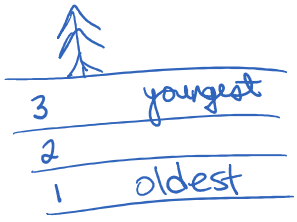
Period 3

Notes: Relative Dating

- placing a series of events (no ages known) in the proper sequence, oldest to youngest, by comparing.

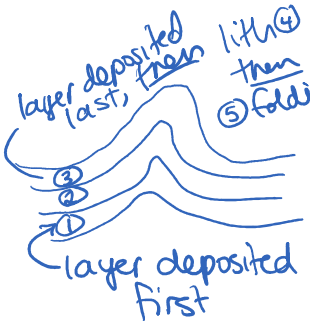
5 Quick Rules

① Principle of superposition



- in an undisturbed pile of sediments (or sedimentary rock) unaffected by folding or faulting, etc, those on the bottom were deposited 1st and are the oldest, with the youngest on top. (ex newspapers in recycle)

② Principle of Horizontality



- especially on a large scale, sediments tend to be deposited in horizontal, flat-lying layers (ex snow falling evens out lumps)
- folds and tilts are from deformation <u>after</u> the sediments have <u>lithified</u> into rock.

③ Principle of Cross-cutting Relationships

- if a fault, dike/pluton cuts across layers of sedimentary rock, the sed. rock must have been there first.
- intrusions/plutons may have metamorphosed the country rock next to it (contact metamorphism)

④ Principle of Inclusion

- if a pluton contains xenoliths (included fragments of other rocks), then the xenoliths are <u>older</u> than the pluton they are in

xenoliths are [illegible]

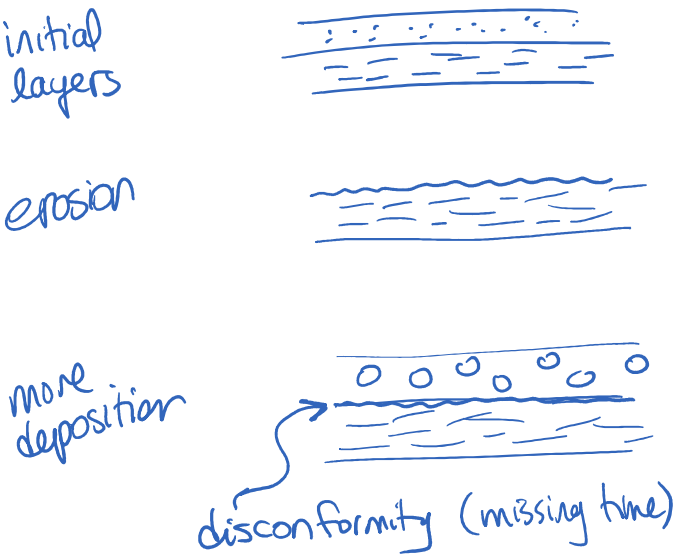
- pebbles in conglomerate
  - ↑ older
  - ↑ younger

⑤ Unconformity

- looks like "missing time"
- a surface in a sed. sequence where there was a lack of deposition or even some erosion for a period of time.

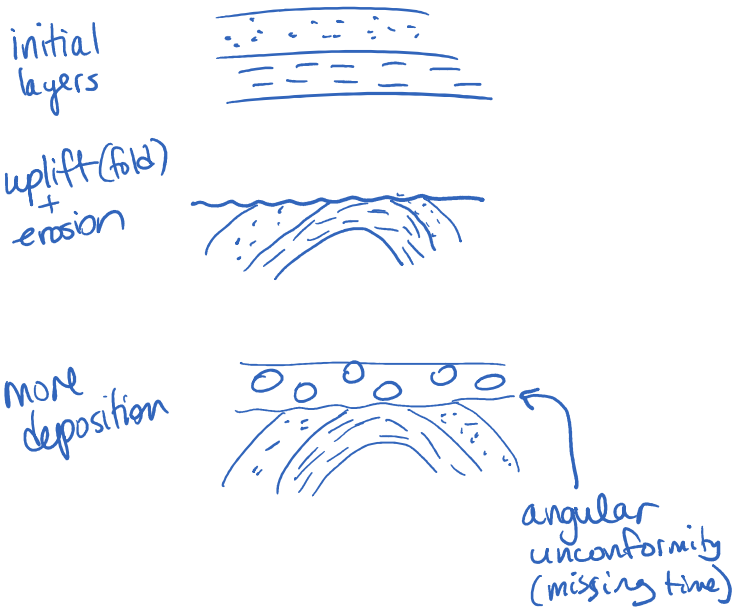
Disconformity

- layers above and below are parallel



Angular unconformity

- layers not parallel



today

Geology 12
Geologic Time

Relative Ages Exercise.

The following 9 cross sections represent hypothetical strata of the earth. Write your answers in the space beside each section.

Questions.

1. (a) State the Law of Superposition.
   (b) List the strata in order from oldest to youngest. (It is convention to always list from oldest to youngest or to write in a column with the youngest at the top.)

2. (a) Complete the list in the column.
   (b) Which event occured first?
   (c) Which event occured last?
   (d) State the Law of Original Horizontality.

3. (a) Complete the list.
   (b) What occured at P ?
   (c) What is a feature like P called?

4. (a) What occured first?
   (b) What occured between the deposition of A and K ?
   (c) What was the last event to have occured?

5. (a) Complete the list.
   (b) How do you know where to put A in the series?
   (c) What is A called?

6. (a) Complete the list.
   (b) What occured at Y ?
   (c) What could have occured between B and C ?
   (d) When did the tilting take place compared to dyke X ? How do you know?

7. (a) Which is the oldest?
   (b) What is Z ? What type? How do you know?
   (c) What happened between X and N ?

8. (a) List in conventional order.
   (b) What type of feature is E ?
   (c) What would you notice along the margins of A ? Why?
   (d) BONUS: Name the type of rock you would probably find between C and A.

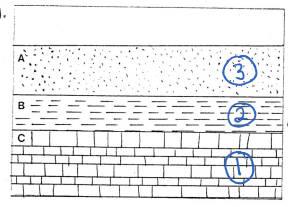
9. (a) List the Igneous activity in order from oldest to youngest.
   (b) What are two pieces of evidence for the order of dykes C and D ?

Legend for Rock Types:

Limestone - 
Sandstone - 
Shale -
Conglomerate - 
Volcanic - 
Plutonic -

1

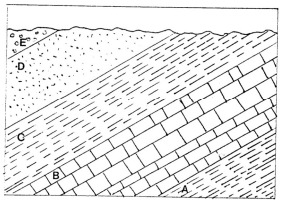
1.



(a) Superposition - if undisturbed, the oldest will be at the bottom

(b) C B A
oldest (there first) youngest

2



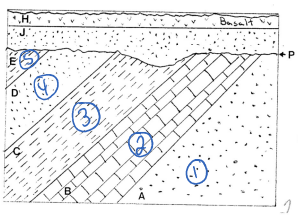
(a) youngest E
D
C
B
oldest A

(b) deposition of A

(c) tilt + erosion

(d) Horizontality - layers are deposited flat - lying

3



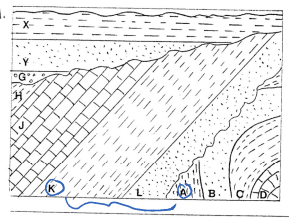
(a) youngest H ← erosion
J
E ← P = erosion = angular unconformity
D
C
B
oldest A

(b) tilt, erosion = angular unconformity

(c)

1

4.



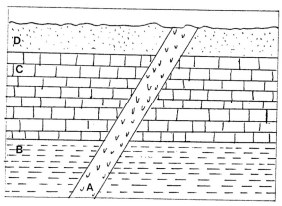
(a) deposition of D

(b) folding, tilt, erosion, L-deposited, K-deposited (tilt is after H)

(c) X deposited or erosion on top

A
B
C
D

5

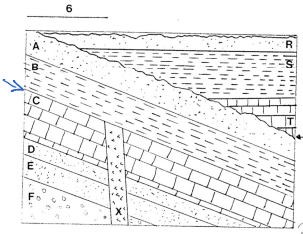


(a) youngest A, D, C, oldest B

(b) "A" cuts across all the layers so is the youngest

(c) Dike

6



(a) R, S, T, A, B, C, D, E, F (youngest → oldest)

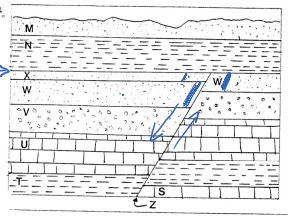
(b) tilt + erosion (unconformity)

(c) X intruded and some erosion leveled X off even with C

(d) if X is right after C, then R and S deposited flat, then tilt.

2

7.

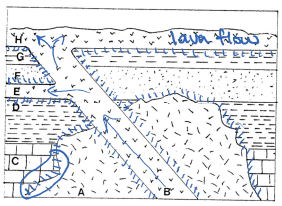


(a) S

(b) fault - normal hanging wall slides down.

(c) erosion - eroded part of W and all of X on the right side of fault.

8



oldest / first possible time / youngest

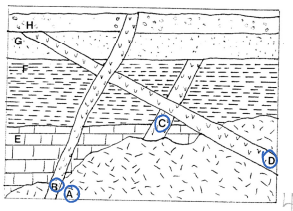
(a) C, D, F, A, G, B, E, H

(b) E = Sill

(c) contact metamorphism

(d) Bonus, marble (limestone metamorphosed)

9



oldest → youngest

(a) C, A, D, B

(b) • D overlaps C
• D overlaps A which overlaps C

H

GEOLOGY 12 Name _____
CHAPTER 8
EXERCISE 13 DATING OF ROCKS AND GEOLOGIC EVENTS

- Refer to the lab manual pages 196-204.
- Review and make notes on the background information as necessary.
- Complete question #3 page 200 and #5 on page 202.

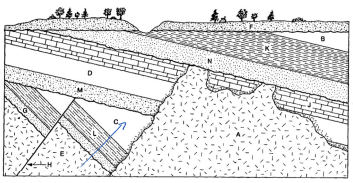


Figure 13.14

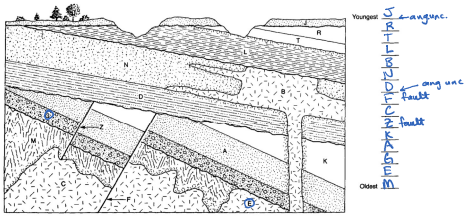


Figure 13.15

5

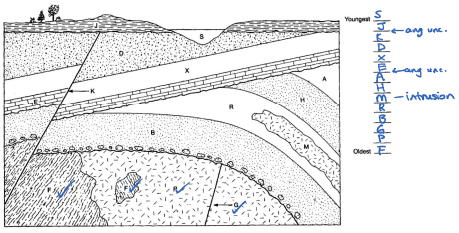


Figure 13.16

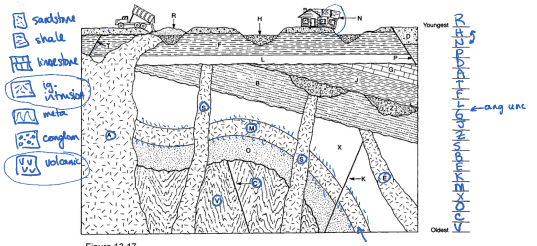
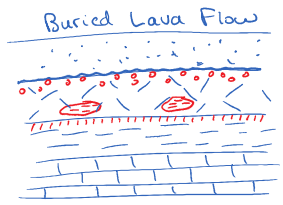


Figure 13.17

- Attach your answers to question #5 and submit for marks.

6

2022 04 11 "Buried Lava flow" vs "Sill"



Did the igneous intrusion flow on the surface and then get buried by the sandstone later? (Buried Lava Flow)
Or did the ig. intrusion squeeze between the sandstone and shale layers? (Sill)

Clues to look for:

Buried Lava Flow	Sill
- vesicles near top	- no vesicles
- contact metamorphism on rock below only	- contact meta of rocks above and below
- included fragments from rock below only	- inc. fragments from rocks above and below.
- possible erosion surface on top	- no erosion (never exposed at surface)

Notes: Radiometric Dating

Radiometric Dating Exercises

Geology 12
Radiometric Dating **Name:**

Set Up:

- Use as much of the graph paper as possible (make a big graph)
- Label the X-axis with number of half lives (0, 1, 2, … 10)
- Label the Y-axis with number of parent atoms (1 to 1000)

Drawing the Graph:

- Begin with 1000 atoms of radioactive parent element and 0 atoms of stable daughter product.
- Plot points to draw the decay curve, showing the decrease in the number of parent atoms through ten half lives.
- Draw in the decay curve using a SMOOTH curve
- Plot points to draw the accumulation curve, showing the increase in the number of atoms of stable daughter product through ten half lives
- Draw in the accumulation curve using a SMOOTH curve
- Note: the half life of the radioactive element you graphed is given as 5730 years.

Questions based on your graph:

1. How many years are equal to 5 half lives?
2. How many parent atoms will be left after 5 half lives?
3. How many daughter atoms will be accumulated after 5 half lives?
4. At what point in time (number of half lives) will the number of parent atoms be equal to the number of daughter atoms?
5. At what point in time (number of years for this sample) will the number of parent atoms be equal to the number of daughter atoms?
6. At what point in time (number of half lives) will the number of daughter atoms be exactly three times the number of parent atoms?
7. How many half lives equals 22,920 years?
8. What element has a half life of 5730 years?
9. What is the stable daughter product of this element?
10. If you have 125 atoms of parent, how many daughter atoms will be present in this example?
11. If you have 125 atoms of parent, how old (number of years) is the sample?

General Questions:

12. Define half life.

13. How many half lives have passed if a rock sample has:

    - 50% daughter and 50% parent?
    - 150 stable and 50 radioactive atoms?
    - 7/8 daughter and 1/8 parent?

14. What is the formula for calculating the age of a rock?

15. Calculate the ages for the above samples if the half life is 5 million years.

16. True or false: uranium 238 dating can be used to find the age of a dinosaur bone?

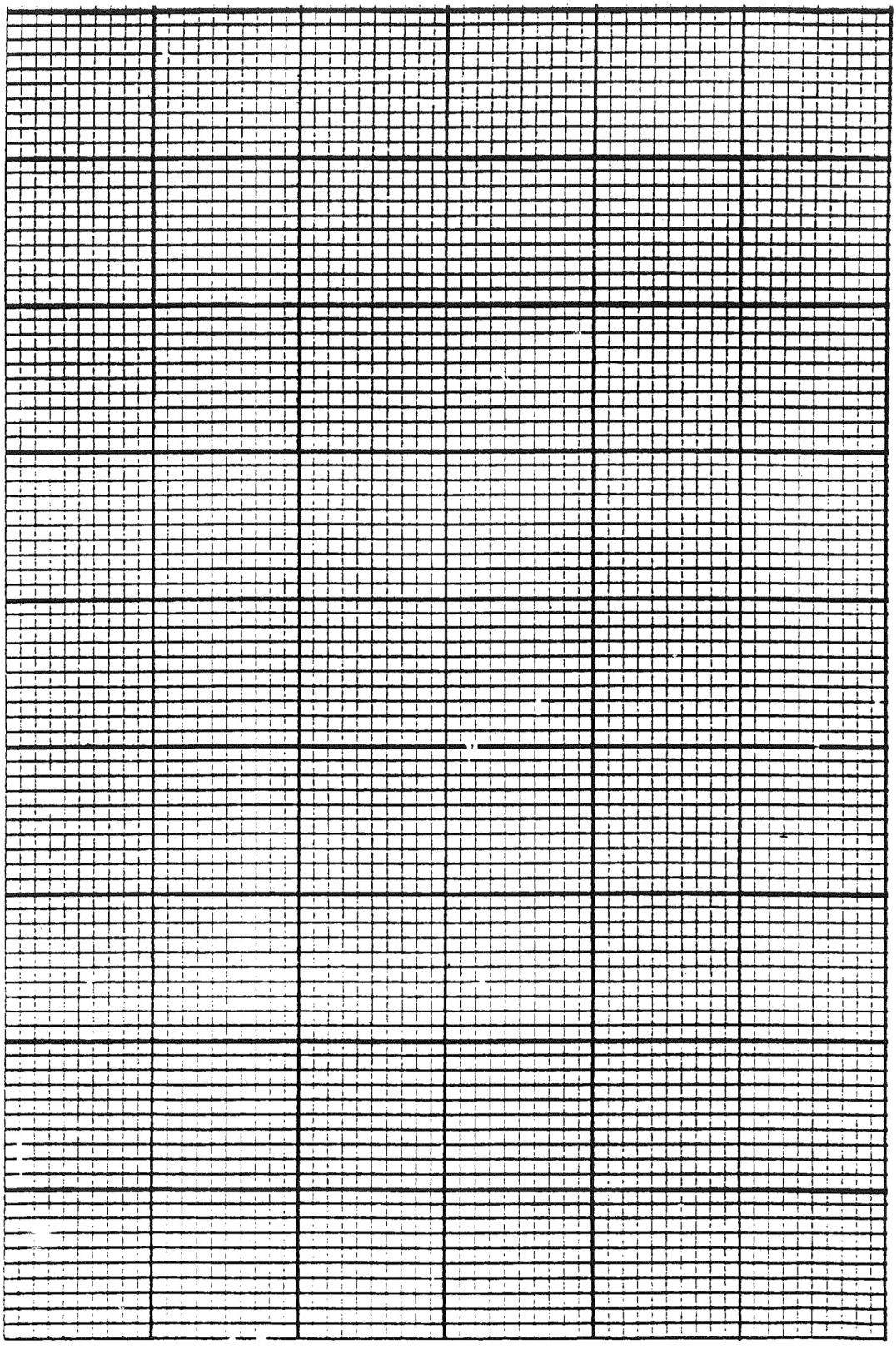
17. True or false: Carbon 14 can be used to find the age of a dinosaur bone?

18. A piece of *wood* found in an ancient tomb has a ratio of 1 parent to 15 daughters.

    - How many half lives have passed?
    - How old is the wood?

19. Explain in detail how to find the age of a rock using radiometric dating.

20. Make up a radiometric dating question and have your partner find the age.



Name:_____

Radiometric Dating

1. a. If a sample started with 100% parent and now has 75% daughter and 25% parent, how many half lives have passed?

   b. If one half life is 7 million years, how old is the sample?

2. How long has a tree been dead if there is an equal amount of carbon-14 as nitrogen-14?

3. How much uranium-238 should be left on Earth compared to what was here when Earth formed 4.5 billion years ago?

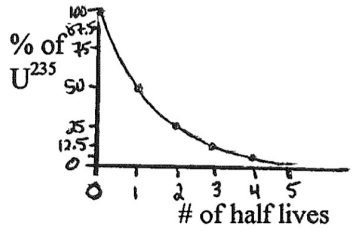
4. a. An igneous rock from some distant galaxy (brought here by aliens) contains 8 parents and 56 daughter atoms. How many half lives have passed?

   b. If the parent is rubidium-87 and the daughter is strontium-87, how old is the sample? (Is this possible in our universe?!)

5. a. There was an earthquake that caused a rock containing argon-40 to fracture. Some of the argon escaped. How?

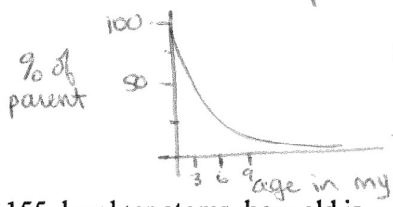
   b. What effect will this have on the apparent age of the rock? Will it look younger or older than it should? Explain.

6. a) Given the following graph, how old is a sample that contains 6.25% parent and 93.75% daughter?



b) What is the age of a rock if 75% is still parent (radioactive)

c) draw a daughter curve.



7. If a piece of paper contains 5 parent atoms and 155 daughter atoms, how old is it? (Hint: what isotope must be being referred to in this case?)

8. If the daughter to parent ratio is 7, how many half lives have passed? How old would the sample be if the parent were thorium-232 and the daughter lead-208?

c:geolradd

10

WS Relative & Absolute Time

GEOLOGY 12 Name _____

CHAPTER 8 WORKSHEET #2

RELATIVE TIME AND ABSOLUTE TIME

Match the descriptions on the right to the persons on the left. Place the letter of the corresponding description in the blank by each name. You may use some descriptions more than once.

_____ 1. Henri Becquerel
_____ 2. Lord Kelvin (reworked Buffon's)
_____ 3. Nicholas Steno
_____ 4. Georges Buffon
_____ 5. John Joly
_____ 6. William Smith
_____ 7. Archbishop Ussher
_____ 8. C.D. Walcott

A. calculated age of earth from number of generations in the Bible
B. proposed the Law of Faunal Succession
C. calculated age of earth based on cooling rate of the earth from an initially molten state
D. proposed the principles of Superposition and Original Horizontality
E. discovered radioactivity of uranium
F. calculated age of earth based on rates of sedimentation
G. calculated age of earth based on amount of salt in the oceans
H. calculated age of earth based on rate of "burning" of the sun – Kant

For fun...

