your answer to questions 6 through 10 on the diagram below which shows three geologic columns representing widely separated rock outcrops. Letters A through E represent fossils found in the outcrops. Line XY represents a fault in column I. The layers have not been overturned.

Rock Outcrops



_____6. What is the oldest layer shown?

(1) glacial soil (2) brown sandstone (3) grey limestone (4) tan limestone

_____7. When did fault XY, located in column I, most likely occur?

(1) before the formation of the grey limestone
(2) during the formation of the grey siltstone
(3) during the formation of the black shale
(4) after the formation of the red sandstone

_____8. Which rock would most likely be produced by the metamorphism of the grey limestone?

(1) quartzite (2) slate (3) marble (4) gneiss

_____9. The wavy line located between the green shale and the tan limestone layers in columns I and II most likely represents

(1) contact metamorphism
(2) a volcanic ash layer
(3) a buried erosion surface
(4) an igneous intrusion

_____10. Fossil A, in the tan limestone layer, is a fossil of the first known coral. This tan limestone layer was most likely deposited during which geologic time interval.

(1) Precambrian (2) Paleozoic (3) Mesozoic (4) Cenozoic

Interpreting the Geologic History of New York State Chart. ESRT pg 9

1. Index fossils are listed on the bottom of pages 8 and 9 in the Earth Science Reference Tables. Highlight the names of these fossils below each illustration.

2. Each index fossil has a letter associated with it. Notice these same letters appear in the chart on page 9 in the column labeled "Time Distribution of Fossils". Each letter is also associated with a specific organism, example trilobites, ammonoids, etc. Highlight the general name for the organism.

3. List the names of the fossils associated with each of the following:

Trilobites
(1) _____
(2) _____
(3) _____

Eurypterids
(1) _____
(2) _____

Graptolites
(1) _____
(2) _____

Nautiloids
(1) _____
(2) _____
(3) _____

Ammonoids
(1) _____

Crinoids
(1) _____
(2) _____

Placoderm Fish
(1) _____

Mammals
(1) _____
(2) _____

Corals
(1) _____
(2) _____
(3) _____

Gastropods
(1) _____
(2) _____

Brachiopods
(1) _____
(2) _____

Vascular Plants
(1) _____
(2) _____
(_____)

Birds
(1) _____

Dinosaurs
(1) _____

4. List the three characteristics of an index fossil

_____

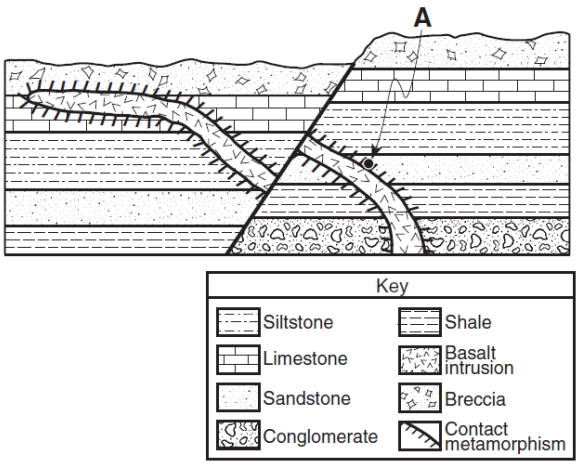
_____

_____

Regents Questions:

Base your answers to questions 1 through 5 on the geologic cross section below. The rock layers have not been overturned. Point *A* is located in the zone of contact Metamorphism.

1. Which metamorphic rock most likely formed at point *A*? _____



2. State the evidence shown by the cross section that supports the inference that the fault is younger than the basalt intrusion.

_____

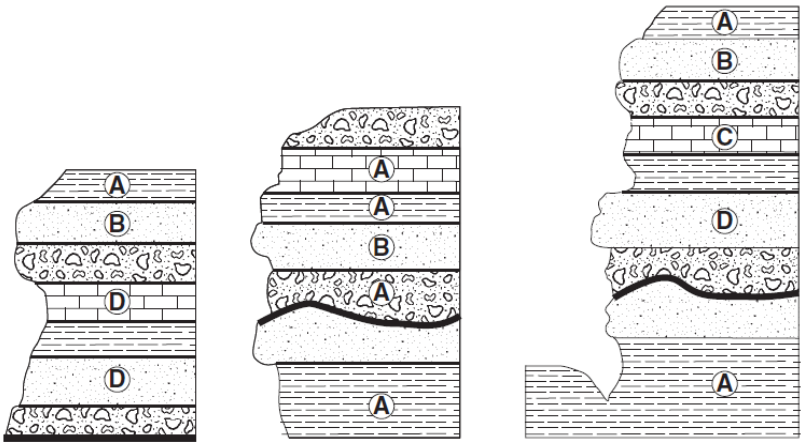
_____

3. List basalt, limestone, and breccia in the order in which they were formed.

_____ , _____ , _____

4. What is the largest silt particle that could be found in the siltstone layer? _____

5. The cross sections below represent three widely separated outcrops of exposed bedrock. Letters *A, B, C,* and *D* represent fossils found in the rock layers.



Which fossil appears to have the best characteristics of an index fossil?
(1) *A* (2) *B* (3) *C* (4) *D*

Explain your reasoning. _____

_____

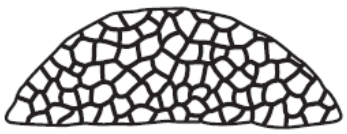
____6. The diagram to the right shows a fossil found in the surface bedrock of New York State.
Which other fossil is most likely to be found in the same age bedrock

(1) Phacops (3) Coelophysis
(2) Condor (4) Tetragraptus

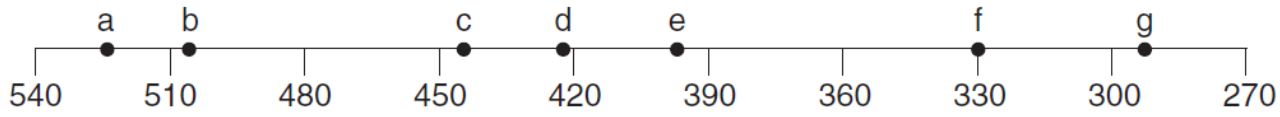
Centroceras

Base your answers to questions 7 through 10 on the geologic time line shown below. Letters *a* through *g* on the time line indicate specific reference points in geologic time.

7. Place an **X** on the geologic time line *below,* so that the center of the **X** shows the time that the coral index fossil *Lichenaria* shown to the right existed on Earth.



Geologic Time Line (millions of years ago)



8. Letter "*a*" indicates a specific time during which geologic period? _____

9. Identify the mountain building event (orogeny) that was occurring in eastern North America at the time represented by letter *g.* _____

10. Identify *one* letter that indicates a time for which there is no rock record in New York State. _____

____11. The drawing to the right shows an artist's view of the dinosaur, based on the fossilized remains. During which period of geologic time have paleontologists inferred that the feathered dinosaur mentioned in the passage existed?

(1) Cambrian (3) Paleogene
(2) Cretaceous (4) Permian

Base your answers to questions 12 through 14 on the table of index fossils shown to the right and on your knowledge of Earth science.

Table of Index Fossils

Eospirifer

Manticoceras

Phacops

12. During what geologic time period did the oldest index fossil shown in this table exist? _____

13. State *one* characteristic of a good index fossil. _____

14. Complete the classification table *below* by filling in the general fossil group name for *each* index fossil.

Fossil Classification

Index Fossil	Eospirifer	Manticoceras	Phacops
General Fossil Group			

____15. During which geologic time interval could this bedrock layer have formed? Fossils of trilobites, graptolites, and eurypterids are found in the same bedrock layer in New York State.

(1) Late Ordovician to Early Devonian
(2) Late Silurian to Early Cretaceous
(3) Early Permian to Late Jurassic
(4) Early Cambrian to Middle Ordovician

____16. The diagram to the right represents a rock sample containing fossilized Coelophysis footprints. According to current knowledge of New York State fossils, during which geologic time period were these footprints most probably made?

(1) Cambrian
(2) Devonian
(3) Tertiary
(4) Triassic

"Interpreting the Generalized Bedrock Geology of NY State Map" ESRT pg 3
& "Geologic History of New York State Chart" ESRT pg 8

The graph below shows the water velocity needed keep different sized particles moving in a stream. This same graph is in your Earth Science Reference tables. Four thin lines have been added to illustrate the increase in particle size able to be transported.

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

1. Below is a copy of a section of the Table on page 8 of your Earth Science Reference Tables.

2. Turn to page 3 in the Earth Science Reference Tables.

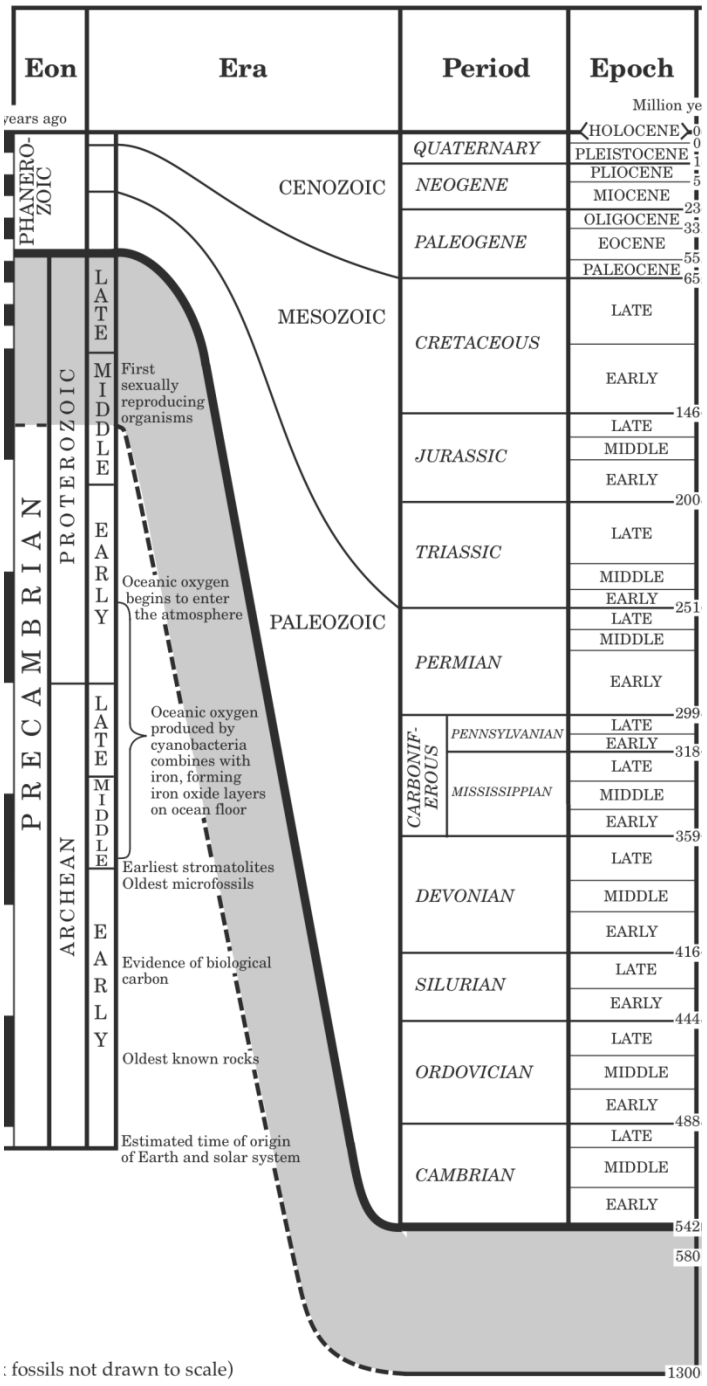
3. Look at the bottom left side of the page under "Geologic Periods and Eras in New York State".

4. Read each piece of information carefully and any periods and eras or epochs that are mentioned, highlight them on the table to the right, beginning with Cretaceous.

5. Turn to page 8 in the Earth Science Reference Tables and highlight the names there as well.

6. Look under the column labeled "NY Rock Record". If the section has some kind of shading in it, it means that the rock record is there. If it is blank, it means it is not present in New York State.

7. Is there a connection between the times you highlighted (Periods, Eras, Epochs) and the rocks that are present in New York State. _____



8. The rock record is complete for the Pleistocene Epoch. The entire section is shaded in.

   Is the rock record for that epoch sediment or bedrock? _____

9. Name the four periods where the rock layer is complete. _____

   _____ , _____ , _____

10. Name three periods that have absolutely no rock record in New York State.

    _____ , _____ , _____

11. An unconformity (missing rock record) occurs when there extreme erosion. Both the Neogene and Paleogene periods have no rock record. Look to the far right of the table on pages 8 and 9 of the reference tables and read the event description at the very top. What caused the rock record during those two periods to go missing?