9. After two half-lives, how much radioactive parent isotope will be left in a given mineral?
   A. 133% B. 50% C. 25% D. 33%

10. If the ratio of daughter isotope to parent isotope is 7, how many half-lives have passed?
   A. can't tell from information given
   B. seven
   C. one
   D. three

11. As each half-life passes, the amount of daughter product will
   A. decrease by half each time
   B. increase by doubling each time
   C. never exceed the amount of parent isotope remaining
   D. increase by the amount of parent isotope which has decayed

12. A mineral being used for radiometric dating contains 600 units of the daughter isotope and 200 units of radioactive parent isotope. How many half-lives have passed?
   A. two
   B. none
   C. three
   D. can't tell from the information given

13. A mineral contains an amount of daughter isotope equal to the amount of radioactive isotope remaining in it. The half-life for the radioactive isotope is 250 million years. How old is the mineral?
   A. 250 million years
   B. 125 million years
   C. 500 million years
   D. just formed; no decay has occurred

14. Rubidium-87 has a half-life of 48.8 billion years. Let's assume that radioactive rubidium would be safe to be around if there was less than 1/64 the original number of radioactive atoms left. How many years would that take?
   A. about 800,000 years
   B. a little over 290 billion years
   C. about 3200 million years
   D. cannot be calculated from the information given

11

15. Placing rocks or geological events in their proper time order is known as _____.
16. In a sequence of sedimentary rock layers, the _____ rock is always on the bottom.
17. Sedimentary rocks, which are now folded or otherwise deformed, initially were deposited as _____ layers of sediments.
18. A _____ is a type of unconformity in which sedimentary rock layers are parallel above and below it.
19. An igneous dike or pluton is _____ in age than the rocks which it cuts across.
20. The Law of Faunal Succession is useful because it allows geologists to correlate rock layers based on the _____ they contain.
21. In the nineteenth century, the age of the earth was thought to be considerably _____ than it is today.
22. Radioactive decay affects the numbers of protons and neutrons in the _____ of an atom.
23. Each _____ particle consists of two protons and two neutrons.
24. _____ particles may be electrons or positrons.
25. Gamma rays are a form of _____ radiation, similar to X-rays.
26. A _____ is used to measure the tiny amounts of parent and daughter isotopes in radiometric age dating.
27. Radioactive decay is a _____ phenomenon, "obeying" the laws of probability.
28. Potassium-40 will decay to the daughter isotope _____.
29. Uranium-235 will decay to the daughter isotope _____.
30. Of the radioactive isotopes used for age dating rocks, _____ has the longest half-life.
31. _____, which has an extremely short half-life by geologic standards, is used primarily for age dating archeological artifacts.
32. If some of the daughter product has escaped from a mineral since the time that radioactive decay started, the derived age of the mineral (or rock) will appear to be too _____.
33. The era of the geologic time scale that represents "middle life" is the _____.
34. The shortest and most recent era of the time scale is the _____.
35. Arrange the terms in order by age from oldest to youngest, as they are arranged in the geologic time scale : Paleozoic, Proterozoic, Cenozoic, Mesozoic, Archean

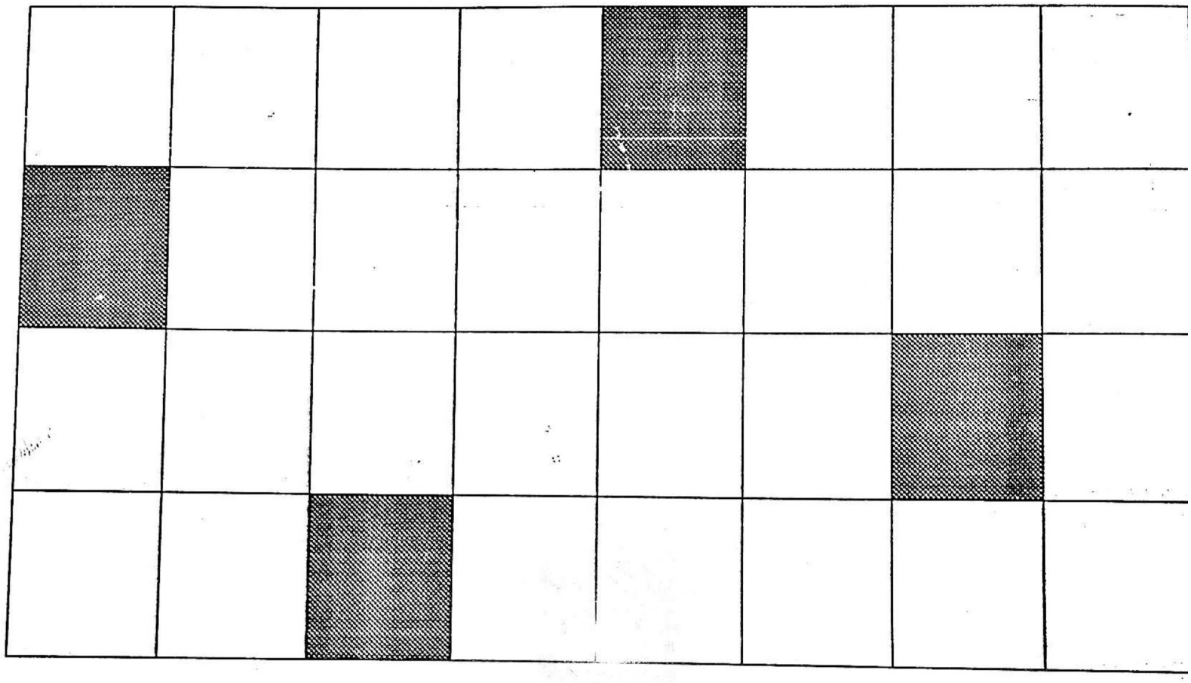
_____
_____
_____
Proterozoic
Archaen
} Precambrian

12

Beginning Activity

Radiometric Decay overhead question:

Use the following diagram representing decayed (white) and undecayed (grey) atoms in a sample to answer the questions below:



If the half life is ~~704 million~~ 1.25 billion years:

a. What radioisotope is represented?
b. How many half lives have passed?
c. How old is the sample?
d. How many parents (undecayed) were there when the rock first formed (before the isotope began to decay?)
e. Draw a graph showing the decay curve for the parent as well as a curve for the increasing daughter.

Macaroni Quiz

(in handouts for practice)

Name:_____

Radiometric Dating Quiz

Find the age, in years, of your sample. Show all your work in the space indicated.

Sample Number: _____

Each bag contains a sample representing a parent isotope and its stable daughter.

Parent:	^{28}Ma	macaronium 28 (natural colour)
Daughter:	^{24}Pa	pastanium 24 (green colour)

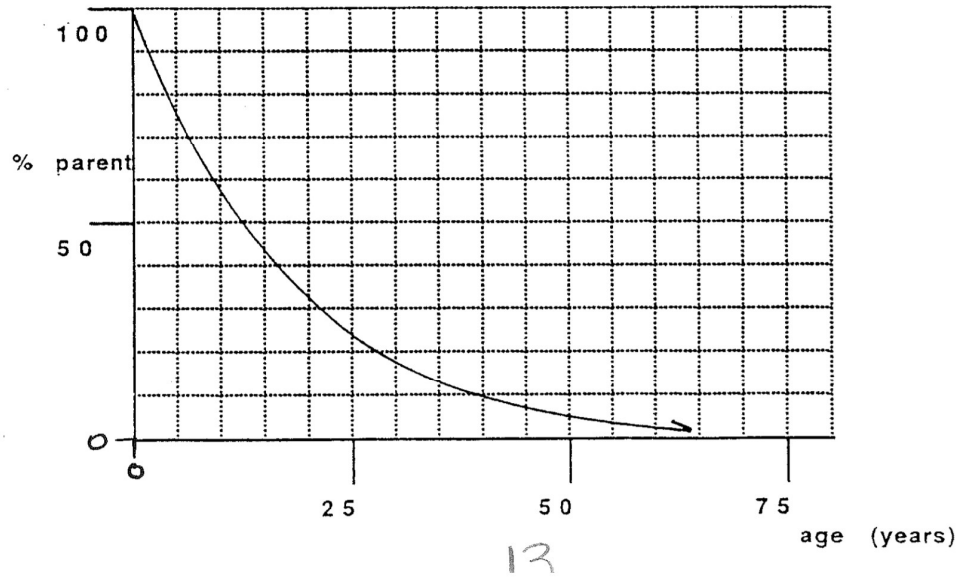
Caution: The atoms are fragile and not edible!

The decay curve for ^{28}Ma is given below.

SHOW ALL CALCULATIONS USED TO FIND THE AGE IN A NEAT ARRANGEMENT IN THIS SPACE.

Radiometric Age:_____

Bonus: Sketch the curve for the stable daughter on the graph.



3

13

Notes: Ch 8 Continued

Name:_____

Chapter 8 Notes Continued

The Geologic Time Scale

The eon called the Phanerozoic takes up less than __% of Earth's history and includes the following eras: Cenozoic - recent life, the age of the _____
Mesozoic - middle life, the age of the _____
Paleozoic - ancient life, the age of the _____

Eras are subdivided into _____ and the periods of the Cenozoic into _____.

The names of periods and epochs are for the place where rocks of that age were well exposed and that time unit was consequently first defined.

The first divisions were done from _____, then radiometric dating (of dikes, etc. that cut through the sedimentary layers) gave _____.

Precise dates for the Phanerozoic is difficult because
- sed. rocks and fossils can't readily be _____ so had to approach it indirectly by determining age limits and making correlations
- radiometric dating has some uncertainty (between 1 and ___%)

The Precambrian includes the __ billion years of time before the Phanerozoic. There were basically no fossils to give a basis for divisions so it was divided into two parts (Archean and Proterozoic) almost arbitrarily. There was widespread igneous activity and mountain building but no single event of global impact.

See the Geological Time Scale, page 164 in text.

How old is the Earth? - A better answer.

No _____ have been preserved unchanged on Earth but we believe the sun, moon, meteorites, etc. formed at the same ____:
moon sample ~ ___ billion years old
meteorite sample ~ _____ billion years old
gives us that the earth is ~ ____ billion years old

Oldest earth material is ___ billion years. Oldest rocks on each continent between 3.6 and 3.9 billion years. Why none at 4.55 billion years old?
- radiometric clocks start when rocks _____ (maybe was molten for long time.)
- rock cycle has been acting since the beginning, changing most rocks at least ____

Earth's History - Quick Summary

Universe
- Big Bang occurred _____ billion years ago, still expanding, open/closed?

14

Stars
- Matter not uniformly distributed so clumps join together due to _____, star is born
- stars burn up their fuel, create _____ elements, supernovae (blow up), spread heavy elements through space
- our earth and sun are made up of matter that likely was cycled through several generations of _____.

Solar System
- our sun is _____ aged, 5 billion years old, 5 billion years to go
- cloud of dust and gas condensed, most mass condensed to form ____, rest into planets
- composition of planets depends on how _____ they are to sun, higher T materials nearest sun (Fe, etc.), "gases" (solid H, He, lighter elements) farther out

Earth
- dust ball condensed; heated by collisions of particles, compression by gravity and radioactive elements so most of the Earth was _____
- slowly cooled, heavy iron _____, light elements _____ making the core, mantle, crust 4 billion years ago
- as cooled, water _____ in atmosphere
- early atmosphere contained almost no _____, blue-green algae and formation of limestone supplied oxygen
- many changes have occurred since _____ formed - continents moved, volcanoes, mountains, erosion, . . .

<u>Life on Earth</u>

0.5 million yrs ago	modern, rational Homo Sapiens, _____ impact in short time!
3-4 million	the most primitive _____ developed
65 million	mammals become dominant (dinosaurs decline)
150 million	warm blooded animals _____ (birds)
200 million	dinosaurs and 1st mammals
400 million	insects, amphibians and reptiles onto continents
400-500 million	animals with backbones (_____) and land plants
600 million	marine animals with shells widespread
1 billion	1st multicelled, soft bodied, oxygen breathing creatures, poorly preserved, _____ fossils
4.6 billion yrs ago	formation of the earth

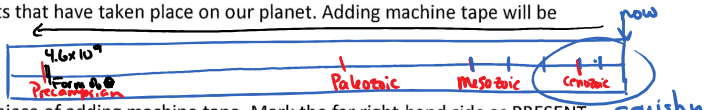
The practical aspects of learning this is that _____ sources come from old plants and animals. If you know the time they lived then you know where to mine.

<u>Dating and Geologic Process Rates</u>
Continents move ~___cm/yr relative to magnetic poles
Uplift rates ~___cm/yr in mountain ranges, erosion rates similar
Must be cautious about extrapolating _____ process rates into past or future!
read page 170

15

Geology 12
Geologic Time Scale Exercise Name: _____

Preliminary Information:
The easiest way to visualize the vast amount of time that the Earth and its past present life forms have existed is by means of a Time Line. In this exercise, you will be constructing a time line which will indicate some of the major events that have taken place on our planet. Adding machine tape will be used to plot such a line.



Procedure:

1. Obtain a 2.5 meter long piece of adding machine tape. Mark the far right-hand side as PRESENT, in red.
2. Using a scale of "1mm = 2 x 10^6 years (2 million)", plot the following by measuring back in time to the left.
   a. The Phanerozoic portion of the time scale, along with all its divisions, on the top edge of the tape.
      i. Eras marked in Red
      ii. Periods marked in Blue
      iii. Epochs marked in Green
   b. Arrange all of the following event s, in order, in black or pencil on the bottom edge of the tape. **Note** the events in the list are not completely in order right now.

Event	Time (Years ago)
Formation of the earth	4.6 x 10^9
First known algae and fungi appear	4.0 x 10^9
First invertebrates appear	570 x 10^6
First fish appear	500 x 10^6
First reptiles appear	300 x 10^6
First amphibians appear	400 x 10^6
First mammals appear	200 x 10^6
First man-like animal	2.5 x 10^6
Pleistocene glaciations (most recent)	1.0 x 10^6
Pacific Coast Orogeny (mountain building)	70 x 10^6
Appalachian mountain building	350 x 10^6
First known plants appear	3.2 x 10^9
First known animals appear	1.2 x 10^9
Oldest rocks on the planet	3.9 x 10^9
First dinosaurs appear	225 x 10^6
Last dinosaurs disappear	66 x 10^6
Age of Canada	1.5 x 10^2
Your birth	_____ = 0 mm

$\frac{4.6 \times 10^3}{2 \times 10^6} = 2.3 \times 10^3$ mm = 2300 mm = 230 cm

$\frac{570 \times 10^6}{2 \times 10^6} = 285$ mm = 28.5 cm

careful with the numbers... they are not in order

$\frac{1.5 \times 10^2}{2 \times 10^6} = \frac{0.00015 \text{ mm}}{2} = 0$

3. Be sure to be creative – add pictures and drawings to your timeline!

16

Notes: Relative Dating with Fossils

Relative Dating with Fossils

-Fossils are used to determine the age of rocks by the **Principle of**_____
Life forms change through time so ... "Rocks are the same _____ if they contain exactly the same type of _____ organism"

-This allowed geologists to relate rock bodies, or a_____/_____of rock, located in different areas of the world—called "_____"

-In identifying the habitat and lifestyles of _____ organisms, we assume that the _____ _____ and _____ laws have always operated (maybe at different _____.)

-By observing _____ processes, we can understand the _____ history and development of the earth and its inhabitants.

-This theory is called_____

-"The present is the key to the past"

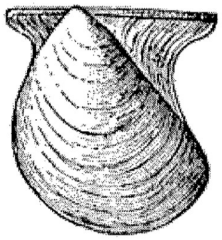
Definition of Fossil:
Fossils are only found in _____ rock. Why?

Process of original preservation:

-most fossils are only partial remains of plants or animals, generally the _____ of the organism that was buried _____ and preserved from _____. Hard parts like _____, _____ and _____ may be preserved.

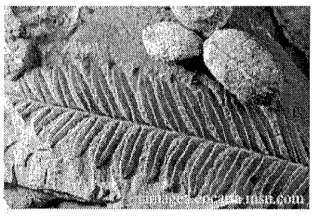
Fossilization Processes:

1. _____



-Given enough time, even the hard parts of fossil may _____leaving a cavity in the hard surrounding sediment. This fossil _____is called a _____. The mold of the interior of a shell formed when a shell fills with _____, hardens, and then becomes _____ of the surrounding shell.
-Trapped insects leave molds in_____(hardened _____.)

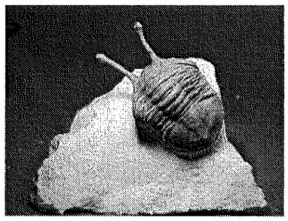
2. _____



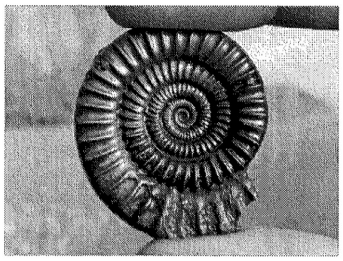
-If other sediment _____ the mold and lithifies, a matching_____ is formed.
-No _____ can be seen with this type of fossilization
-This is the most common mode of_____of many _____ fossils
e.g. _____, _____

17

3. _____
–The removal of other elements leaving the _____ behind (like peat formation)
e.g. _____ usually fossilized this way



4. _____
-The original hard parts have **additional** _____ materials deposited in _____ spaces.



5. _____
-Minerals in _____ in _____ waters replace _____materials as it dissolves or decays
-With this type of fossilization, you can see the _____
e.g. Petrified wood is _____ replacement.

Conditions necessary for the preservation of _____ parts

-Soft tissues are destroyed due to _____ before lithification or _____ during diagenosis. Usually they are best preserved as _____ films (carbonization) on a rock _____

-However under unusual conditions, soft part _____ may be preserved relatively intact.

-Ex. The world famous _____ Fossil Deposit near Field, B.C. found by Charles Walcott in 1909.

-This is what happened approximately 530 million years ago. There was no life on land and most life was small and lived along _____. A _____ from a soft bank buried the _____ organisms in silt. The water was _____ and _____. The silt flattened, hardened (_____) and became the sedimentary rock _____. Fossil _____ of the organisms were formed. Hundreds of millions of years later, colliding _____ caused the shale to be thrown up as part of an 8,000 foot _____. It is this unusual, detailed snapshot of life as it was _____ million years ago, replicas of _____ and all, that makes the Burgess Shale deposit so valuable. (Note: _____ the actual flesh, but a _____ _____ version/shape of it.)

Therefore, the required conditions necessary for the preservation of soft tissue are:

1. _____burial of
2. _____ organism in
3. _____, low _____ water followed by
4. _____lithification of sediment.

18

Another unusual event: Mammoth found in _____ with flesh still intact. This is original preservation.