    _____

12. There are different ways to state of age of rocks. You can either name the era, period, or epoch or state the age in millions of years. For example, how old is the Allegheny

    Plateau? _____ or _____ million years old
    name on key between … and …

13. Determine the age of each of the following regions or locations in New York State.

    Watertown _____ or _____ million years old

    St. Lawrence Lowlands _____ or _____ million years old

    Old Forge _____ or _____ million years old

    Syracuse _____ or _____ million years old

14. Name three index fossils that may be found Elmira, NY. *(there are more than three)*

    _____ , _____ , _____

15. Why is it unlikely that any index fossils will be found in the Adirondack Mountains.?

    _____

ONE MORE SECTION

16. Look at the column labeled "Inferred Positions of Earth's Landmasses". These illustrations show the inferred movement of the landmasses throughout geologic time.

    What continent is shaded in dark black _____

17. In which compass direction has North America moved throughout time? _____

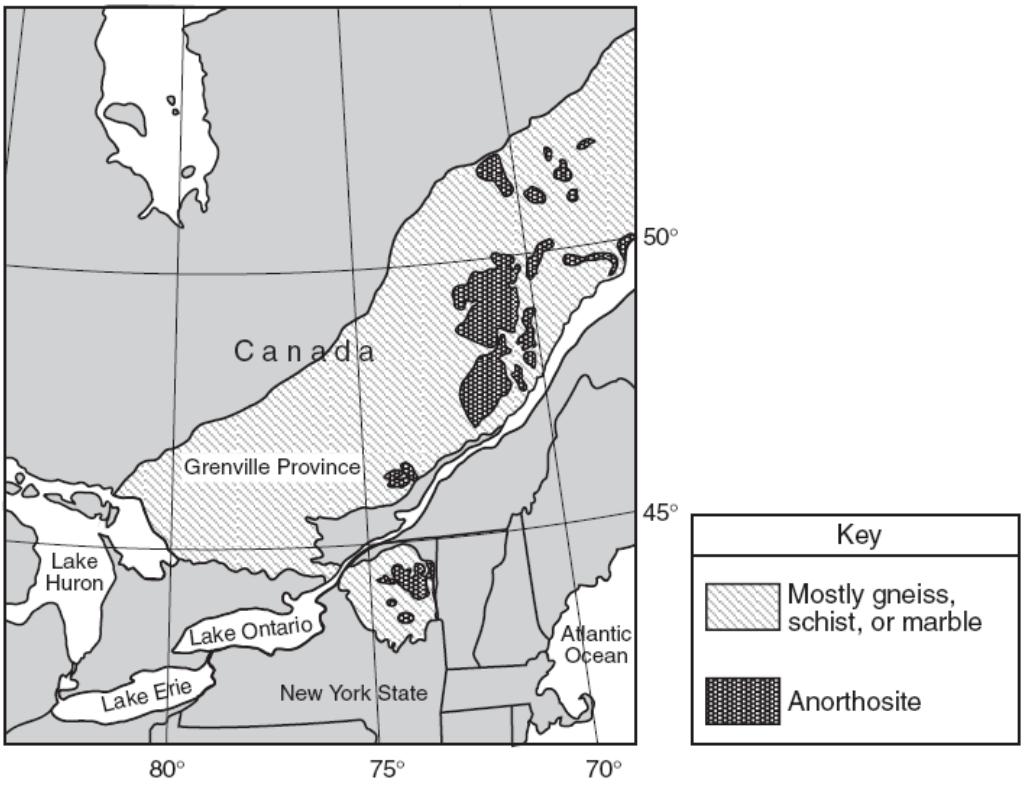
18. Where was North America located 458 million years ago? _____

19. In what hemisphere was most of the land mass 458 million years ago? _____

20. In what hemisphere was most of the land mass 59 million years ago? _____

Regents Questions:

Base your answers to questions 1 through 3 on the map below. The map shows some regions where metamorphic bedrock of the Grenville Province in northeastern North America is exposed at Earth's surface.



____1. The bedrock of the Grenville Province is generally thought to have formed approximately
(1) 250 million years ago (3) 560 million years ago
(2) 400 million years ago (4) 1100 million years ago

____2. Which New York State location has surface bedrock that consists mainly of anorthositic rock?
(1) Old Forge (2) Massena (3) Mt. Marcy (4) Utica

____3. Which location has surface bedrock that consists mostly of gneiss, schist, or marble?
(1) 43° N 81° W (2) 47° N 69° W (3) 46° N 78° W (4) 49° N 71° W

____4. The presence of which index fossil in the surface bedrock most likely indicates that a forest environment once existed in the region?
(1) *Aneurophyton* (2) *Centroceras* (3) *Cystiphyllum* (4) *Bothriolepis*

The diagram below shows an index fossil found in surface bedrock in some parts of New York State. In which New York State landscape region is this gastropod fossil most likely found in the surface bedrock?


Maclurites

(1) Tug Hill Plateau (3) Adirondack Mountains
(2) Allegheny Plateau (4) Newark Lowlands

Mini Lesson 3: Absolute Time

Absolute time is usually determined by radioactive dating. Certain rocks contain radioactive isotopes (unstable elements). Over time the isotopes stabilize into a new element known as the decay product. It takes a specific amount of time for $\frac{1}{2}$ of the original isotope to change into the decay product. This is known as one half-life. A half –life is the amount of time required for one half of the isotope to disintegrate into its decay product. Since nothing affects the decay rate of these isotopes, scientists can determine the age of a rock by comparing the amount of decay product with the amount of original isotope found in the rock. The absolute age of a specimen (fossil) or rock is used to help place things in relative order on a time scale.

Certain isotopes are used to date specific materials. Carbon-14 isotopes, for example, are used to determine the approximate age of most organic material such as wood, charcoal, animals, etc. When these organisms die the Carbon-14 begins to decay into Nitrogen-14. They cannot be used to date material older because the half-life of Carbon-14 is too short, only 5,700 years. Uranium-238 can be used to date rocks as old as Earth (4.5 billion years old), because it has a very long half life.

Need to know:

1. How is absolute time determined? _____
2. What are radioactive isotopes? _____
3. What is the stabilized isotope called? _____
4. What is a half life? _____

   _____
5. What do scientists compare in order to determine the age of a rock? _____

   _____
6. Which isotope is used to date organic materials? _____
7. Which isotope can be used to date rocks as old as Earth? _____
8. Why can't Carbon-14 be used to determine the age of a fossil of a dinosaur? _____

   _____
9. Why can't Uranium-238 be used to determine the age of a fossil of a dinosaur? _____

   _____

"Interpreting the Radioactive Decay Data Chart" ESRT front page

- Look at the "Radioactive Decay Data" table on the front page of the Earth Science Reference Tables. The decay product is the element that the unstable isotope becomes when it stabilizes. These are listed in the disintegration column of the table.