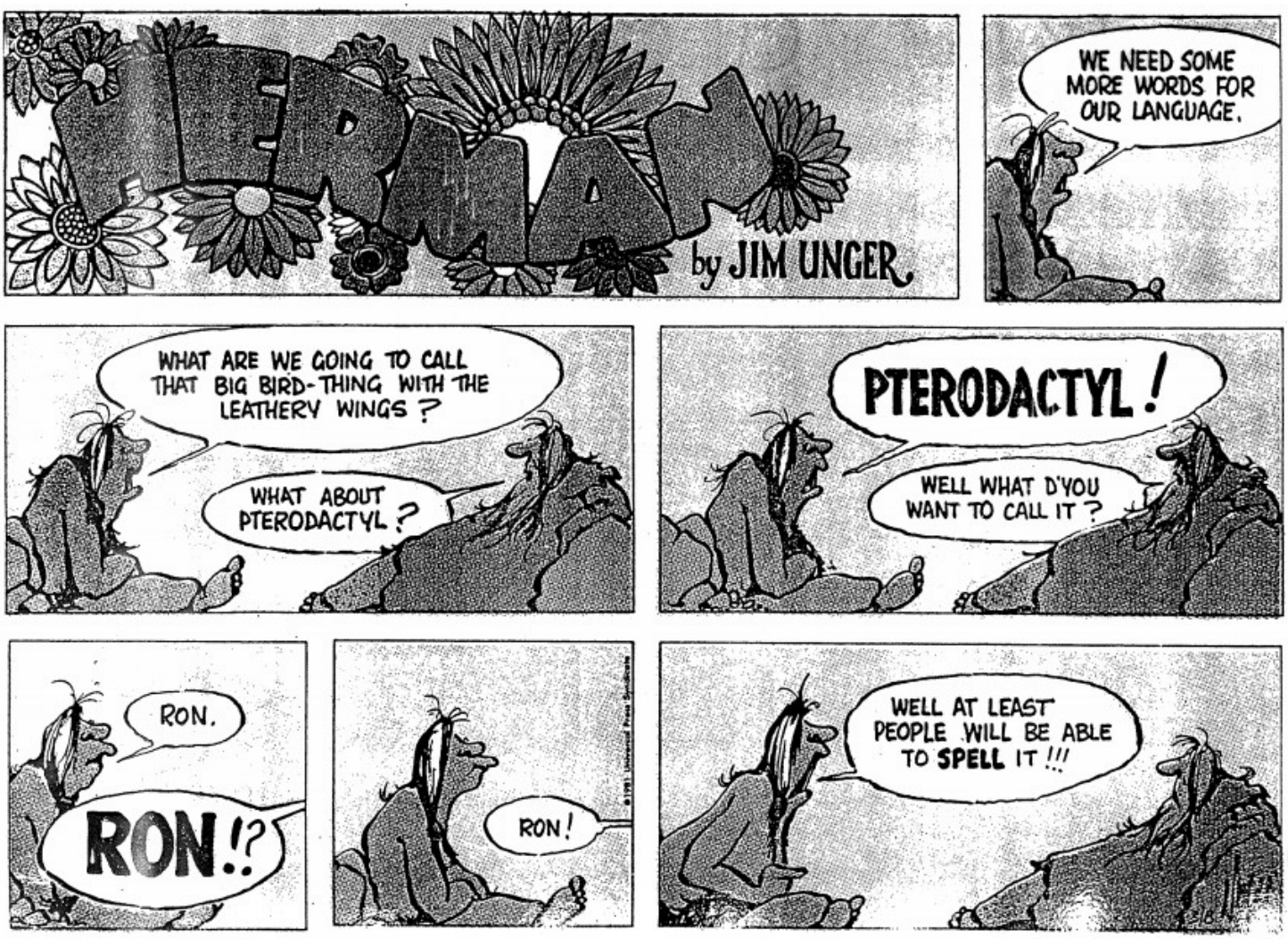
Index Fossils and the Necessary Characteristics

A fossil that is _____ but _____ is useful in correlating rocks of the same age in different areas and is referred to as "_____" (or guide) _____. The required characteristics of index fossils are:

1. They must be _____ to identify from other similar fossils. They must be _____ in some way
2. They must be found over a _____ geographic area.
3. They must have a _____ time range so that they occur in only a _____ rock layers.
4. They must be _____ and _____ to fossilize

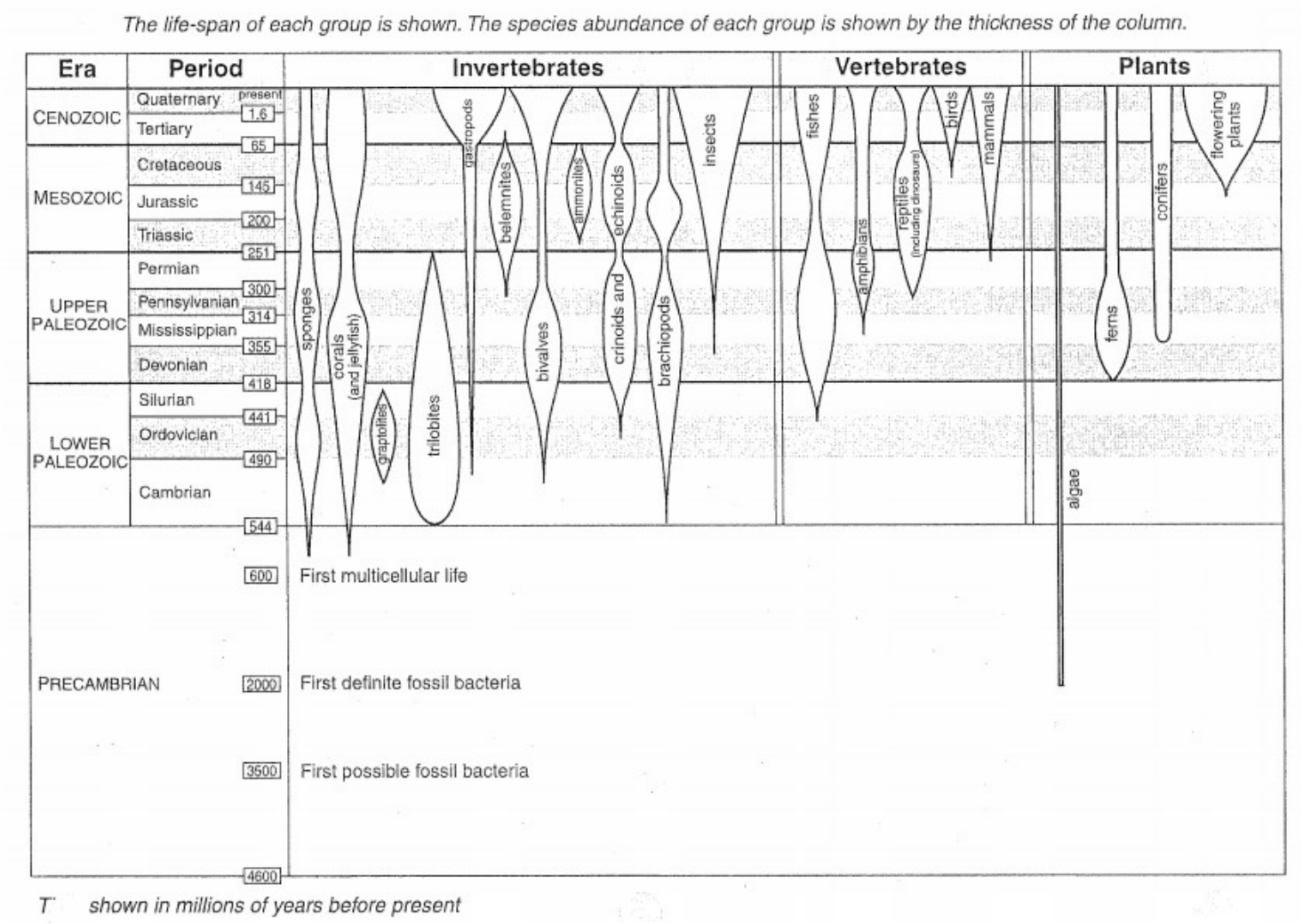
19

Herman Comic



Skull Comic

Development of Life through Time



Fossil Activity (pictures)

Fossil Activity

Use the "Interpreting Earth History" (IEH) lab manual pages 91-101 and 119-131 (5th ed) to fill in the attached fossil id sheet. Find the phylum name, sub name, where they lived (marine, lake, land, etc.), when they lived, if they are extinct or not, what relatives are living today, etc. Write the information in the space provided beside each group of pictures.

GEOLOGICAL TIME SCALE

ERA	PERIOD	EPOCH	TIME m.y.
Cenozoic	Quaternary	Holocene	0.01
		Pleistocene	2
	Tertiary	Pliocene	5
		Miocene	24
		Oligocene	37
		Eocene	58
		Paleocene	66
Mesozoic	Cretaceous		144
	Jurassic		208
	Triassic		245
Paleozoic	Permian		286
	Carboniferous: Pennsylvanian		320
	Carboniferous: Mississippian		360
	Devonian		408
	Silurian		438
	Ordovician		505
	Cambrian		570
Precambrian			4000*

Based on Hamblin, *The Earth's Dynamic Systems*, 1982. Dates from Montgomery, *Physical Geology*, 1987.

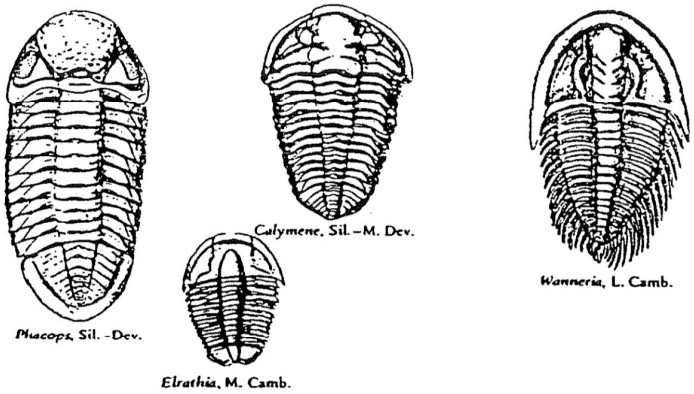
It is recognized that there is some variation in the dates given in the literature.

*Approximate age of the oldest rocks.

20

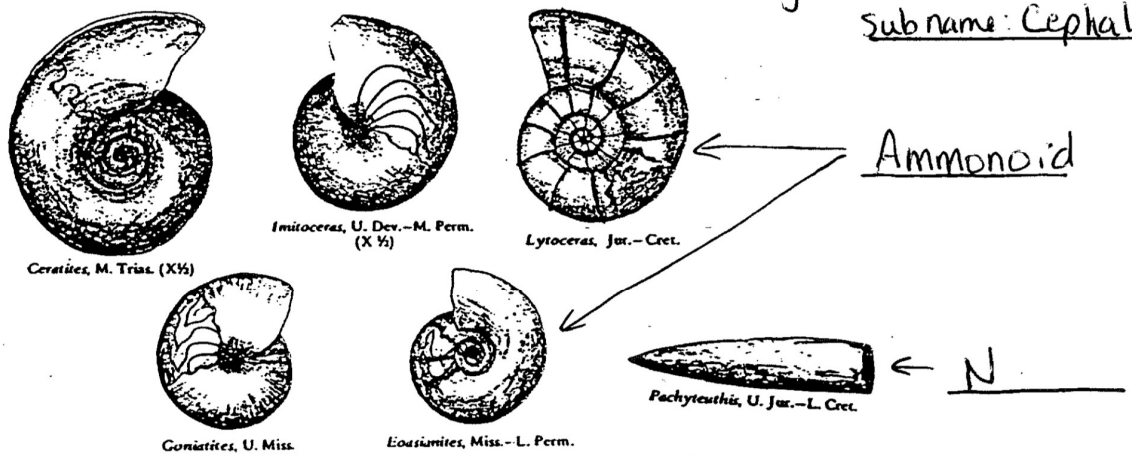
Phylum: Arthropoda

Subname: Trilobite



Phylum: Mollusca

Subname: Cephalopod

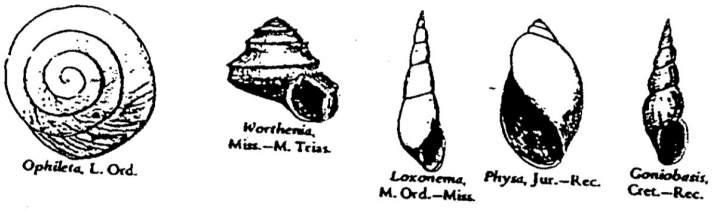


Ammonoid

N

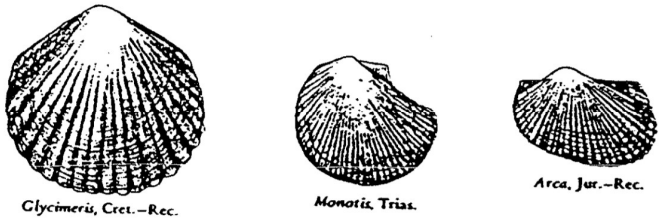
Phylum: Mollusca

G



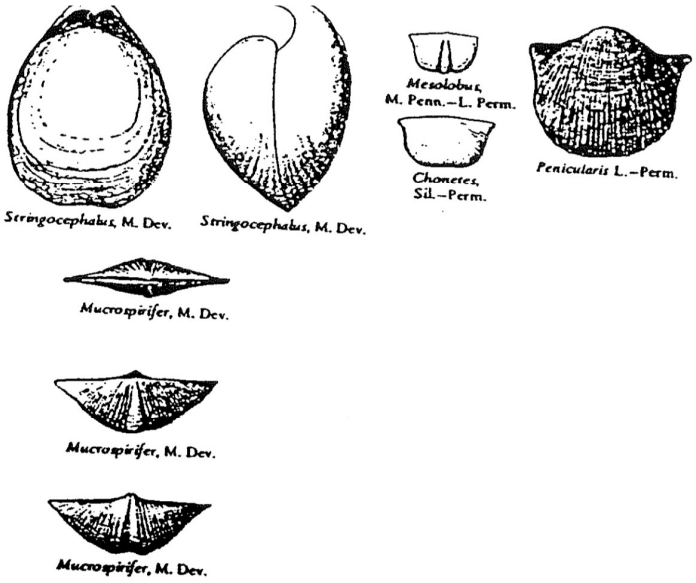
Phylum: M

P

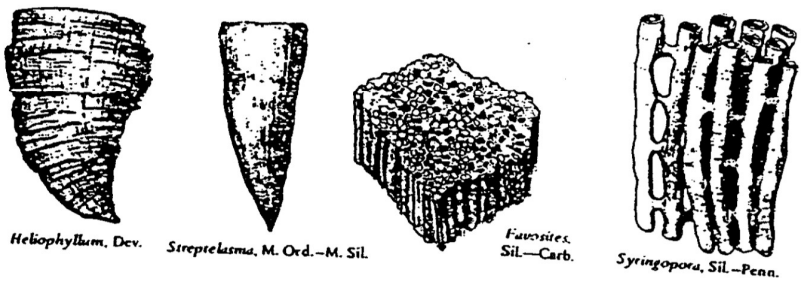


21

Phylum:

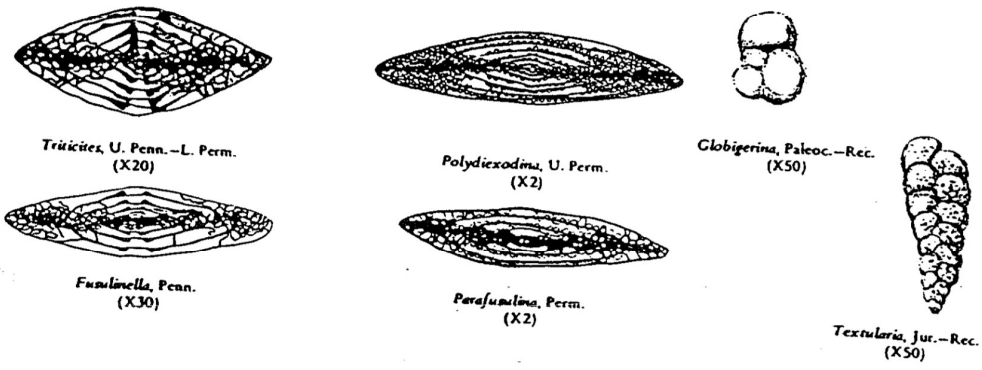


Phylum:



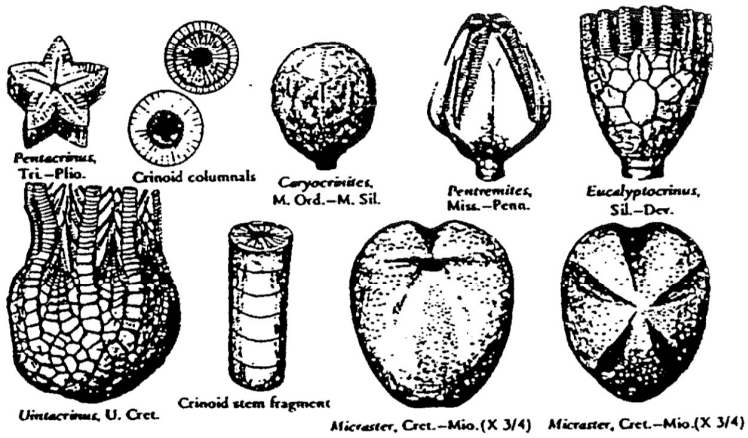
Phylum: Protazoa

F

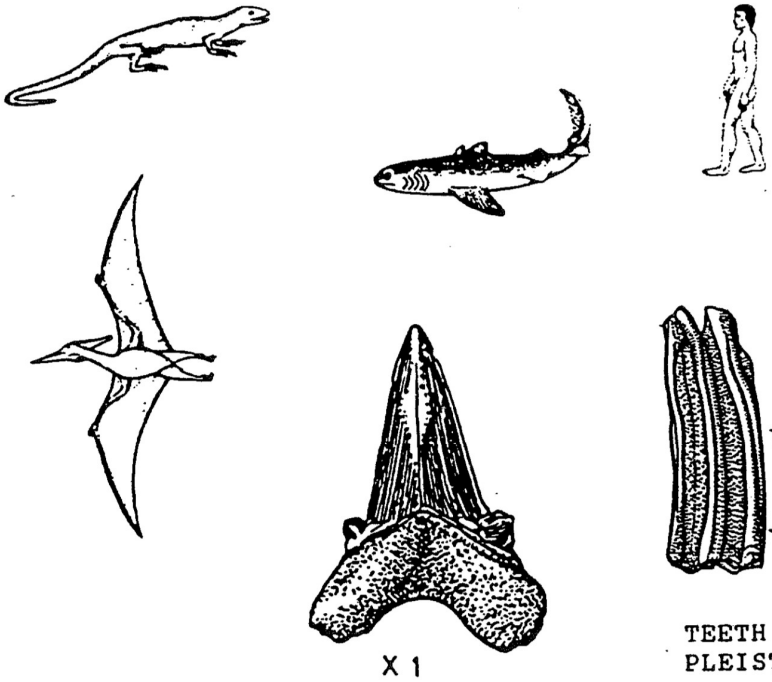


22

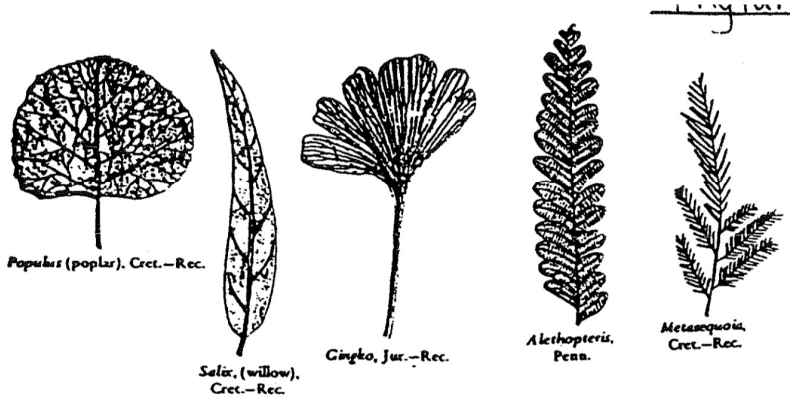
Phylum: _____



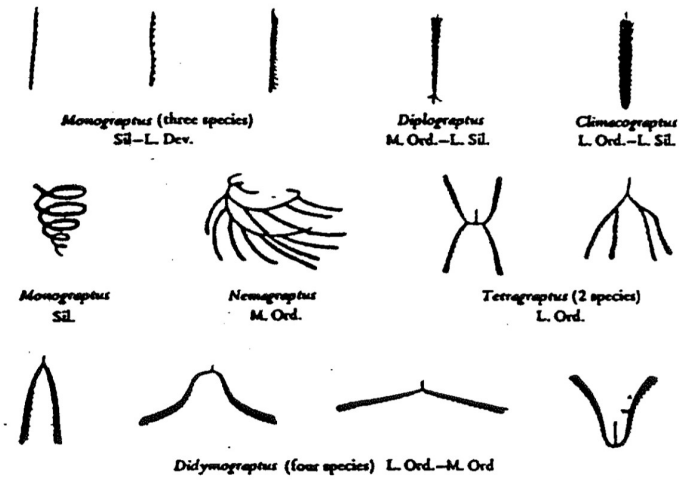
Phylum: _____



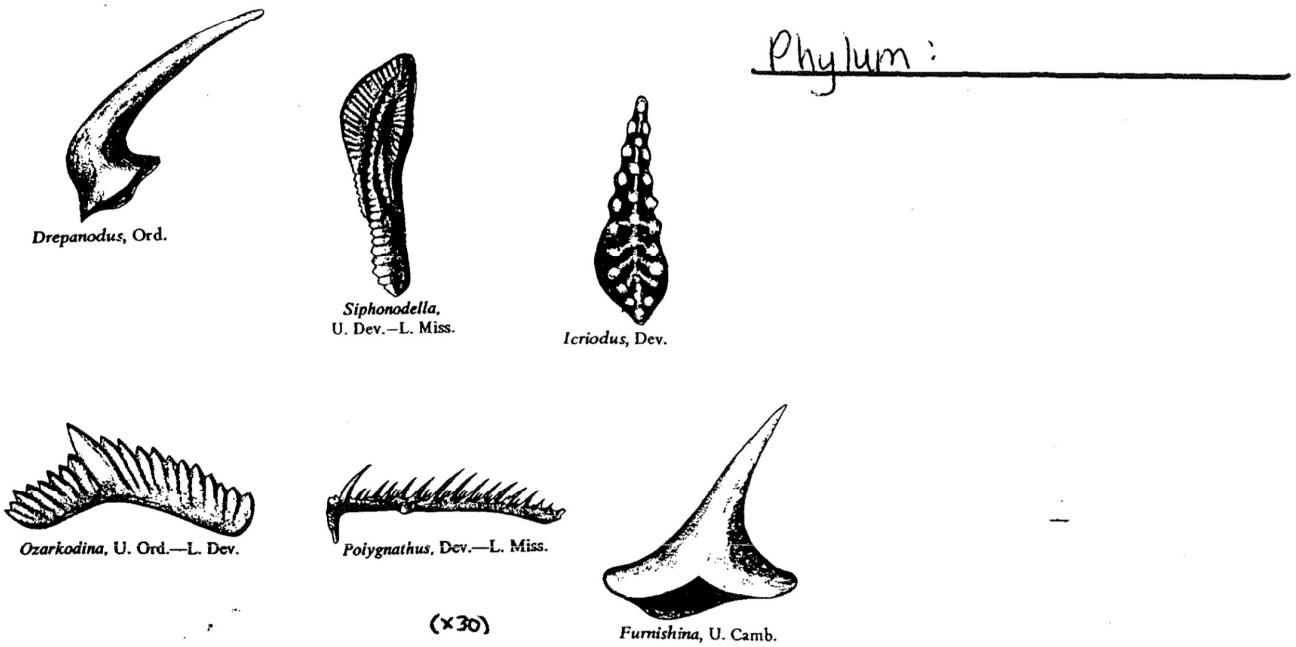
23



Phylum:

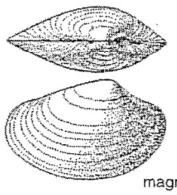
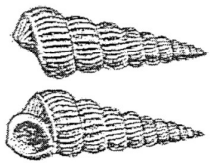
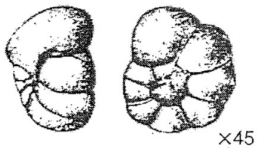
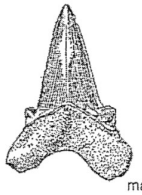
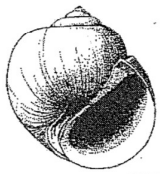
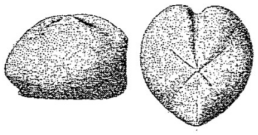
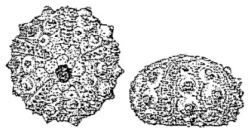
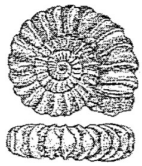
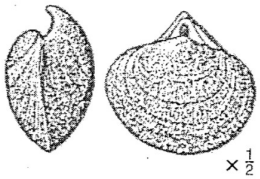
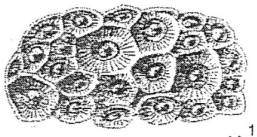
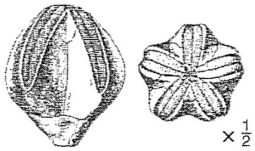
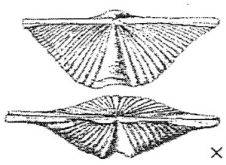
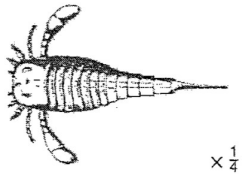
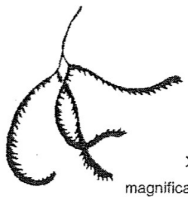
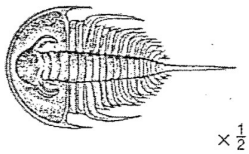


Phylum:



Fossil Samples

Fossil Samples

1 Tertiary (Miocene)  ×½ magnification	2 Tertiary (Oligocene)  ×1 magnification	3 Tertiary (Eocene to Holocene)  ×45 magnification	4 Tertiary (Eocene)  ×½ magnification
5 Tertiary (Paleocene)  ×1 magnification	6 Cretaceous  ×3 magnification	7 Jurassic to Holocene  ×½ magnification	8 Jurassic  ×¼ magnification
9 Triassic  ×½ magnification	10 Permian  ×½ magnification	11 Permian  ×½ magnification	12 Pennsylvanian  ×½ magnification
13 Mississippian  ×½ magnification	14 Mississippian  ×½ magnification	15 Devonian  ×½ magnification	16 Devonian  ×1 magnification
17 Silurian  ×¼ magnification	18 Ordovician to Devonian  ×25 magnification	19 Ordovician  ×½ magnification	20 Cambrian  ×½ magnification

Fossil Activity (specimens)

Fossil Activity: Find a fossil in the set, of the phylum indicated, and complete each row. For some phyla, there are more than one specimen to choose from.

	Phylum	Subname(s)	Period	Location	Diagram of specimen	Google information
1	Vertebrata					
2	Brachiopoda					
3	Mollusca	G				
4	Mollusca	M				
5	Mollusca	C				
6	Echinodermata					
7	Plant					
8	Arthropoda					
9	Cnidaria					

Practice Phyla Quiz

Identify the following:

1.

Phyla:
where lived:

2.

Phyla:
name:

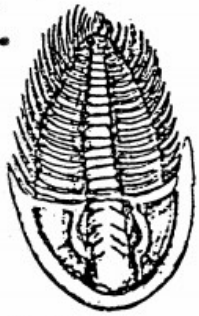
3.

Phyla:
name:

4.

Phyla:
name:

5.

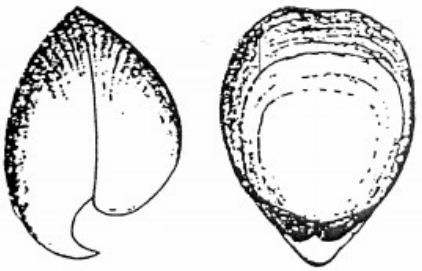


Phyla:
name:
Era:

6.

Phyla:
name:

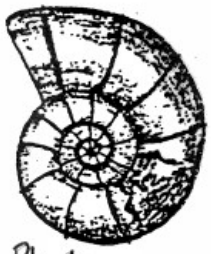
7.



Phyla:
sed. environment (where lived):

Phyla Quiz

1.

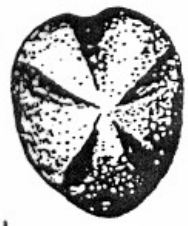


Phyla:
Name:

2.

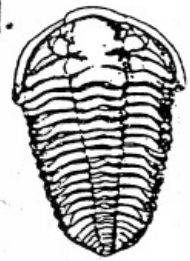
Phyla:
name:

3.



Phyla:

4.



Phyla:
name:
Era dominant:

5.

Phyla:
name:
Common relative:

6.

Phyla:
name:

7.

Phyla:
Era

Faunal Succession Activity

GEOLOGY 12
THE FOSSIL RECORD
FAUNAL SUCCESSION/CORRELATION

STUDENT EXERCISE

A. THE PRINCIPLE OF FAUNAL SUCCESSION

Each successive time interval of earth history has a unique assemblage of fossil types. As a result, rock units can be dated and correlated by analysis of their fossil content and comparison to standard reference sequences. The term **index fossil** is named for those fossils which are useful in age determinations. Index fossils are useful in that they are abundant, have a wide geographic range, and have a rapid evolutionary pattern which results in a short geologic time range which is easy to pinpoint.

Fossils are almost exclusively found in sedimentary rock; therefore, biostratigraphic correlation is ordinarily not possible in igneous or metamorphic rock, and as a result, is limited in its usefulness. As well, where sedimentary rocks do contain fossils (and there are many locations around the world), there is no single place where all strata are found together, complete, and stacked neatly in order, making correlation difficult.

The illustrations in Figure 1 show cross-sections of layered sedimentary rock from different locations. At least one index fossil was found in each layer. The key in Figure 2 gives the type of each index fossil as well as the name of the period of geologic time during which it lived. Note that the time periods are randomly arranged.

PROCEDURES:

1. Cut out the six columns from the sheet provided.
2. Apply your knowledge of the law of superposition, and arrange the columns side-by-side on a blank piece of paper such that fossils are relatively lined up and correlated.
3. Draw lines to show correlation from one locality to another. Note that some fossils disappear in some localities.

QUESTIONS:

1. Explain the absence of some fossils in some localities.
2. List the time periods from Figure 2 in order, from youngest at the top to the oldest.

B. SEDIMENTARY STRUCTURES

PROCEDURE:

Read over the various sedimentary structures and their descriptions on pp 26-33 of the lab text.

QUESTIONS:

1. Which of the structures discussed in this exercise might be useful in helping to distinguish the top from the bottom of a bed?
2. Which of these structures might be useful in determining the direction in which the current flowed?
3. Place an X in the table on the following page under each environment in which the sedimentary structure may form.

Arrange columns and glue onto this page.

Part A

Figure 1

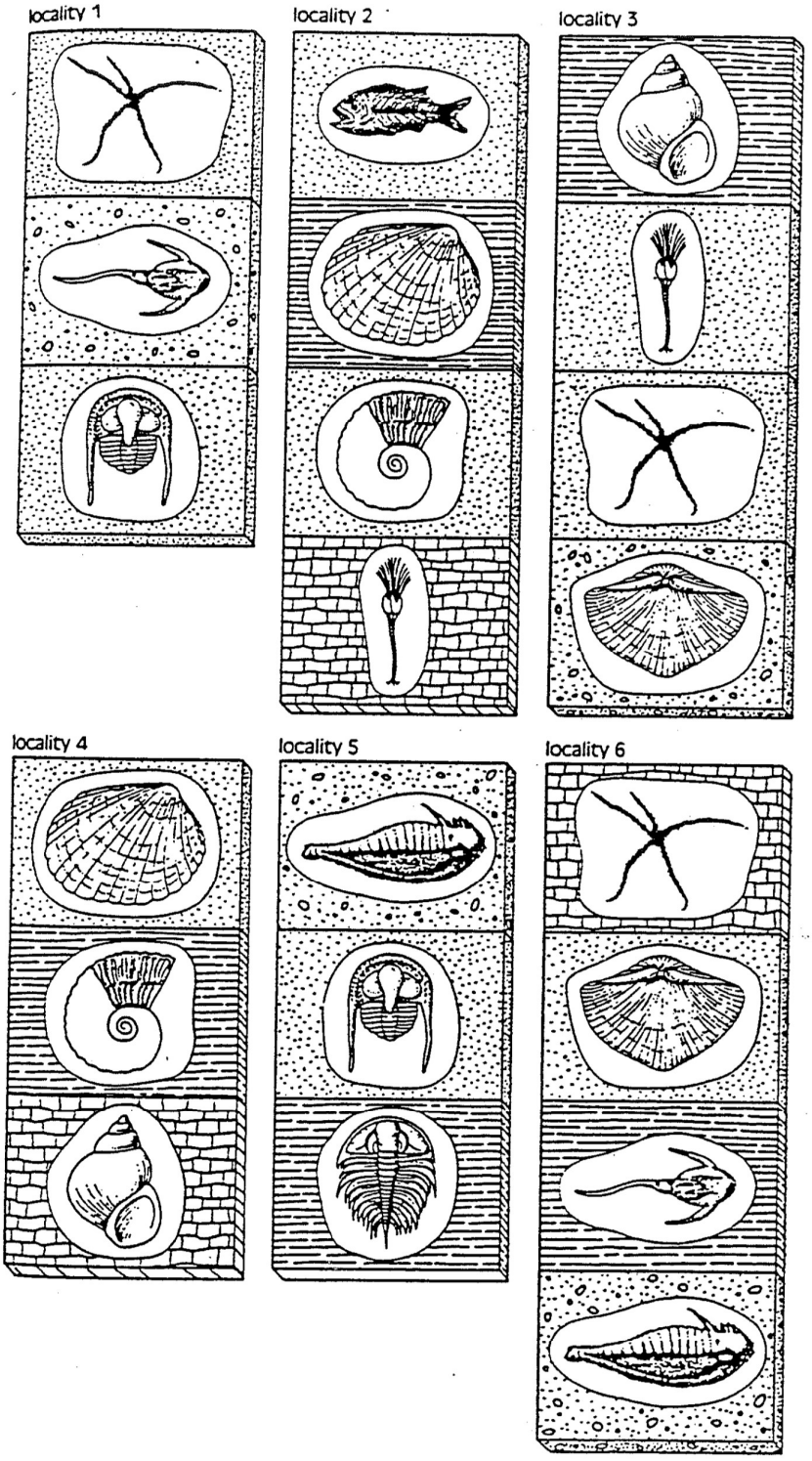
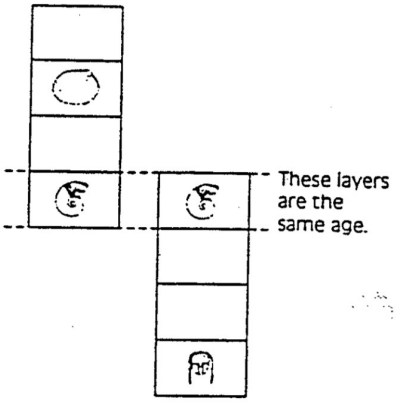


Figure 2
Geological cross-sections representing sedimentary rocks from six localities.

Key

Fossil	Type and period
	crinoid, Permian
	trilobite (*Olenellus*), Cambrian
	jawless fish, Devonian
	starfish, Pennsylvanian
	trilobite, Ordovician
	snail, Triassic
	eurypterid, Silurian
	ammonite, Jurassic
	brachiopod, Mississippian
	bony fish, Cenozoic
	clam, Cretaceous

Align the columns in Figure 1 so that layers of similar age are matched.



Sed Env / Which way is up?

In which environments do these structures form?

Sedimentary structure	River, stream	Shallow sea	Beach	Dry lake bottom	Sand dunes (wind)	Deep sea	Tidal flat
Asymmetrical ripple marks							
Symmetrical ripple marks							
Cross-bedding							
Mudcracks							
Raindrop prints							
Lamination							
Graded bedding							
Flute marks							
Tool marks							
Tracks							
Trails							
Burrows							
Stromatolites							

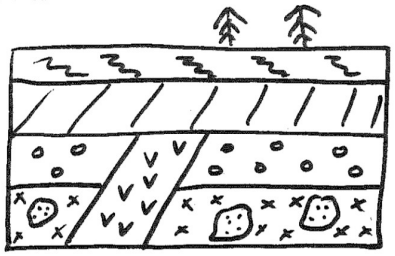
Which way is up?

GEOL 12 C-4

Review Page

Review Questions

1. Put the following in order, where 1 is oldest and 6 is youngest.



2. State the laws used to put the above in order.
3. Where is the unconformity and what kind is it?

4a) If you have $\frac{7}{8}$ daughter and $\frac{1}{8}$ parent, how many half lives have passed?

b) How would you calculate the age if the parent is potassium?

c) What is special about the daughter in this case?

5. If a sedimentary layer is on top of a 5 million year old lava flow and both are cut across by a 3 mill. year old dike, how old is the sed. rock?

6. When did each of the following occur?
   a) fish dominate
   b) earliest life
   c) age of invertebrates

7. What conditions are nec. for fossil preservation?

8. What is the difference btwn replacement and permineralization?

9. List any 5 of the 10 phyla.

10. If a sed. rock has a star fish and coral fossils, what [illegible]

Making a Mold and Cast Fossil

April 25, 2016 9:04 AM

You need:

2 strips of plastecine

something to press into the plastecine

Coat the side to be pressed in, in petroleum jelly - pull it out = mold

Once mold is made then come get wet plaster of paris

Notes: Evolution

May 3, 2016 9:47 AM

Law of Faunal Succession – animal life forms change through time; the same life form is never exactly duplicated independently at two different times in history

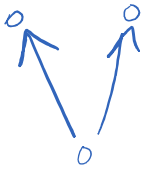
– if exactly the same type of fossil is found in 2 rocks, then those rocks are the same age

→ correlation is possible

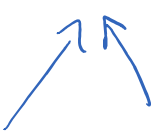
Why do animal life forms change through time?

Principles of Evolution

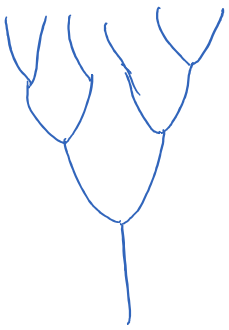
1. Divergence – the separation of single species into two or more groups exploring different habitats



2. Convergence – two or more groups of different species experience similar selective (survival) needs, thus become alike in some traits or features.



3. Adaptive Radiation - Adaptation is the adjustment that a population makes to its environment over a period of time.



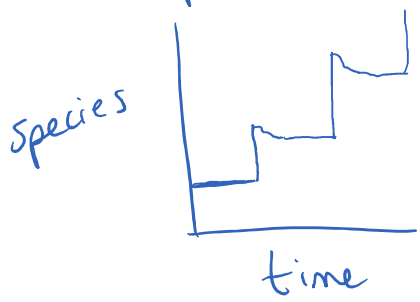
- when members of a single population undergo evolutionary divergence (successive generations become less and less alike) this is adaptive radiation

4. Natural Selection - survival of those organisms best suited to their environment

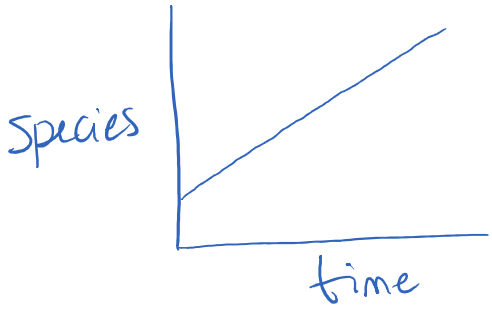
5. Extinction - species that can't adapt die out
   - the extinction of intermediate species helps explain the wide separation between the major groups of animals.

6. Punctuated Equilibrium - a model of the mechanism of evolutionary change that proposed that long periods of no change (status) are punctuated by periods of rapid formation of new species (speciation), followed by natural selection acting on the species.

the species.



7. Gradualism – approaching a desired end by gradual stages



* Difficult to decide between punc. eq. and grad. because many changes occur in the soft parts (muscles, tendons, etc) which don't fossilize easily.

Ch8 + Fossils Test

May 4, 2016 9:36 AM

45 mc
10 marks written

- fossils best in shale (fine sediments)
- unconformity
- relative dating
- radiometric dating (inc. graph to get half life)
- index fossil defn
- fossil recognition
- fossilization methods
- trace fossils
- timescale
- uniformitarianism *
- effective dating ranges. (see chart of isotope pairs)
- "up" direction
- evolution

W: how rad. dating works ... parent/daughter/h.l./Age ...
soft parts fossilization conditions
disconformity vs angular conformity
Solar System formation --- Earth ---

****Masters****

April 12, 2016 11:09 AM

Notes: Relative Dating

Relative Dating Exercises

Geology 12
Geologic Time

Relative Ages Exercise.

The following 9 cross sections represent hypothetical strata of the earth. Write your answers in the space beside each section.

Questions.

1. (a) State the Law of Superposition.
   (b) List the strata in order from oldest to youngest. (It is convention to always list from oldest to youngest or to write in a column with the youngest at the top.)

2. (a) Complete the list in the column.
   (b) Which event occured first?
   (c) Which event occured last?
   (d) State the Law of Original Horizontality.

3. (a) Complete the list.
   (b) What occured at P ?
   (c) What is a feature like P called?

4. (a) What occured first?
   (b) What occured between the deposition of A and K ?
   (c) What was the last event to have occured?

5. (a) Complete the list.
   (b) How do you know where to put A in the series?
   (c) What is A called?

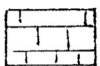
6. (a) Complete the list.
   (b) What occured at Y ?
   (c) What could have occured between B and C ?
   (d) When did the tilting take place compared to dyke X ? How do you know?

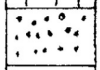
7. (a) Which is the oldest?
   (b) What is Z ? What type? How do you know?
   (c) What happened between X and N ?

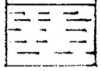
8. (a) List in conventional order.
   (b) What type of feature is E ?
   (c) What would you notice along the margins of A ? Why?
   (d) BONUS: Name the type of rock you would probably find between C and A.

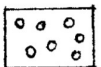
9. (a) List the Igneous activity in order from oldest to youngest.
   (b) What are two pieces of evidence for the order of dykes C and D ?