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

1. What is the decay product for (^{14}C) ? _____
2. How long does it take for one half of the element to decay? (half-life) _____ years
3. What are the two decay product for (^{40}K) ? _____ and _____

   How long does it take for one half of the element to decay? (half-life) _____ years
4. What is the decay product for (^{238}U) ? _____

   How long does it take for one half of the element to decay? (half-life) _____ years
5. What is the decay product for (^{87}Rb) ? _____

   How long does it take for one half of the element to decay? (half-life) _____ years
6. Which element has the shortest half-life? _____
7. An element with a short half-life is used to date (younger or older) rocks and fossils?
8. Which element has the longest half-life? _____
9. An element with a long half-life is used to date (younger or older) rocks and fossils?
10. To determine the age of a rock you need to determine how many half-lives an isotope has undergone. In this example you will use Carbon-14. It has a half-life of 5.7×10^3 years. This means it takes 5.7×10^3 years to go through 1 half-life.

    (a) What is another way to write 5.7×10^3 years? _____ years

    (b) How many years does it take to go through 1 half-life? _____ years

    (c) How many years does it take to go through 2 half-lives? _____ years

    (d) How many years does it take to go through 3 half-lives? _____ years

    (e) How many years does it take to go through 4 half-lives? _____ years
11. To determine how many half-lives an isotope has undergone, you need to divide the age by the number of years in one half-life. In this example you will use Potassium-40. It has a half-life of 1.3×10^9 years. This means it takes 1.3×10^9 years to go through 1 half-life.

    (a) How many half-lives did a sample go through if it is 2.6×10^9 years old? _____

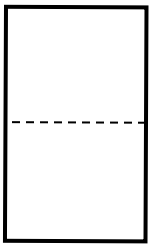
    (b) How many half-lives did a sample go through if it is 3.9×10^9 years old? _____

    (c) How many half-lives did a sample go through if it is 6.5×10^9 years old? _____

    (d) How many half-lives did a sample go through if it is 1.3×10^9 years old? _____

    (e) How many half-lives did a sample go through if it is 5.2×10^9 years old? _____

Procedure A: Half-lives and Fractions



1. Take a full sheet of paper. This represents the unstable isotope, Carbon -14. Fold the paper in half one way then turn the paper over and refold it along the same crease. Carefully rip the paper in half along the crease. This represents one (1) half life. One piece represents the unstable isotope (Carbon-14) and the other half represents the decay product (N-14). Label 1 half "N-14" and set it aside.

    a) What fraction represents the amount of C-14 after one half life? _____

    - What is the percent of C-14 remaining after one half life? _____ %

    b) What fraction represents the amount of N-14 after one half life? _____

    - What is the percent of N-14 remaining after one half life? _____ %

2. Take the half that represents the parent isotope, C-14 and cut it in half. Label one half "N-14" (the decay product) and set it aside.

    a) What fraction represents the amount of C-14 after two half lives? _____

    - What is the percent of C-14 remaining after two half lives? _____ %

    b) What fraction represents the amount of N-14 after two half lives? _____

    - What is the percent of N-14 remaining after two half lives? _____ %

3. Take the half that represents the parent isotope, C-14 and cut it in half. Label one half "N-14" (the decay product) and set it aside.

    a) What fraction represents the amount of C-14 after three half lives? _____

    - What is the percent of C-14 remaining after three half lives? _____ %

    b) What fraction represents the amount of N-14 after three half lives? _____

    - What is the percent of N-14 remaining after three half lives? _____ %

4. Take the half that represents the parent isotope, C-14 and cut it in half. Label one half "N-14" (the decay product) and set it aside.

    a) What fraction represents the amount of C-14 after four half lives? _____

    - What is the percent of C-14 remaining after four half lives? _____ %

    b) What fraction represents the amount of N-14 after four half lives? _____

    - What is the percent of N-14 remaining after four half lives? _____ %

5. Take the half that represents the parent isotope, C-14 and cut it in half. Label one half "N-14" (the decay product) and set it aside.

   a) What fraction represents the amount of C-14 after five half lives? _____

   - What is the percent of C-14 remaining after five half lives? _____ %

   b) What fraction represents the amount of N-14 after five half lives? _____

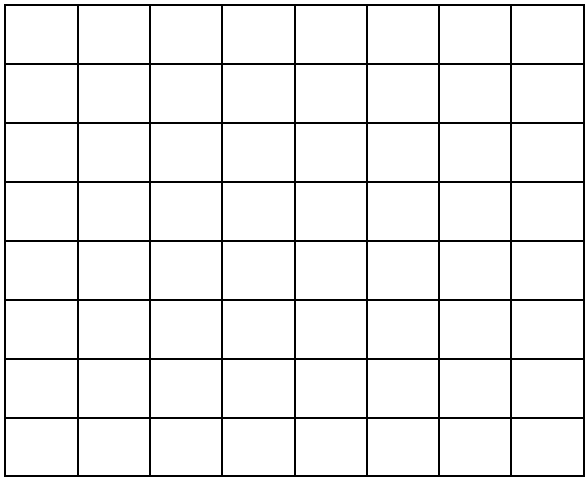
   - What is the percent of N-14 remaining after five half lives? _____ %

Procedure B: Completing Charts and Graphs

1. Fill in the "Number of Years" column in the table below. We are going to use Carbon-14 as our example. 1 half-life has been done for you. Multiply the time for 1 half-life by the number of half-lives.

Number of half-lives	Number of years	Parent Isotope		Decay Product	
		Number	Percent	Number	Percent
0	0	64	100%	0	0 %
1	5,700				
2					
3					
4					
5					
6					

2. How many total boxes are in the diagram to the right? ____



   (a) Using a color pencil, shade in $\frac{1}{2}$ of the boxes in the diagram to the right to illustrate 1 half-life.

   - How many boxes are still not colored in? Write that number in the table above in the column labeled **Parent Isotope** in the 1 half-life row.
   - Write down the percentage that is still the parent isotope in the table above.
   - How many boxes did you color in? Write that number in the table above in the column labeled Decay Product.
   - Write down the percentage that is now the Decay Product.

(b) Using a different color pencil, shade in ½ of the uncolored boxes in the diagram to the above to illustrate the second half-life.

- How many boxes are still not colored in? Write that number in the table on page 35 in the column labeled **Parent Isotope** in the 2 half-life row.
- Write down the percentage that is still the parent isotope in the table above.
- How many total boxes are colored in? Write that number in the table above in the column labeled Decay Product.
- Write down the percentage that is now the Decay Product.