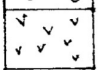
Legend for Rock Types:

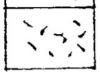
Limestone - 

Sandstone - 

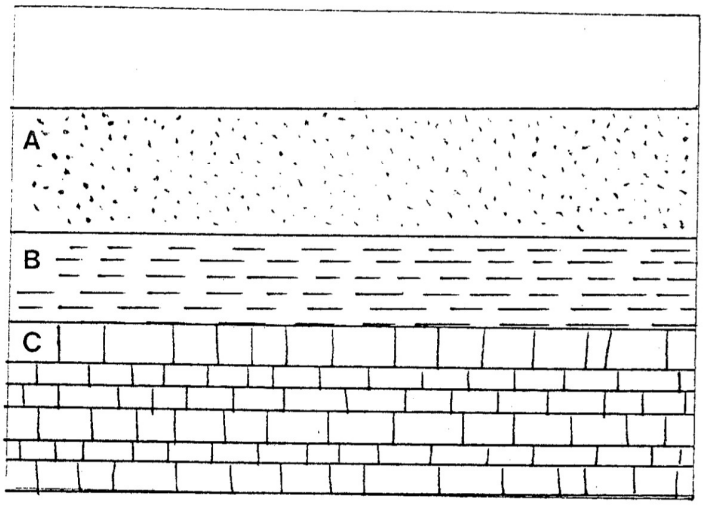
Shale - 

Conglomerate - 

Volcanic - 

Plutonic - 

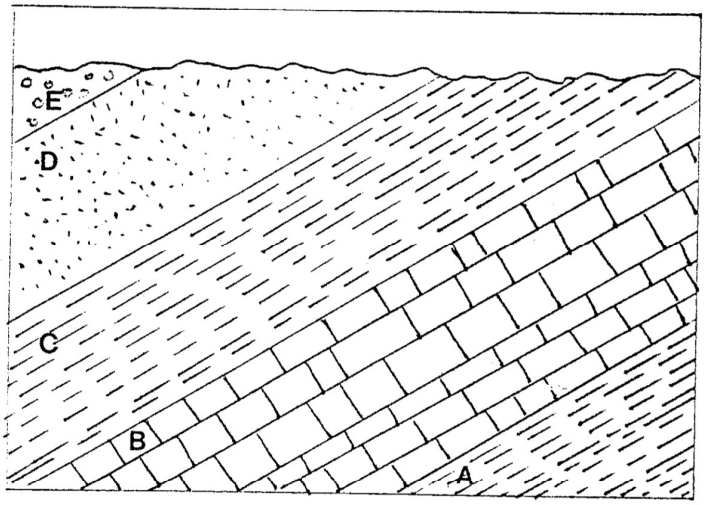
1.



(a) _____

(b) _____

2



(a) youngest _____

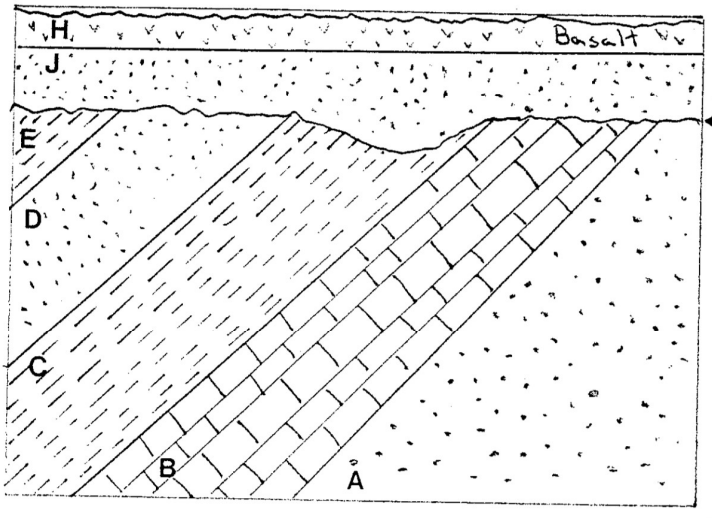
oldest _____

(b) _____

(c) _____

(d) _____

3



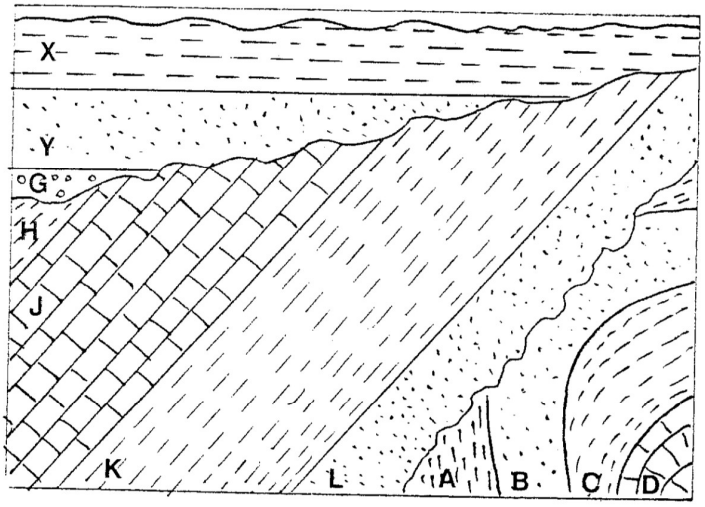
(a) youngest _____

oldest _____

(b) _____

(c) _____

4.

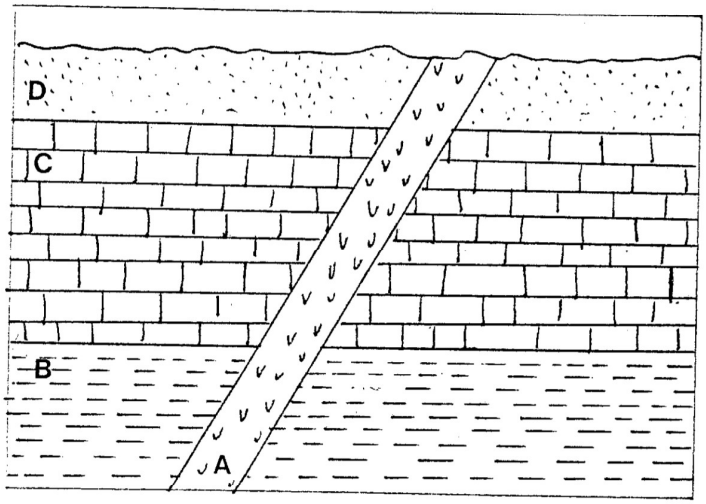


(a) _____

(b) _____

(c) _____

5 _____

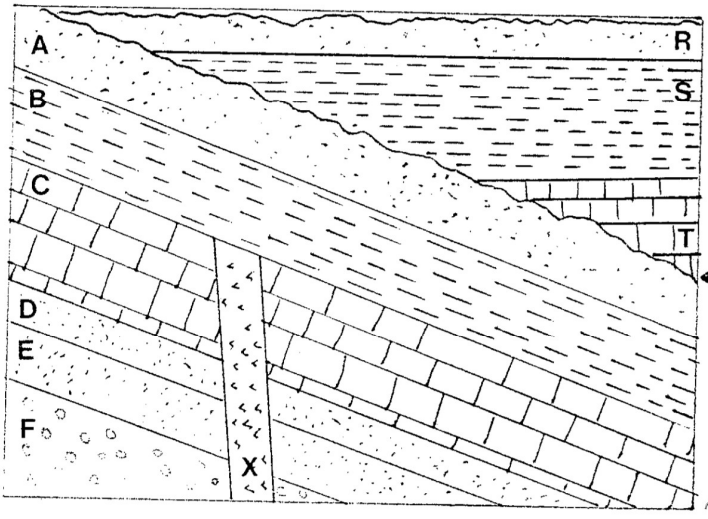


(a) youngest _____

(b) _____

(c) _____

6 _____



(a) _____ youngest

_____ oldest

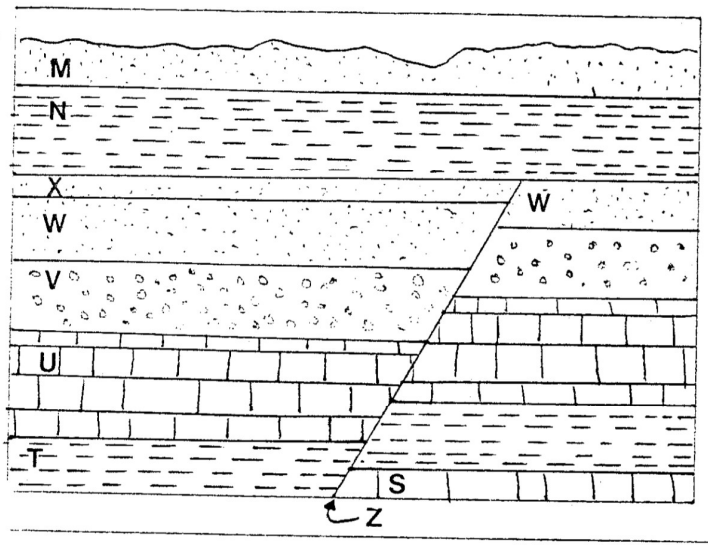
(b) _____

(c) _____

(d) _____

2

7.

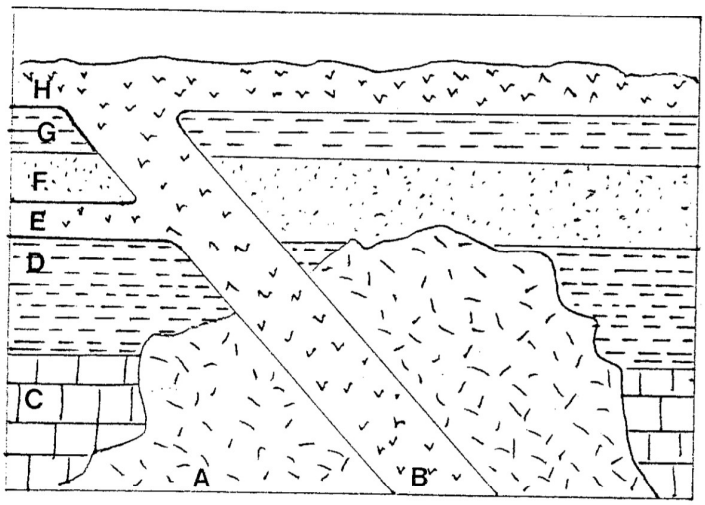


(a) _____

(b) _____

(c) _____

8



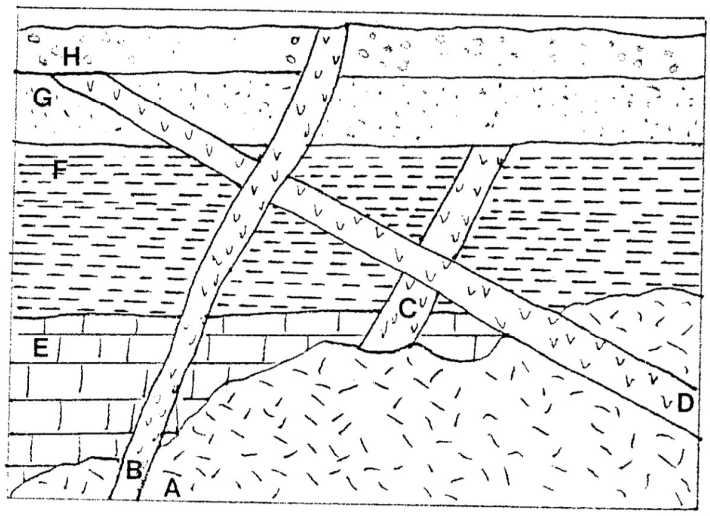
(a) _____

(b) _____

(c) _____

(d) Bonus, _____

9



(a) _____

(b) _____

4

GEOLOGY 12 Name _____

CHAPTER 8

EXERCISE 13 DATING OF ROCKS AND GEOLOGIC EVENTS

- Refer to the lab manual pages 196-204.
- Review and make notes on the background information as necessary.
- Complete question #3 page 200 and #5 on page 202.

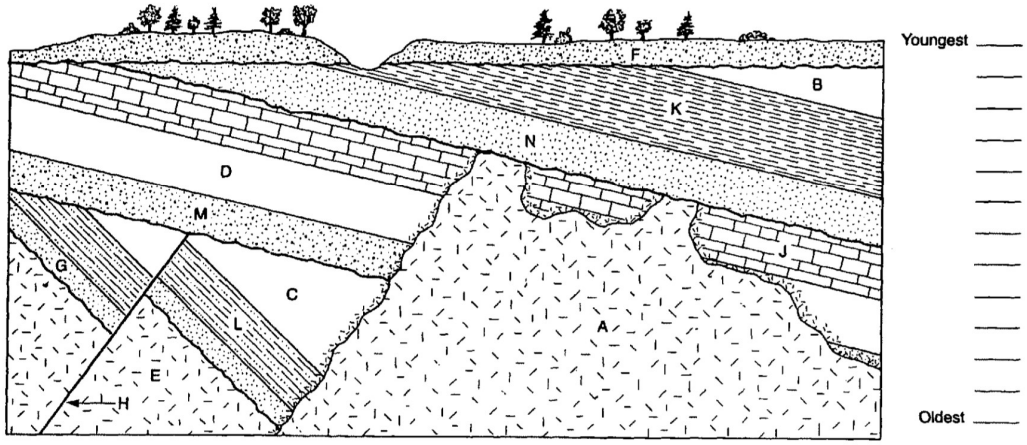


Figure 13.14

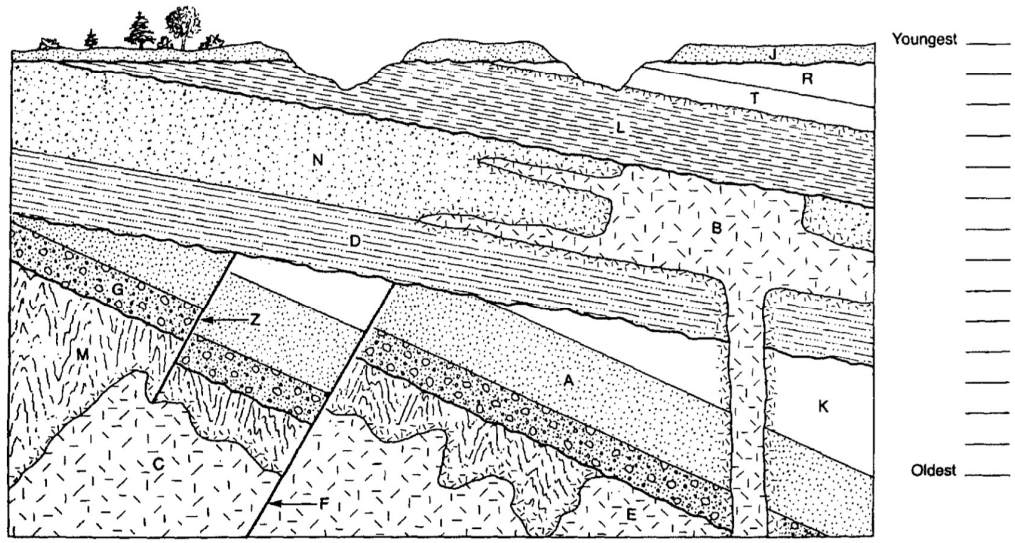


Figure 13.15

5

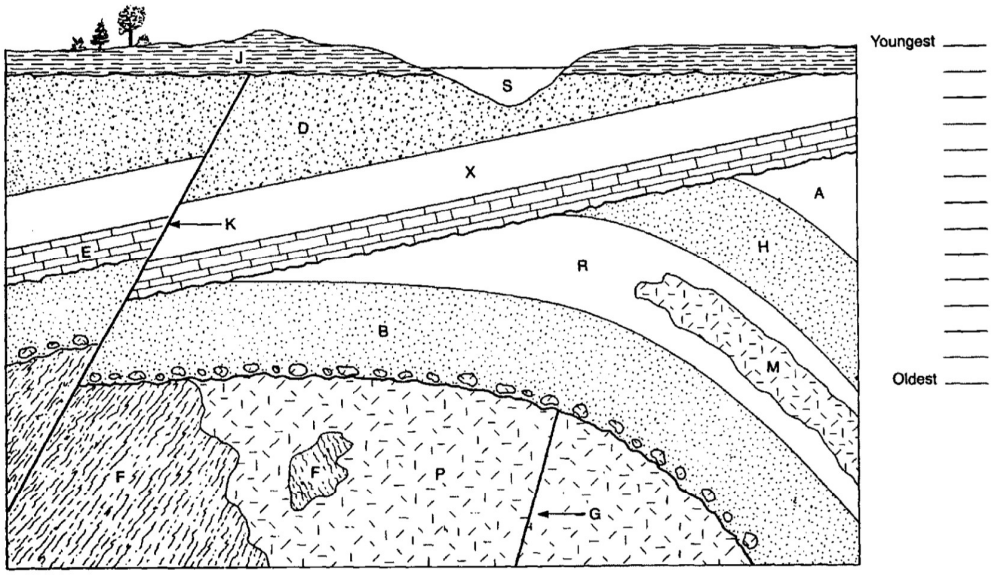


Figure 13.16

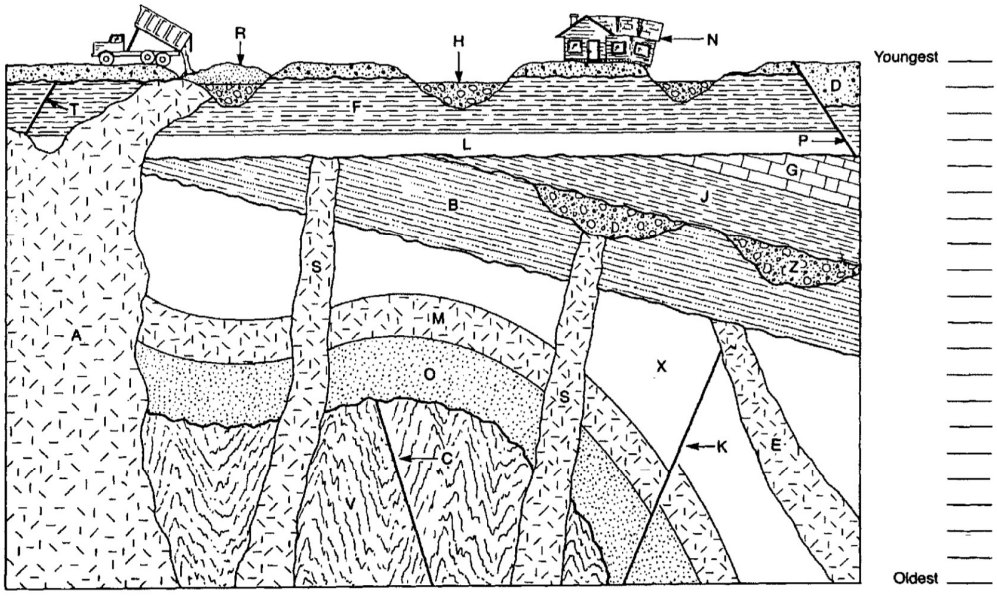


Figure 13.17

- Attach your answers to question #5 and submit for marks.

6

Notes: Radiometric Dating

Radiometric Dating Exercises

Geology 12
Radiometric Dating **Name:**

Set Up:

- Use as much of the graph paper as possible (make a big graph)
- Label the X-axis with number of half lives (0, 1, 2, … 10)
- Label the Y-axis with number of parent atoms (1 to 1000)

Drawing the Graph:

- Begin with 1000 atoms of radioactive parent element and 0 atoms of stable daughter product.
- Plot points to draw the decay curve, showing the decrease in the number of parent atoms through ten half lives.
- Draw in the decay curve using a SMOOTH curve
- Plot points to draw the accumulation curve, showing the increase in the number of atoms of stable daughter product through ten half lives
- Draw in the accumulation curve using a SMOOTH curve
- Note: the half life of the radioactive element you graphed is given as 5730 years.

Questions based on your graph:

1. How many years are equal to 5 half lives?
2. How many parent atoms will be left after 5 half lives?
3. How many daughter atoms will be accumulated after 5 half lives?
4. At what point in time (number of half lives) will the number of parent atoms be equal to the number of daughter atoms?
5. At what point in time (number of years for this sample) will the number of parent atoms be equal to the number of daughter atoms?
6. At what point in time (number of half lives) will the number of daughter atoms be exactly three times the number of parent atoms?
7. How many half lives equals 22,920 years?
8. What element has a half life of 5730 years?
9. What is the stable daughter product of this element?
10. If you have 125 atoms of parent, how many daughter atoms will be present in this example?
11. If you have 125 atoms of parent, how old (number of years) is the sample?

General Questions:

12. Define half life.

13. How many half lives have passed if a rock sample has:

    - 50% daughter and 50% parent?
    - 150 stable and 50 radioactive atoms?
    - 7/8 daughter and 1/8 parent?

14. What is the formula for calculating the age of a rock?

15. Calculate the ages for the above samples if the half life is 5 million years.

16. True or false: uranium 238 dating can be used to find the age of a dinosaur bone?

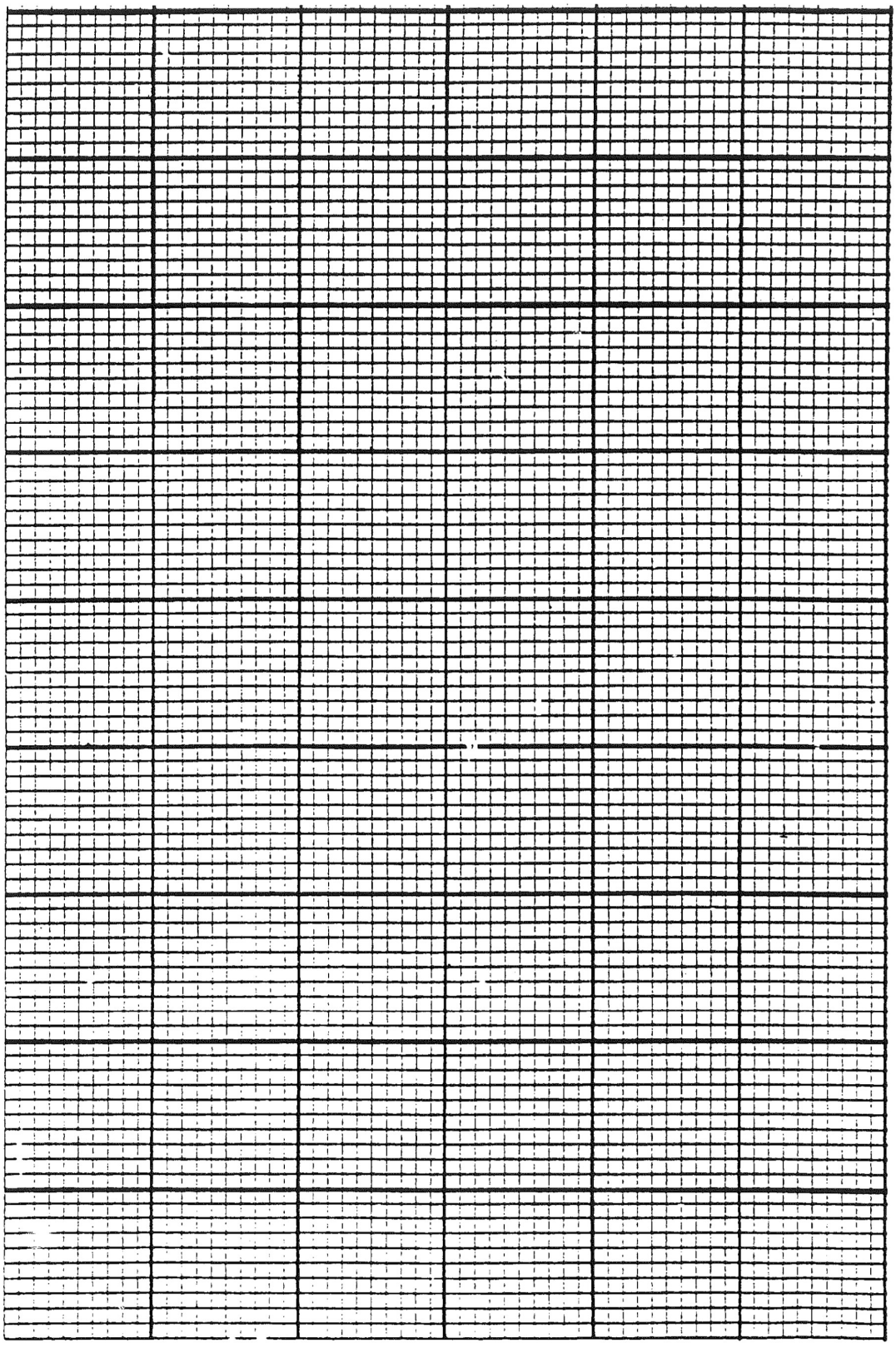
17. True or false: Carbon 14 can be used to find the age of a dinosaur bone?

18. A piece of *wood* found in an ancient tomb has a ratio of 1 parent to 15 daughters.

    - How many half lives have passed?
    - How old is the wood?

19. Explain in detail how to find the age of a rock using radiometric dating.

20. Make up a radiometric dating question and have your partner find the age.



Name:_____

Radiometric Dating

1. a. If a sample started with 100% parent and now has 75% daughter and 25% parent, how many half lives have passed?

   b. If one half life is 7 million years, how old is the sample?

2. How long has a tree been dead if there is an equal amount of carbon-14 as nitrogen-14?

3. How much uranium-238 should be left on Earth compared to what was here when Earth formed 4.5 billion years ago?

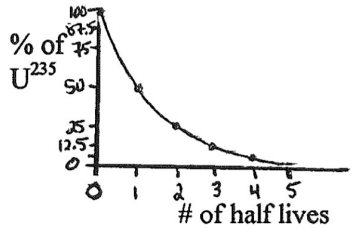
4. a. An igneous rock from some distant galaxy (brought here by aliens) contains 8 parents and 56 daughter atoms. How many half lives have passed?

   b. If the parent is rubidium-87 and the daughter is strontium-87, how old is the sample? (Is this possible in our universe?!)

5. a. There was an earthquake that caused a rock containing argon-40 to fracture. Some of the argon escaped. How?

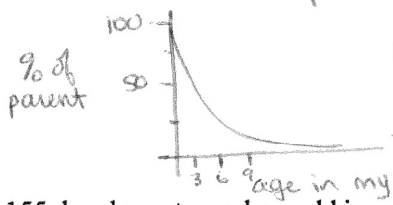
   b. What effect will this have on the apparent age of the rock? Will it look younger or older than it should? Explain.

6. (a) Given the following graph, how old is a sample that contains 6.25% parent and 93.75% daughter?



b) What is the age of a rock if 75% is still parent (radioactive)

c) draw a daughter curve.



7. If a piece of paper contains 5 parent atoms and 155 daughter atoms, how old is it? (Hint: what isotope must be being referred to in this case?)

8. If the daughter to parent ratio is 7, how many half lives have passed? How old would the sample be if the parent were thorium-232 and the daughter lead-208?

c:geolradd

WS Relative & Absolute Time

GEOLOGY 12 Name _____

CHAPTER 8 WORKSHEET #2

RELATIVE TIME AND ABSOLUTE TIME

Match the descriptions on the right to the persons on the left. Place the letter of the corresponding description in the blank by each name. You may use some descriptions more than once.

_____ 1. Henri Becquerel
_____ 2. Lord Kelvin (reworked Buffon's)
_____ 3. Nicholas Steno
_____ 4. Georges Buffon
_____ 5. John Joly
_____ 6. William Smith
_____ 7. Archbishop Ussher
_____ 8. C.D. Walcott

A. calculated age of earth from number of generations in the Bible
B. proposed the Law of Faunal Succession
C. calculated age of earth based on cooling rate of the earth from an initially molten state
D. proposed the principles of Superposition and Original Horizontality
E. discovered radioactivity of uranium
F. calculated age of earth based on rates of sedimentation
G. calculated age of earth based on amount of salt in the oceans
H. calculated age of earth based on rate of "burning" of the sun – Kant

For fun...

9. After two half-lives, how much radioactive parent isotope will be left in a given mineral?
   A. 133% B. 50% C. 25% D. 33%

10. If the ratio of daughter isotope to parent isotope is 7, how many half-lives have passed?
   A. can't tell from information given
   B. seven
   C. one
   D. three

11. As each half-life passes, the amount of daughter product will
   A. decrease by half each time
   B. increase by doubling each time
   C. never exceed the amount of parent isotope remaining
   D. increase by the amount of parent isotope which has decayed

12. A mineral being used for radiometric dating contains 600 units of the daughter isotope and 200 units of radioactive parent isotope. How many half-lives have passed?
   A. two
   B. none
   C. three
   D. can't tell from the information given

13. A mineral contains an amount of daughter isotope equal to the amount of radioactive isotope remaining in it. The half-life for the radioactive isotope is 250 million years. How old is the mineral?
   A. 250 million years
   B. 125 million years
   C. 500 million years
   D. just formed; no decay has occurred

14. Rubidium-87 has a half-life of 48.8 billion years. Let's assume that radioactive rubidium would be safe to be around if there was less than 1/64 the original number of radioactive atoms left. How many years would that take?
   A. about 800,000 years
   B. a little over 290 billion years
   C. about 3200 million years
   D. cannot be calculated from the information given

11

15. Placing rocks or geological events in their proper time order is known as _____.
16. In a sequence of sedimentary rock layers, the _____ rock is always on the bottom.
17. Sedimentary rocks, which are now folded or otherwise deformed, initially were deposited as _____ layers of sediments.
18. A _____ is a type of unconformity in which sedimentary rock layers are parallel above and below it.
19. An igneous dike or pluton is _____ in age than the rocks which it cuts across.
20. The Law of Faunal Succession is useful because it allows geologists to correlate rock layers based on the _____ they contain.
21. In the nineteenth century, the age of the earth was thought to be considerably _____ than it is today.
22. Radioactive decay affects the numbers of protons and neutrons in the _____ of an atom.
23. Each _____ particle consists of two protons and two neutrons.
24. _____ particles may be electrons or positrons.
25. Gamma rays are a form of _____ radiation, similar to X-rays.
26. A _____ is used to measure the tiny amounts of parent and daughter isotopes in radiometric age dating.
27. Radioactive decay is a _____ phenomenon, "obeying" the laws of probability.
28. Potassium-40 will decay to the daughter isotope _____.
29. Uranium-235 will decay to the daughter isotope _____.
30. Of the radioactive isotopes used for age dating rocks, _____ has the longest half-life.
31. _____, which has an extremely short half-life by geologic standards, is used primarily for age dating archeological artifacts.
32. If some of the daughter product has escaped from a mineral since the time that radioactive decay started, the derived age of the mineral (or rock) will appear to be too _____.
33. The era of the geologic time scale that represents "middle life" is the _____.
34. The shortest and most recent era of the time scale is the _____.
35. Arrange the terms in order by age from oldest to youngest, as they are arranged in the geologic time scale : Paleozoic, Proterozoic, Cenozoic, Mesozoic, Archean

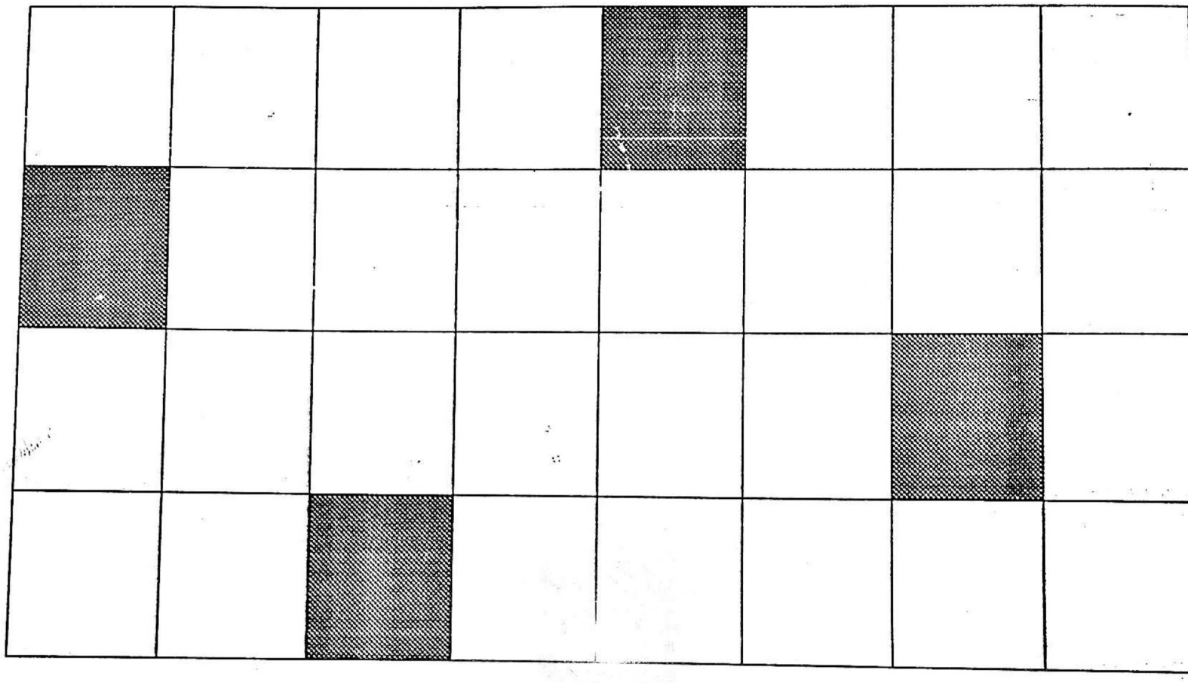
_____
_____
_____
Proterozoic
Archaen
} Precambrian

12

Beginning Activity

Radiometric Decay overhead question:

Use the following diagram representing decayed (white) and undecayed (grey) atoms in a sample to answer the questions below:



If the half life is ~~704 million~~ 1.25 billion years:

a. What radioisotope is represented?
b. How many half lives have passed?
c. How old is the sample?
d. How many parents (undecayed) were there when the rock first formed (before the isotope began to decay?)
e. Draw a graph showing the decay curve for the parent as well as a curve for the increasing daughter.

Macaroni Quiz

(in handouts for practice)

Name:_____

Radiometric Dating Quiz

Find the age, in years, of your sample. Show all your work in the space indicated.

Sample Number: _____

Each bag contains a sample representing a parent isotope and its stable daughter.

Parent:	^{28}Ma	macaronium 28 (natural colour)
Daughter:	^{24}Pa	pastanium 24 (green colour)

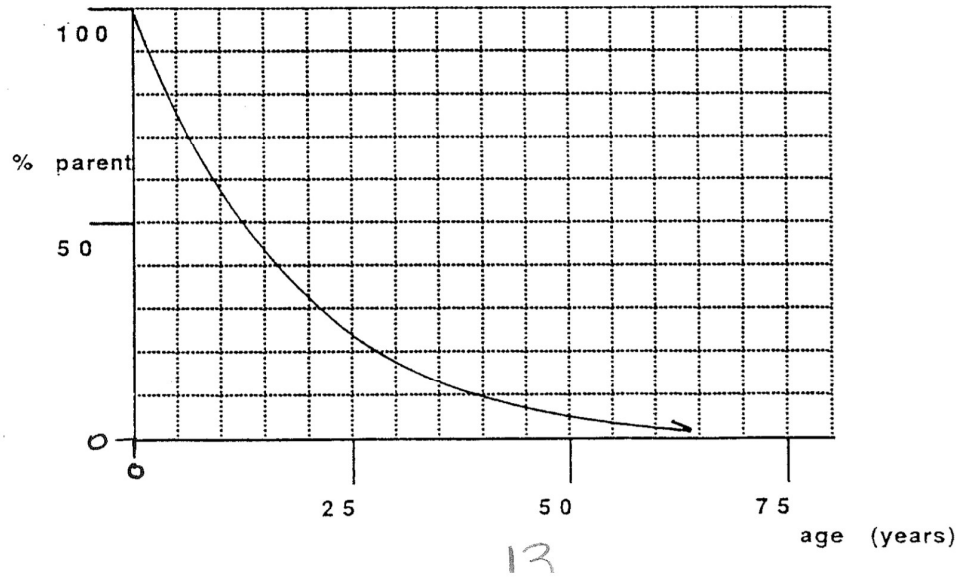
Caution: The atoms are fragile and not edible!

The decay curve for ^{28}Ma is given below.

SHOW ALL CALCULATIONS USED TO FIND THE AGE IN A NEAT ARRANGEMENT IN THIS SPACE.

Radiometric Age:_____

Bonus: Sketch the curve for the stable daughter on the graph.



3

13

Notes: Ch 8 Continued

Name:_____

Chapter 8 Notes Continued

The Geologic Time Scale

The eon called the Phanerozoic takes up less than __% of Earth's history and includes the following eras: Cenozoic - recent life, the age of the _____
Mesozoic - middle life, the age of the _____
Paleozoic - ancient life, the age of the _____

Eras are subdivided into _____ and the periods of the Cenozoic into _____.

The names of periods and epochs are for the place where rocks of that age were well exposed and that time unit was consequently first defined.

The first divisions were done from _____, then radiometric dating (of dikes, etc. that cut through the sedimentary layers) gave _____.

Precise dates for the Phanerozoic is difficult because
- sed. rocks and fossils can't readily be _____ so had to approach it indirectly by determining age limits and making correlations
- radiometric dating has some uncertainty (between 1 and ___%)

The Precambrian includes the __ billion years of time before the Phanerozoic. There were basically no fossils to give a basis for divisions so it was divided into two parts (Archean and Proterozoic) almost arbitrarily. There was widespread igneous activity and mountain building but no single event of global impact.

See the Geological Time Scale, page 164 in text.

How old is the Earth? - A better answer.

No _____ have been preserved unchanged on Earth but we believe the sun, moon, meteorites, etc. formed at the same ____:
moon sample ~ ___ billion years old
meteorite sample ~ _____ billion years old
gives us that the earth is ~ ____ billion years old

Oldest earth material is ___ billion years. Oldest rocks on each continent between 3.6 and 3.9 billion years. Why none at 4.55 billion years old?
- radiometric clocks start when rocks _____ (maybe was molten for long time.)
- rock cycle has been acting since the beginning, changing most rocks at least ____

Earth's History - Quick Summary

Universe
- Big Bang occurred _____ billion years ago, still expanding, open/closed?

14

Stars
- Matter not uniformly distributed so clumps join together due to _____, star is born
- stars burn up their fuel, create _____ elements, supernovae (blow up), spread heavy elements through space
- our earth and sun are made up of matter that likely was cycled through several generations of _____.

Solar System
- our sun is _____ aged, 5 billion years old, 5 billion years to go
- cloud of dust and gas condensed, most mass condensed to form ____, rest into planets
- composition of planets depends on how _____ they are to sun, higher T materials nearest sun (Fe, etc.), "gases" (solid H, He, lighter elements) farther out

Earth
- dust ball condensed; heated by collisions of particles, compression by gravity and radioactive elements so most of the Earth was _____
- slowly cooled, heavy iron _____, light elements _____ making the core, mantle, crust 4 billion years ago
- as cooled, water _____ in atmosphere
- early atmosphere contained almost no _____, blue-green algae and formation of limestone supplied oxygen
- many changes have occurred since _____ formed - continents moved, volcanoes, mountains, erosion, . . .

<u>Life on Earth</u>

0.5 million yrs ago	modern, rational Homo Sapiens, _____ impact in short time!
3-4 million	the most primitive _____ developed
65 million	mammals become dominant (dinosaurs decline)
150 million	warm blooded animals _____ (birds)
200 million	dinosaurs and 1st mammals
400 million	insects, amphibians and reptiles onto continents
400-500 million	animals with backbones (_____) and land plants
600 million	marine animals with shells widespread
1 billion	1st multicelled, soft bodied, oxygen breathing creatures, poorly preserved, _____ fossils
4.6 billion yrs ago	formation of the earth

The practical aspects of learning this is that _____ sources come from old plants and animals. If you know the time they lived then you know where to mine.

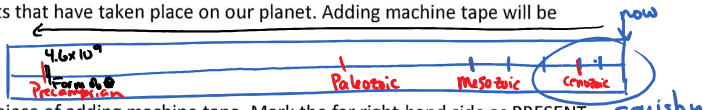
<u>Dating and Geologic Process Rates</u>
Continents move ~___cm/yr relative to magnetic poles
Uplift rates ~___cm/yr in mountain ranges, erosion rates similar
Must be cautious about extrapolating _____ process rates into past or future!
read page 170

15

Time Scale Exercise

Geology 12
Geologic Time Scale Exercise Name: _____

Preliminary Information:
The easiest way to visualize the vast amount of time that the Earth and its past present life forms have existed is by means of a Time Line. In this exercise, you will be constructing a time line which will indicate some of the major events that have taken place on our planet. Adding machine tape will be used to plot such a line.



squishy

Procedure:

1. Obtain a 2.5 meter long piece of adding machine tape. Mark the far right-hand side as PRESENT, in red.
2. Using a scale of "1mm = 2 x 10^6 years (2 million)", plot the following by measuring back in time to the left.
   a. The Phanerozoic portion of the time scale, along with all its divisions, on the top edge of the tape.
      i. Eras marked in Red
      ii. Periods marked in Blue
      iii. Epochs marked in Green
   b. Arrange all of the following event s, in order, in black or pencil on the bottom edge of the tape. **Note** the events in the list are not completely in order right now.