(c) Using a different color pencil, shade in ½ of the uncolored boxes in the diagram to the above to illustrate the second half-life.

- How many boxes are still not colored in? Write that number in the table on page 35 in the column labeled **Parent Isotope** in the 3 half-life row.
- Write down the percentage that is still the parent isotope in the table above.
- How many total boxes are colored in? Write that number in the table above in the column labeled Decay Product.
- Write down the percentage that is now the Decay Product.

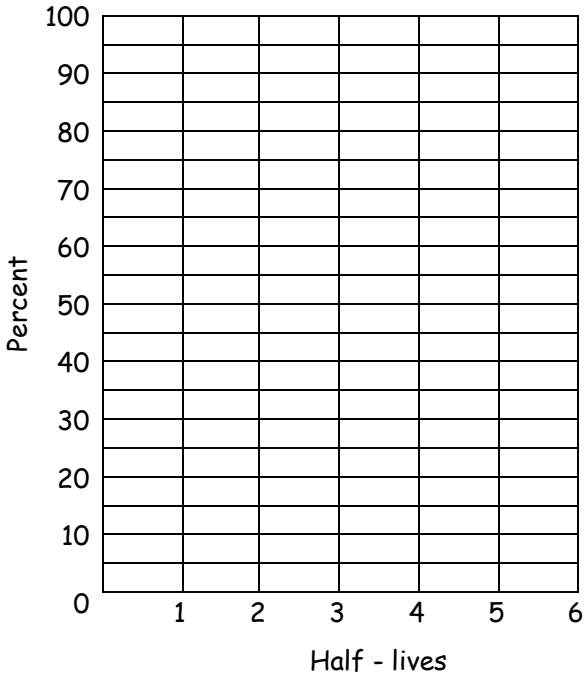
(d) Continue this process until there is only one empty box left.

3. Using the columns labeled "Number of half-lives " and "Percent" under PARENT isotope, place a dot for each value. For example at number of half-lives is zero, percent of parent isotope is 100%. Connect the dots with a smooth line.

4. Using the columns labeled "Number of half-lives " and "Percent" under DECAY PRODUCT, place a dot for each value. For example at number of half-lives is zero, percent of decay produce is 0%. Connect the dots with a smooth line.

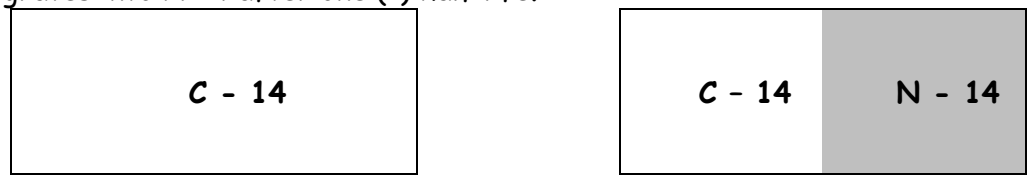
5. What do you observe is happening to the amount of parent isotopes as the decay product increases?

_____



Regents Questions:

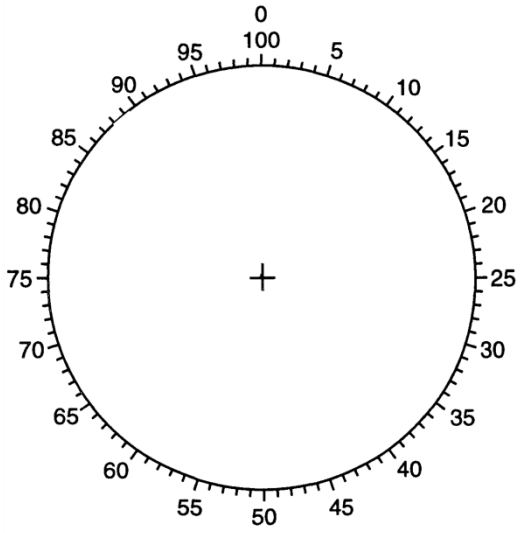
1. The box below represents the unstable element C-14. The box next to it illustrates how much C-14 disintegrates into N-14 after one (1) half life.



In the boxes below, shade in the correct proportion of N-14 to its parent isotope, C-14, after two and then three half-lives. Label both the sections that are C-14 and N-14 in each diagram.

Two half lives **Three half lives**

2. In the pie graph to the right, shade in the percentage of ***parent*** ***isotope*** after four half lives.



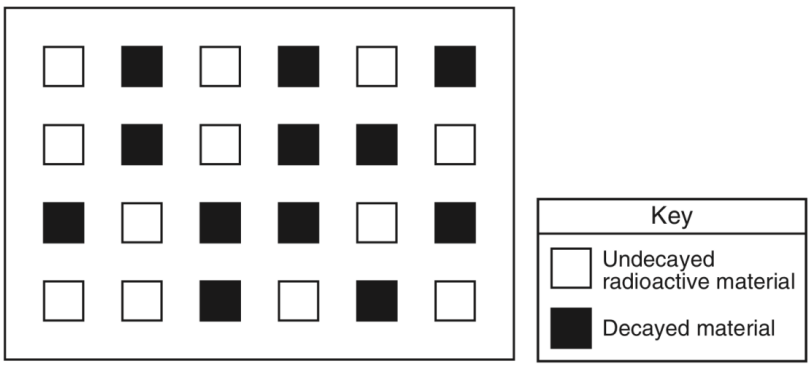
3. The diagram below represents a model of a radioactive sample with a half-life of 5000 years. The white boxes represent undecayed radioactive material and the shaded boxes represent the decayed material after the first half-life.

(a) Shade in the number of additional boxes that will represent 2 half lives.

(b) Name the radioactive isotope that has a half-life closest in duration to this radioactive sample.

_____

Radioactive Sample After First Half-Life



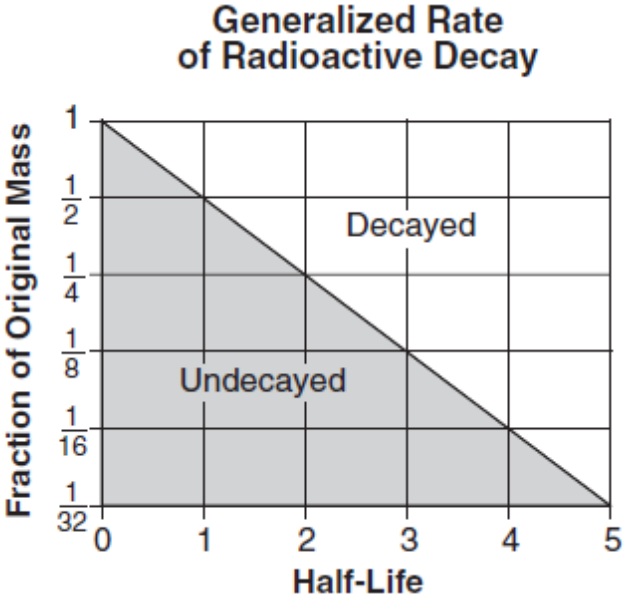
____4. The table to the right shows information about the radioactive decay of carbon-14. What is the amount of carbon-14 remaining after 28,500 years?