Event	Time (Years ago)
Formation of the earth	4.6 x 10^9
First known algae and fungi appear	4.0 x 10^9
First invertebrates appear	570 x 10^6
First fish appear	500 x 10^6
First reptiles appear	300 x 10^6
First amphibians appear	400 x 10^6
First mammals appear	200 x 10^6
First man-like animal	2.5 x 10^6
Pleistocene glaciations (most recent)	1.0 x 10^6
Pacific Coast Orogeny (mountain building)	70 x 10^6
Appalachian mountain building	350 x 10^6
First known plants appear	3.2 x 10^9
First known animals appear	1.2 x 10^9
Oldest rocks on the planet	3.9 x 10^9
First dinosaurs appear	225 x 10^6
Last dinosaurs disappear	66 x 10^6
Age of Canada	1.5 x 10^2
Your birth	_____ = 0 mm

$\frac{4.6 \times 10^3}{2 \times 10^6} = 2.3 \times 10^3$ mm = 2300 mm = 230 cm

$\frac{570 \times 10^6}{2 \times 10^6} = 285$ mm = 28.5 cm

careful with the numbers... they are not in order

$\frac{1.5 \times 10^2}{2 \times 10^6} = \frac{0.000\,15}{2} = 0$ mm

3. Be sure to be creative – add pictures and drawings to your timeline!

16

Notes: Relative Dating with Fossils

Relative Dating with Fossils

-Fossils are used to determine the age of rocks by the **Principle of**_____
Life forms change through time so ... "Rocks are the same _____ if they contain exactly the same type of _____ organism"

-This allowed geologists to relate rock bodies, or a_____/_____of rock, located in different areas of the world—called "_____"

-In identifying the habitat and lifestyles of _____ organisms, we assume that the _____ _____ and _____ laws have always operated (maybe at different _____.)

-By observing _____ processes, we can understand the _____ history and development of the earth and its inhabitants.

-This theory is called_____

-"The present is the key to the past"

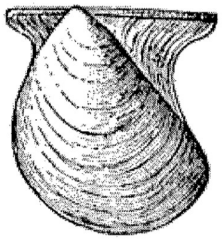
Definition of Fossil:
Fossils are only found in _____ rock. Why?

Process of original preservation:

-most fossils are only partial remains of plants or animals, generally the _____ of the organism that was buried _____ and preserved from _____. Hard parts like _____, _____ and _____ may be preserved.

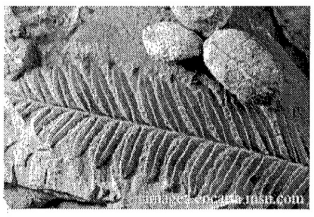
Fossilization Processes:

1. _____



-Given enough time, even the hard parts of fossil may _____leaving a cavity in the hard surrounding sediment. This fossil _____is called a _____. The mold of the interior of a shell formed when a shell fills with _____, hardens, and then becomes _____ of the surrounding shell.
-Trapped insects leave molds in_____(hardened _____.)

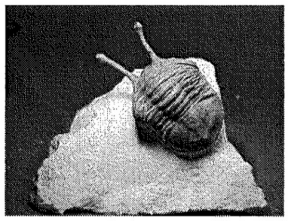
2. _____



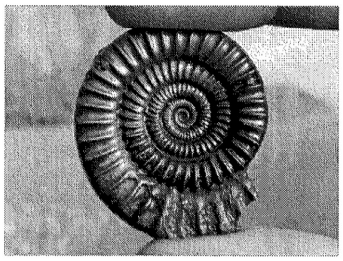
-If other sediment _____ the mold and lithifies, a matching_____ is formed.
-No _____ can be seen with this type of fossilization
-This is the most common mode of_____of many _____ fossils
e.g. _____, _____

17

3. _____
–The removal of other elements leaving the _____ behind (like peat formation)
e.g. _____ usually fossilized this way



4. _____
-The original hard parts have **additional** _____ materials deposited in _____ spaces.



5. _____
-Minerals in _____ in _____ waters replace _____materials as it dissolves or decays
-With this type of fossilization, you can see the _____
e.g. Petrified wood is _____ replacement.

Conditions necessary for the preservation of _____ parts

-Soft tissues are destroyed due to _____ before lithification or _____ during diagenosis. Usually they are best preserved as _____ films (carbonization) on a rock _____

-However under unusual conditions, soft part _____ may be preserved relatively intact.

-Ex. The world famous _____ Fossil Deposit near Field, B.C. found by Charles Walcott in 1909.

-This is what happened approximately 530 million years ago. There was no life on land and most life was small and lived along _____. A _____ from a soft bank buried the _____ organisms in silt. The water was _____ and _____. The silt flattened, hardened (_____) and became the sedimentary rock _____. Fossil _____ of the organisms were formed. Hundreds of millions of years later, colliding _____ caused the shale to be thrown up as part of an 8,000 foot _____. It is this unusual, detailed snapshot of life as it was _____ million years ago, replicas of _____ and all, that makes the Burgess Shale deposit so valuable. (Note: _____ the actual flesh, but a _____ _____ version/shape of it.)

Therefore, the required conditions necessary for the preservation of soft tissue are:

1. _____burial of
2. _____ organism in
3. _____, low _____ water followed by
4. _____lithification of sediment.

18

Another unusual event: Mammoth found in _____ with flesh still intact. This is original preservation.

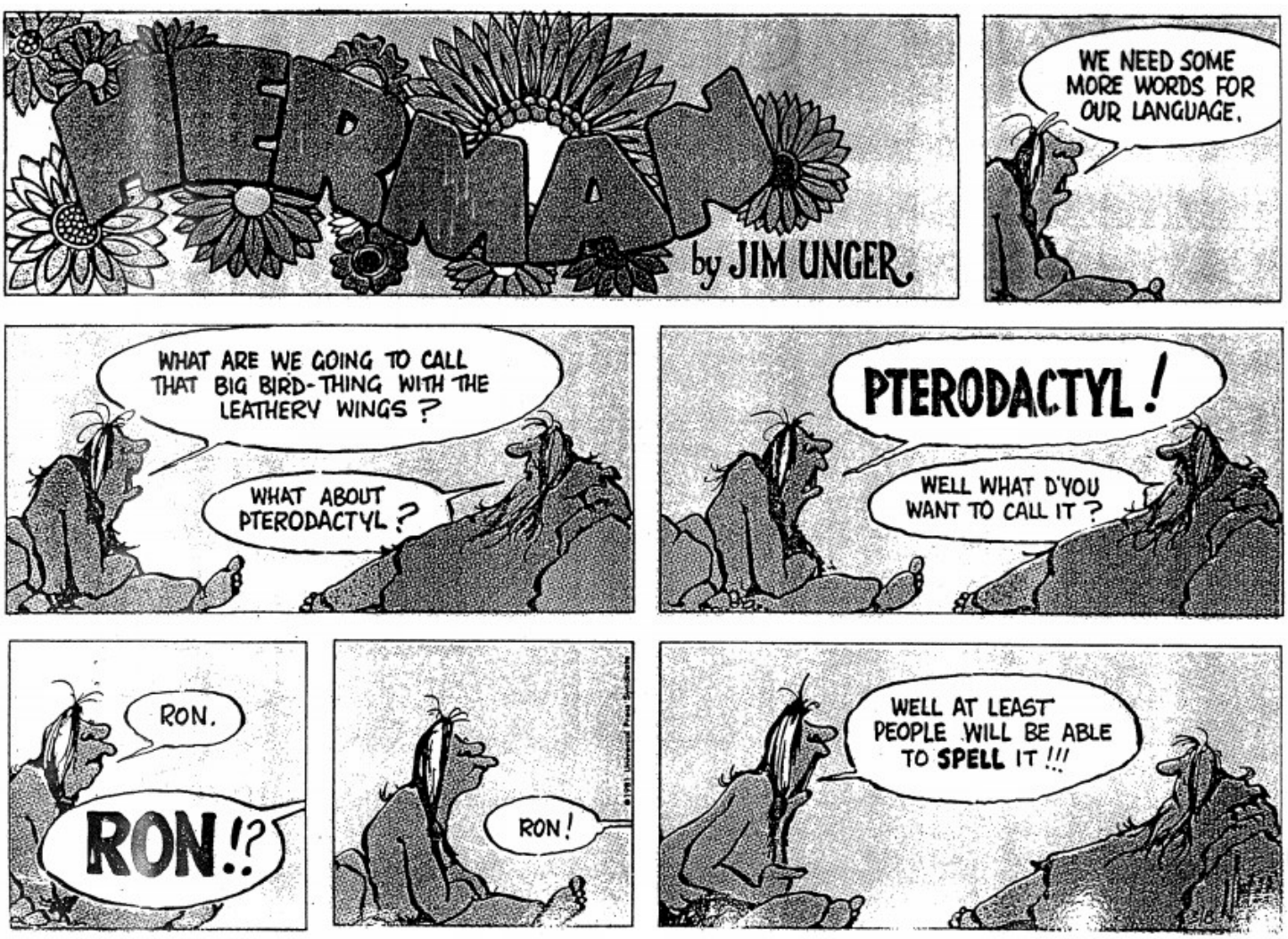
Index Fossils and the Necessary Characteristics

A fossil that is _____ but _____ is useful in correlating rocks of the same age in different areas and is referred to as "_____" (or guide) _____. The required characteristics of index fossils are:

1. They must be _____ to identify from other similar fossils. They must be _____ in some way
2. They must be found over a _____ geographic area.
3. They must have a _____ time range so that they occur in only a _____ rock layers.
4. They must be _____ and _____ to fossilize

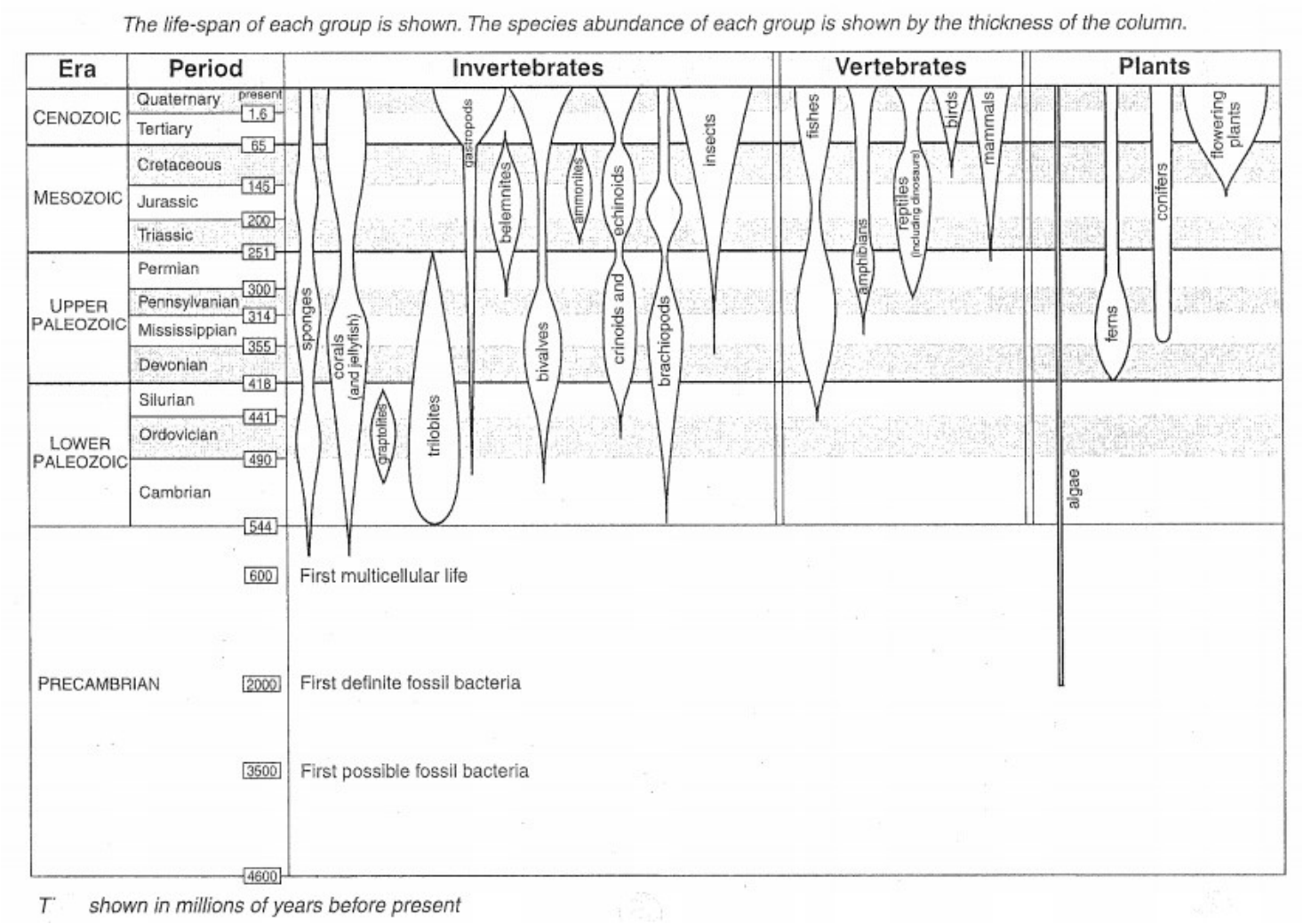
19

Herman Comic



Skull Comic

Development of Life through Time



Fossil Activity (pictures)

Fossil Activity

Use the "Interpreting Earth History" (IEH) lab manual pages 91-101 and 119-131 (5th ed) to fill in the attached fossil id sheet. Find the phylum name, sub name, where they lived (marine, lake, land, etc.), when they lived, if they are extinct or not, what relatives are living today, etc. Write the information in the space provided beside each group of pictures.

GEOLOGICAL TIME SCALE

ERA	PERIOD	EPOCH	TIME m.y.
Cenozoic	Quaternary	Holocene	0.01
		Pleistocene	2
	Tertiary	Pliocene	5
		Miocene	24
		Oligocene	37
		Eocene	58
		Paleocene	66
Mesozoic	Cretaceous		144
	Jurassic		208
	Triassic		245
Paleozoic	Permian		286
	Carboniferous: Pennsylvanian		320
	Carboniferous: Mississippian		360
	Devonian		408
	Silurian		438
	Ordovician		505
	Cambrian		570
Precambrian			4000*

Based on Hamblin, *The Earth's Dynamic Systems*, 1982. Dates from Montgomery, *Physical Geology*, 1987.

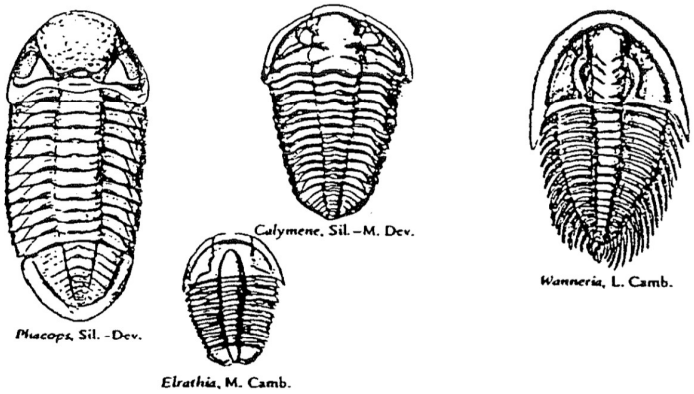
It is recognized that there is some variation in the dates given in the literature.

*Approximate age of the oldest rocks.

20

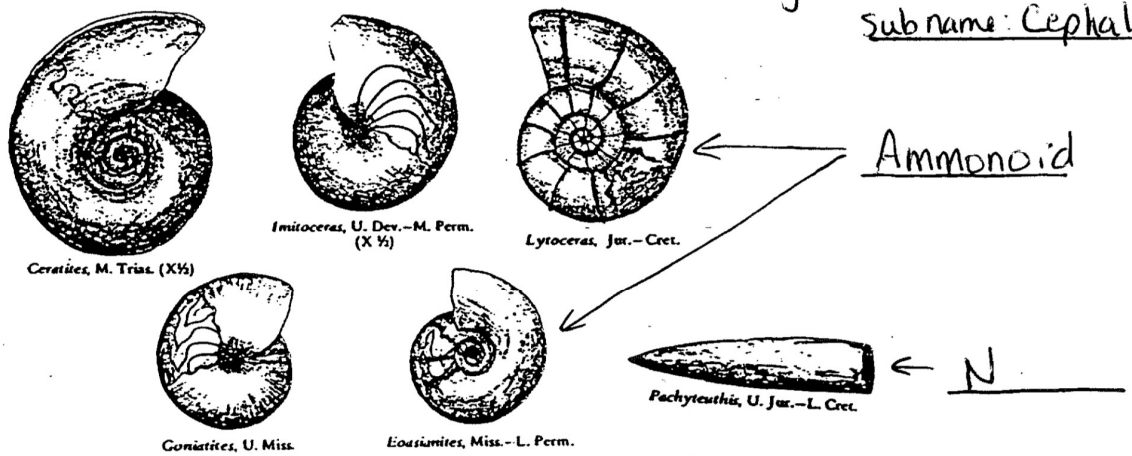
Phylum: Arthropoda

Subname: Trilobite



Phylum: Mollusca

Subname: Cephalopod

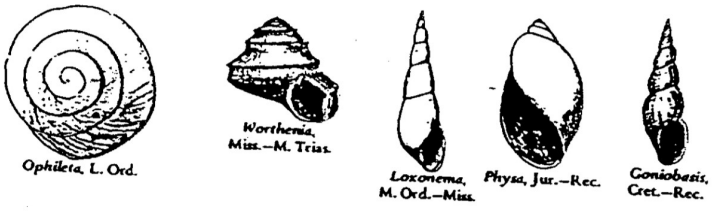


Ammonoid

N

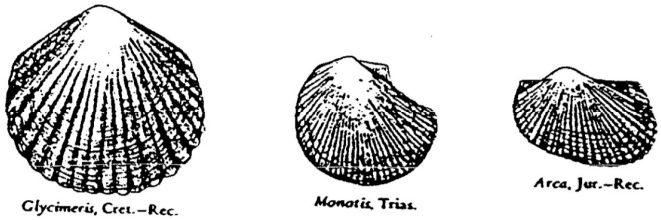
Phylum: Mollusca

G



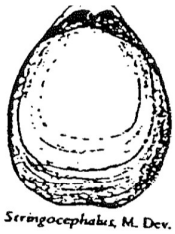
Phylum: M

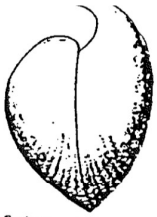
P



21

Phylum:


Stringocephalus, M. Dev.


Stringocephalus, M. Dev.


Mesolobus, M. Penn.–L. Perm.


Chonetes, Sil.–Perm.


Penicularis L.–Perm.


Mucrospirifer, M. Dev.


Mucrospirifer, M. Dev.


Mucrospirifer, M. Dev.

Phylum:


Heliophyllum, Dev.


Streptelasma, M. Ord.–M. Sil.


Favosites, Sil.–Carb.


Syringopora, Sil.–Penn.