(1) 1/16 (3) 1/32

(2) 15/16 (4)

Half-Life	Mass of Original Carbon-14 Remaining (g)	Number of Years
0	1	0
1	1/2	5,700
2	1/4	11,400
3	1/8	17,100

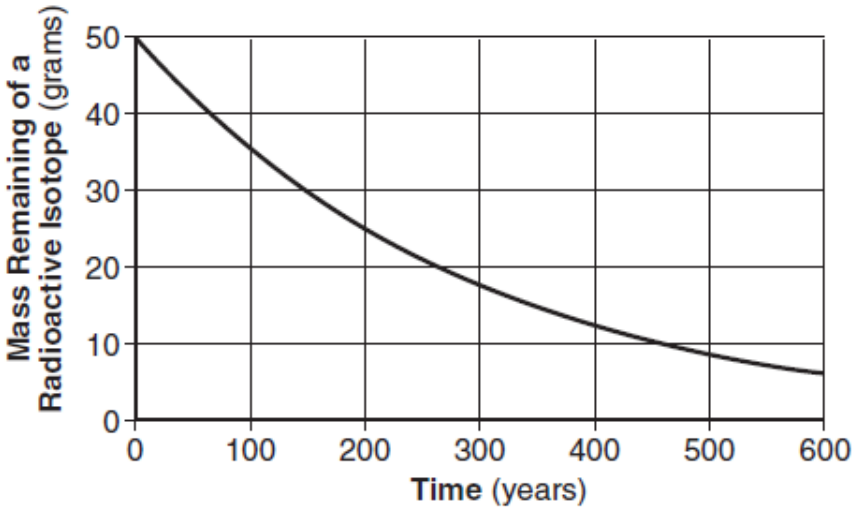
Base your answers to questions 5 and 6 on the graph to the right, which shows the generalized rate of decay of radioactive isotopes over 5 half-lives.



___5. If the original mass of a radioactive isotope was 24 grams, how many grams would remain after 3 half-lives?
(1) 12 (2) 24 (3) 3 (4) 6

___6. Which radioactive isotope takes the greatest amount of time to undergo the change shown on the graph?
(1) carbon-14 (3) uranium-238|
(2) potassium-40 (4) rubidium-87

___7. The graph to the below shows the radioactive decay of a 50-gram sample of a radioactive isotope. According to the graph, what is the half-life of this isotope?
(1) 100 years (3) 200 years (2) 150 years (4) 300 years



Mini Lesson 4: Evolution

Evolution is the gradual change in organisms from generation to generation. How well a species could adapt to a changing environment, find necessary food, avoid being eaten and its ability to reproduce are directly related to its survival. Evidence of evolution is provided by fossils, in that many organisms that once existed, are now extinct. For example, there was a mass extinction of the dinosaurs at the end of the Mesozoic Era. This is believed to be caused by a meteor impact which put so much dust and debris into the atmosphere that certain plants and eventually the dinosaurs became extinct. Humans have existed for only a very short amount of geologic time and depending on how well we can adapt will determine how long we will be here.

Scientists believe that the evolution of life also caused dramatic changes in the composition of Earth's atmosphere. Earth's atmosphere used to be composed of mainly carbon dioxide which came from outgassing of volcanoes as Earth cooled. Earth's earliest life-forms were bacteria called cyanobacteria. They used energy from the Sun for photosynthesis and oxygen was released as a byproduct. This is how scientists believe the atmosphere we have today was formed. What once was primarily carbon dioxide is now 78% nitrogen and 21% oxygen.

Need to know:

1. What is evolution? _____

2. What are four factors that may lead to evolution for survival?

   (a) _____

   (b) _____

   (c) _____

   (d) _____

4. Where can you find evidence of evolution? _____

   _____

5. What do scientists believe caused the extinction of dinosaurs? _____

   _____

6. How long have humans been on Earth? _____

7. What does our survival depend on? _____

8. What element was abundant in Earth's early atmosphere? _____

9. What is the name of the oxygen producing bacteria? _____

10. What process released oxygen as a byproduct? _____

Regents Questions:

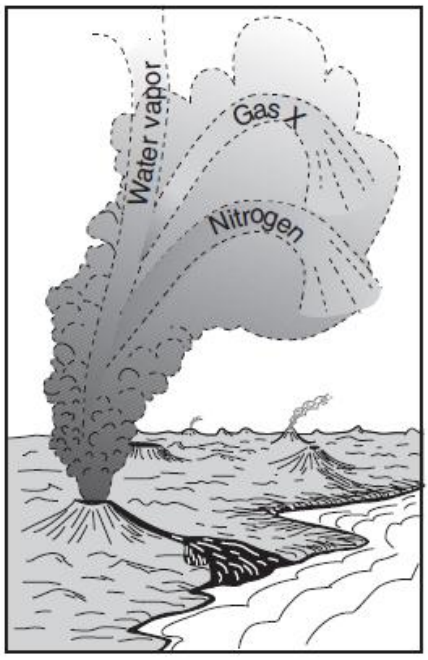
_____1. Scientists believe that Earth's early atmosphere changed in composition as a result of
(1) the appearance of oxygen-producing organisms
(2) the drifting of the continents
(3) the changes in Earth's magnetic field
(4) a transfer of gases from the Sun

_____2. It is inferred that during the early Archean Era the atmosphere of Earth contained water vapor, carbon dioxide, nitrogen, and other gases in small amounts. These gases probably came from
(1) precipitation of groundwater
(2) volcanic eruptions
(3) evaporation of Paleozoic oceans
(4) convection currents in the mantle

_____3. Scientists have inferred that Earth's original atmosphere was formed by the
(1) outgassing from Earth's interior
(2) erosion of Earth's surface
(3) decay of microorganisms in Earth's oceans
(4) radioactive decay of elements in Earth's core

_____4. Earth's early atmosphere formed during the Early Archean Era. Which gas was generally **absent** from the atmosphere at that time?
(1) water vapor (2) nitrogen (3) carbon dioxide (4) oxygen

_____5. The diagram to the right shows a process thought to have produced Earth's early atmosphere.
Which major component is shown as gas *X*?
(1) helium
(2) ozone
(3) carbon dioxide
(4) hydrogen



_____6. The gases in Earth's early atmosphere are inferred to have come primarily from
(1) meteor showers
(2) melting of glacial ice
(3) volcanic eruptions
(4) evaporation of seawater

_____7. Most scientists believe Earth's Early Archean atmosphere was formed primarily by gases released from
(1) stream erosion
(2) chemical weathering
(3) volcanic eruptions
(4) plant transpiration

_____8. What is inferred to be the main source of the free oxygen that first entered Earth's atmosphere?
(1) meteorite impacts releasing oxygen
(2) oxygen-producing organisms
(3) melting of glacial ice into hydrogen and oxygen
(4) radioactive decay of rocks containing oxygen

Base your answers to questions 9 through 12 on the passage below.

Earth's Early Atmosphere

Early in Earth's history, the molten outer layers of Earth released gases to form an early atmosphere. Cooling and solidification of that molten surface formed the early lithosphere approximately 4.4 billion years ago. Around 3.3 billion years ago, photosynthetic organisms appeared on Earth and removed large amounts of carbon dioxide from the atmosphere, which allowed Earth to cool even faster. In addition, they introduced oxygen into Earth's atmosphere, as a by-product of photosynthesis. Much of the first oxygen that was produced reacted with natural Earth elements, such as iron, in the lithosphere and produced new varieties of rocks and minerals. Eventually, photosynthetic organisms produced enough oxygen so that it began to accumulate in Earth's atmosphere. About 450 million years ago, there was enough oxygen in the atmosphere to allow for the development of an ozone layer 30 to 50 kilometers above Earth's surface. This layer was thick enough to protect organisms developing on land from the ultraviolet radiation from the Sun.

9. State *one* reason why the first rocks on Earth were most likely igneous in origin.

_____

10. Identify *one* mineral with a red-brown streak that formed when oxygen in Earth's early atmosphere combined with iron. _____

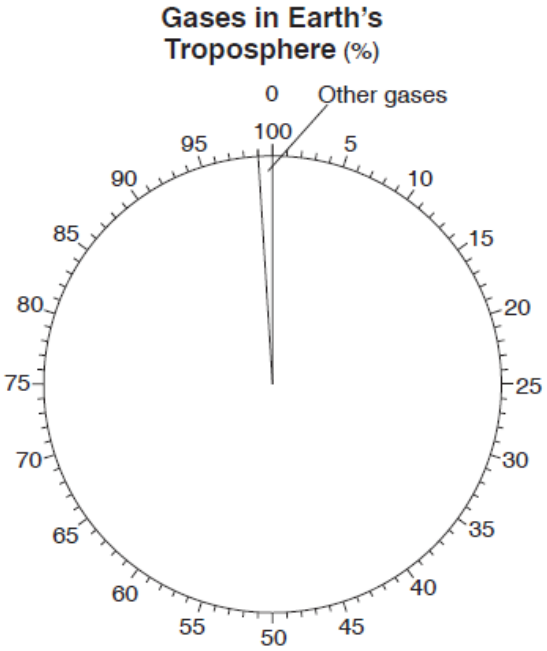
11. Identify the temperature zone of the atmosphere in which the ozone layer developed.

_____

12. Complete the pie graph *to the right* to show the percent by volume of nitrogen and oxygen gases currently found in Earth's troposphere.

    Label each section of the graph with the name of the gas.

    The percentage of other gases is shown.



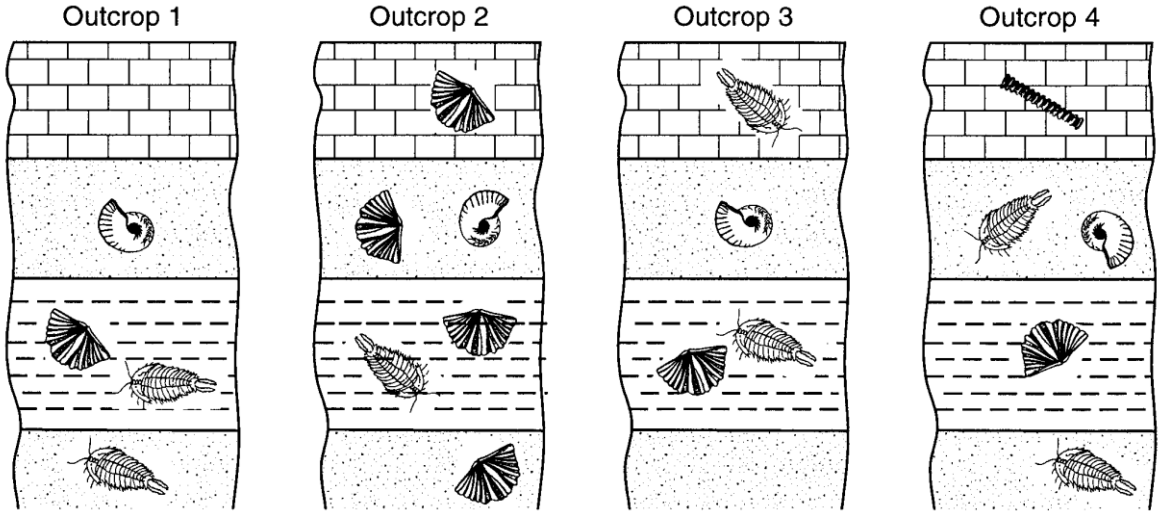
_____13. Three extinct organisms are shown in the diagrams below. Which other life-form reached its peak development during the same period in geologic history that these three life-forms first appeared on Earth?
1) dinosaurs 3) mastodonts
2) stromatolites 4) eurypterids

Cystiphyllum, a solitary coral

Baragwanathia, a lycopod — an early land plant

Palaeophonus, a scorpion — one of the first land animals

_____14. The diagrams below represent the rock layers and fossils found at four widely separated rock outcrops.



Which fossil appears to be the best index fossil?

(1)  (2)  (3)  (4) 

_____15. A fossil shell contains 25% of the original amountof its carbon-14. Approximately how many years ago was this shell part of a living organism?(1) 5,700 years ago (3) 17,100 years ago
(2) 11,400 years ago (4) 22,800 years ago

_____16. Which sequence shows the correct order of Earth's geologic time intervals from oldest to youngest?
(1) Archean → Mesozoic → Cenozoic → Paleozoic → Proterozoic
(2) Archean → Proterozoic → Paleozoic → Mesozoic → Cenozoic
(3) Cenozoic → Mesozoic → Paleozoic → Proterozoic → Archean
(4) Cenozoic → Paleozoic → Archean → Mesozoic → Proterozoic

_____17. Which event occurred earliest in geologic history?
(1) appearance of the earliest grasses
(2) appearance of the earliest birds
(3) the Grenville Orogeny
(4) the intrusion of the Palisades Sill

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Great diversity of life-forms with shelly parts
Mass extinction of many land and marine organisms (including trilobites)
Mass extinction of dinosaurs, ammonoids, and many land plants
Humans, mastodonts, mammoths
Large carnivorous mammals
Earliest mammals
Earliest birds
Earliest dinosaurs
Earliest insects
Earliest flowering plants
Many modern groups of mammals
Earth's first forests
Mammal-like reptiles
Abundant reptiles
Earliest grasses
Earth's first coral reefs
Abundant amphibians
Extensive coal-forming forests

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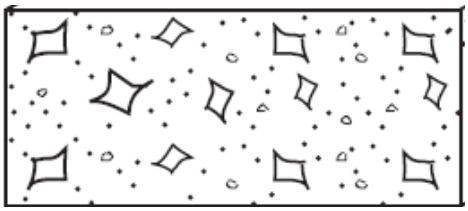
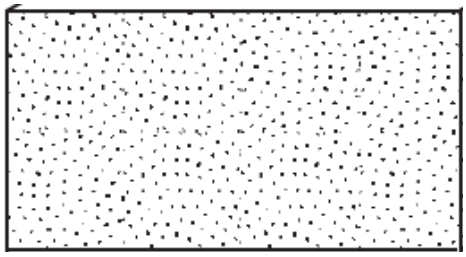
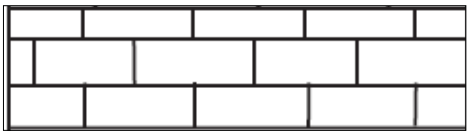
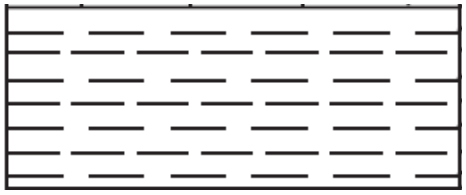
Outcrop diagrams

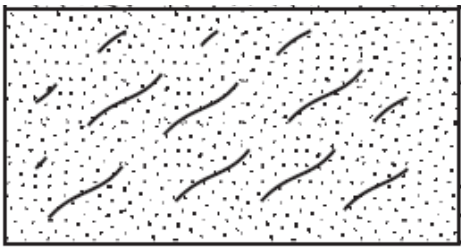
Cut out each rock type

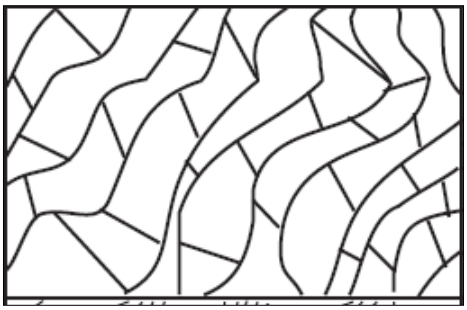


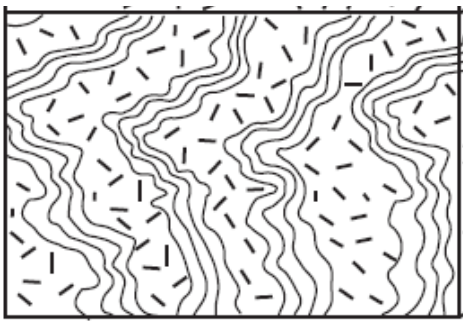












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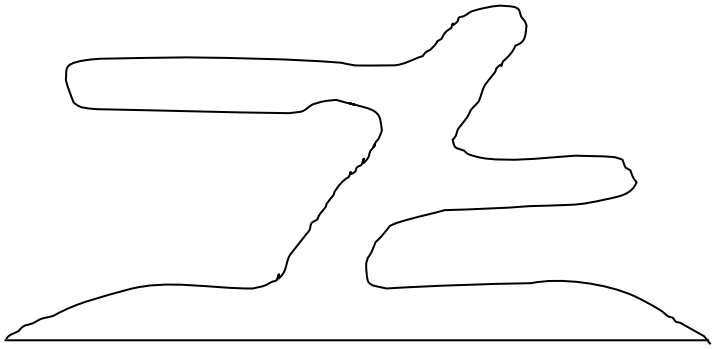
Sequence Box 1

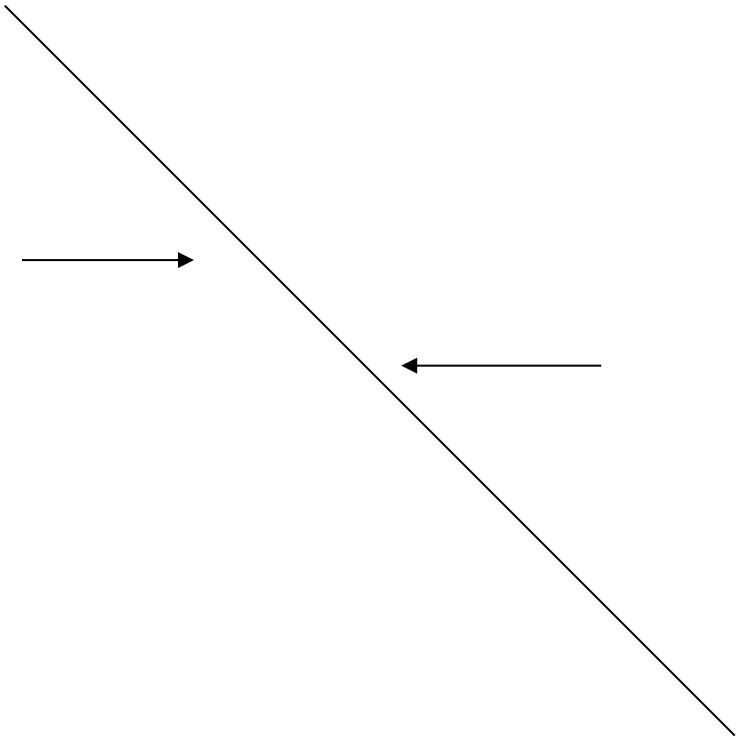
Sandstone
limestone
Conglomerate
Shale
Granite

Sequence Box 2

Limestone
Siltstone
Dolostone
Shale
Conglomerate



Sequence Box 1



Sequence Box 2