Phylum: Protazoa

F


Triticites, U. Penn.–L. Perm. (X20)


Fusulinella, Penn. (X30)


Polydiexodina, U. Perm. (X2)

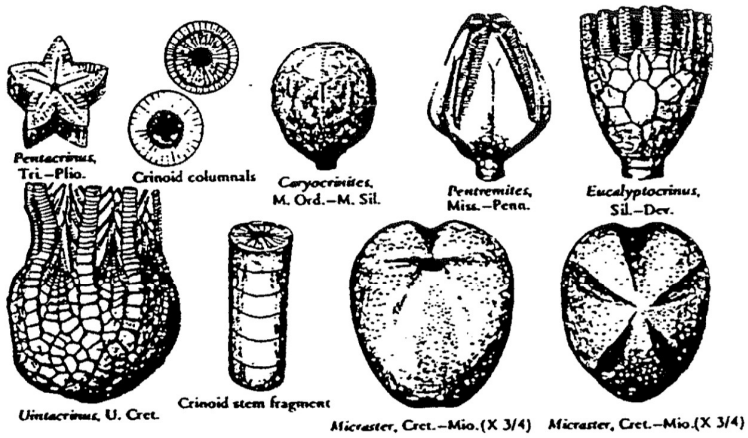

Parafusulina, Perm. (X2)


Globigerina, Paleoc.–Rec. (X50)

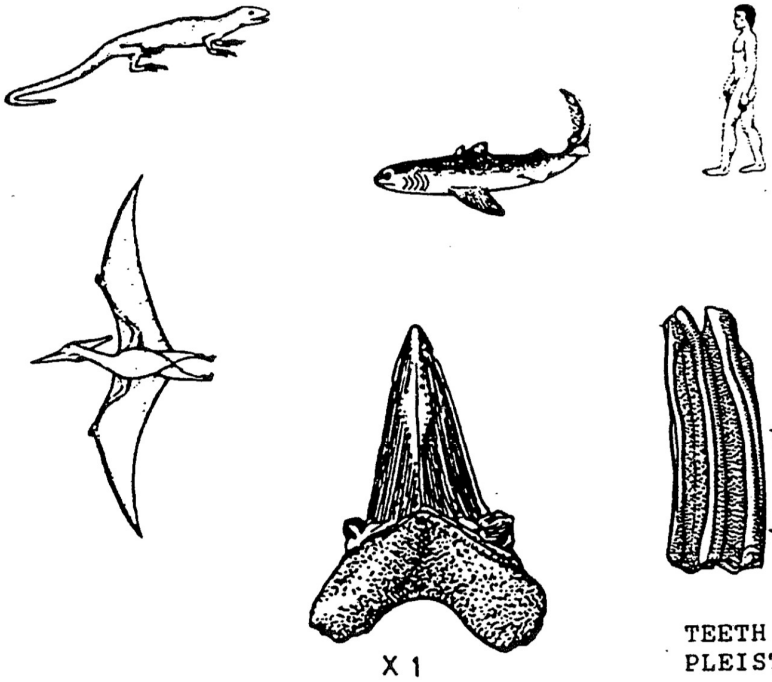

Textularia, Jur.–Rec. (X50)

22

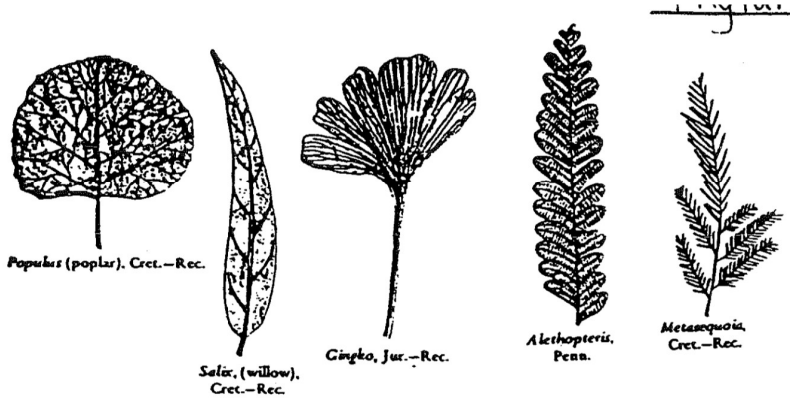
Phylum: _____



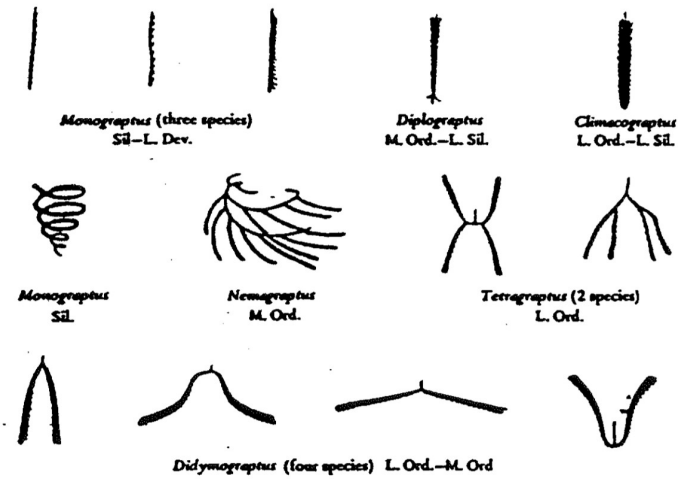
Phylum: _____



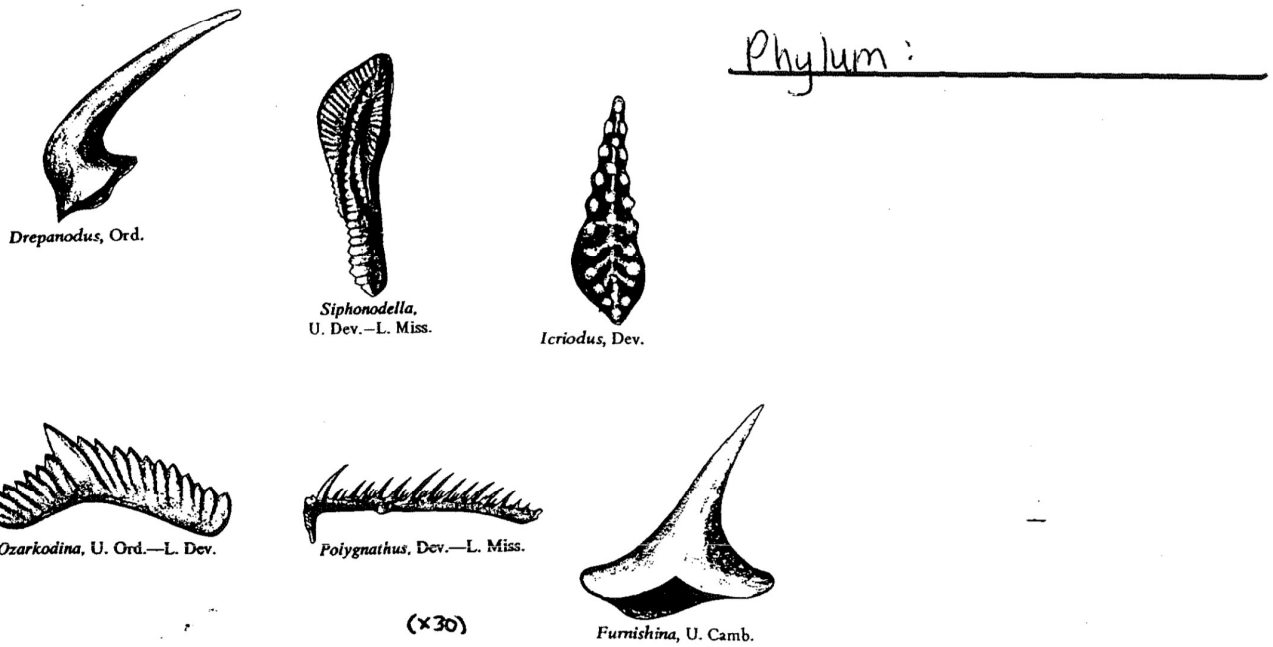
23



Phylum:

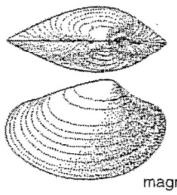
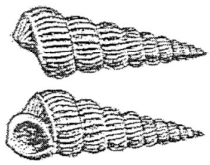
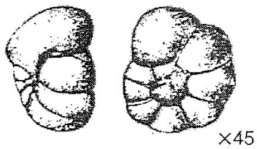
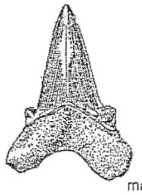
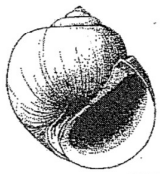
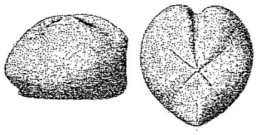
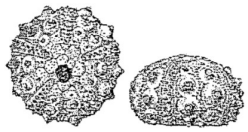
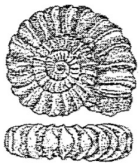
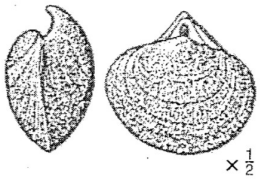
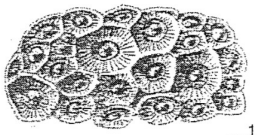
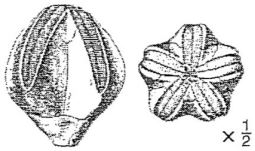
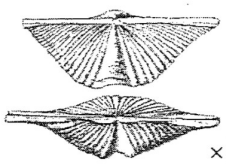
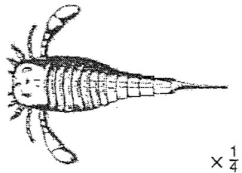
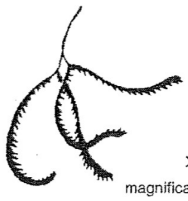
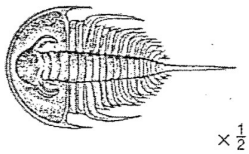


Phylum:



Fossil Samples

Fossil Samples

1 Tertiary (Miocene)  ×½ magnification	2 Tertiary (Oligocene)  ×1 magnification	3 Tertiary (Eocene to Holocene)  ×45 magnification	4 Tertiary (Eocene)  ×½ magnification
5 Tertiary (Paleocene)  ×1 magnification	6 Cretaceous  ×3 magnification	7 Jurassic to Holocene  ×½ magnification	8 Jurassic  ×¼ magnification
9 Triassic  ×½ magnification	10 Permian  ×½ magnification	11 Permian  ×½ magnification	12 Pennsylvanian  ×½ magnification
13 Mississippian  ×½ magnification	14 Mississippian  ×½ magnification	15 Devonian  ×½ magnification	16 Devonian  ×1 magnification
17 Silurian  ×¼ magnification	18 Ordovician to Devonian  ×25 magnification	19 Ordovician  ×½ magnification	20 Cambrian  ×½ magnification

Fossil Activity (specimens)

Fossil Activity: Find a fossil in the set, of the phylum indicated, and complete each row. For some phyla, there are more than one specimen to choose from.

	Phylum	Subname(s)	Period	Location	Diagram of specimen	Google information
1	Vertebrata					
2	Brachiopoda					
3	Mollusca	G				
4	Mollusca	M				
5	Mollusca	C				
6	Echinodermata					
7	Plant					
8	Arthropoda					
9	Cnidaria					

Practice Phyla Quiz

Identify the following:

1.

Phyla:
where lived:

2.

Phyla:
name:

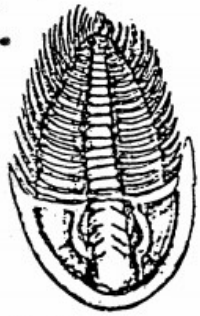
3.

Phyla:
name:

4.

Phyla:
name:

5.

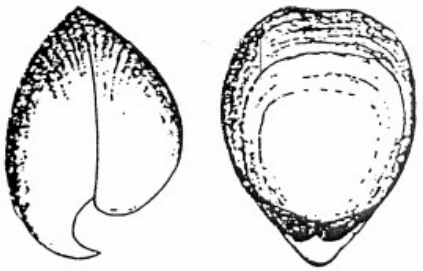


Phyla:
name:
Era:

6.

Phyla:
name:

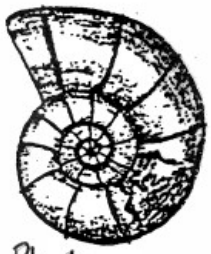
7.



Phyla:
sed. environment (where lived):

Phyla Quiz

1.

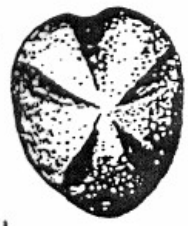


Phyla:
Name:

2.

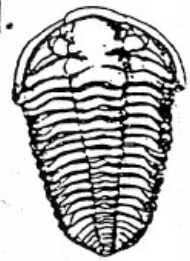
Phyla:
name:

3.



Phyla:

4.



Phyla:
name:
Era dominant:

5.

Phyla:
name:
Common relative:

6.

Phyla:
name:

7.

Phyla:
Era

Faunal Succession Activity

GEOLOGY 12
THE FOSSIL RECORD
FAUNAL SUCCESSION/CORRELATION

STUDENT EXERCISE

A. THE PRINCIPLE OF FAUNAL SUCCESSION

Each successive time interval of earth history has a unique assemblage of fossil types. As a result, rock units can be dated and correlated by analysis of their fossil content and comparison to standard reference sequences. The term **index fossil** is named for those fossils which are useful in age determinations. Index fossils are useful in that they are abundant, have a wide geographic range, and have a rapid evolutionary pattern which results in a short geologic time range which is easy to pinpoint.

Fossils are almost exclusively found in sedimentary rock; therefore, biostratigraphic correlation is ordinarily not possible in igneous or metamorphic rock, and as a result, is limited in its usefulness. As well, where sedimentary rocks do contain fossils (and there are many locations around the world), there is no single place where all strata are found together, complete, and stacked neatly in order, making correlation difficult.

The illustrations in Figure 1 show cross-sections of layered sedimentary rock from different locations. At least one index fossil was found in each layer. The key in Figure 2 gives the type of each index fossil as well as the name of the period of geologic time during which it lived. Note that the time periods are randomly arranged.

PROCEDURES:

1. Cut out the six columns from the sheet provided.
2. Apply your knowledge of the law of superposition, and arrange the columns side-by-side on a blank piece of paper such that fossils are relatively lined up and correlated.
3. Draw lines to show correlation from one locality to another. Note that some fossils disappear in some localities.

QUESTIONS:

1. Explain the absence of some fossils in some localities.
2. List the time periods from Figure 2 in order, from youngest at the top to the oldest.

B. SEDIMENTARY STRUCTURES

PROCEDURE:

Read over the various sedimentary structures and their descriptions on pp 26-33 of the lab text.

QUESTIONS:

1. Which of the structures discussed in this exercise might be useful in helping to distinguish the top from the bottom of a bed?
2. Which of these structures might be useful in determining the direction in which the current flowed?
3. Place an X in the table on the following page under each environment in which the sedimentary structure may form.

Arrange columns and glue onto this page.

Part A

Figure 1

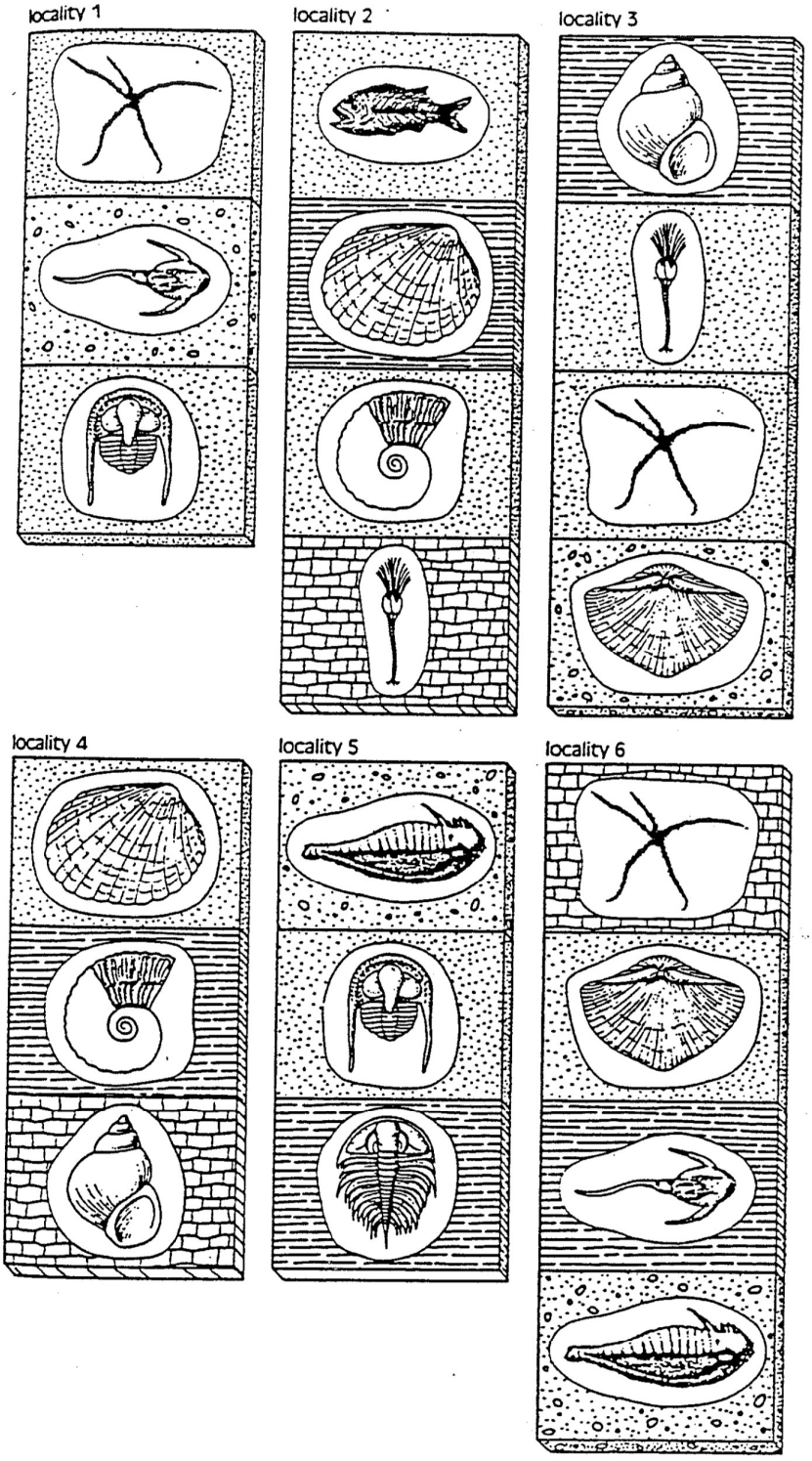
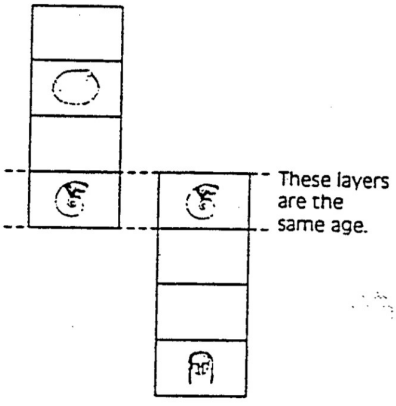


Figure 2
Geological cross-sections representing sedimentary rocks from six localities.

Key

Fossil	Type and period
	crinoid, Permian
	trilobite (*Olenellus*), Cambrian
	jawless fish, Devonian
	starfish, Pennsylvanian
	trilobite, Ordovician
	snail, Triassic
	eurypterid, Silurian
	ammonite, Jurassic
	brachiopod, Mississippian
	bony fish, Cenozoic
	clam, Cretaceous

Align the columns in Figure 1 so that layers of similar age are matched.



Sed Env / Which way is up?

In which environments do these structures form?

Sedimentary structure	River, stream	Shallow sea	Beach	Dry lake bottom	Sand dunes (wind)	Deep sea	Tidal flat
Asymmetrical ripple marks							
Symmetrical ripple marks							
Cross-bedding							
Mudcracks							
Raindrop prints							
Lamination							
Graded bedding							
Flute marks							
Tool marks							
Tracks							
Trails							
Burrows							
Stromatolites							

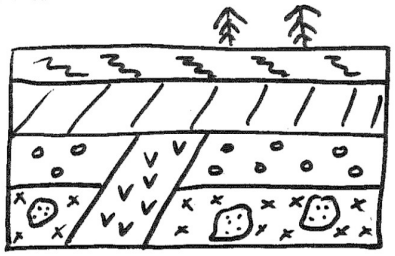
Which way is up?

GEOL 12 C-4

Review Page

Review Questions

1. Put the following in order, where 1 is oldest and 6 is youngest.



2. State the laws used to put the above in order.
3. Where is the unconformity and what kind is it?

4a) If you have $\frac{7}{8}$ daughter and $\frac{1}{8}$ parent, how many half lives have passed?

b) How would you calculate the age if the parent is potassium?

c) What is special about the daughter in this case?

5. If a sedimentary layer is on top of a 5 million year old lava flow and both are cut across by a 3 mill. year old dike, how old is the sed. rock?

6. When did each of the following occur?
   a) fish dominate
   b) earliest life
   c) age of invertebrates

7. What conditions are nec. for fossil preservation?

8. What is the difference btwn replacement and permineralization?

9. List any 5 of the 10 phyla.

10. If a sed. rock has a star fish and coral fossils, what [illegible]

Making a Mold and Cast Fossil

April 25, 2016 9:04 AM

You need:

2 strips of plastecine

something to press into the plastecine

Coat the side to be pressed in, in petroleum jelly - pull it out = mold

Once mold is made then come get wet plaster of paris

Notes: Evolution

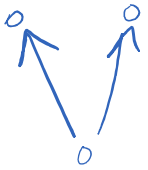
May 3, 2016 9:47 AM

Law of Faunal Succession – animal life forms change through time; the same life form is never exactly duplicated independently at two different times in history
- if exactly the same type of fossil is found in 2 rocks, then those rocks are the same age
  → correlation is possible

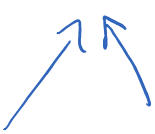
Why do animal life forms change through time?

Principles of Evolution

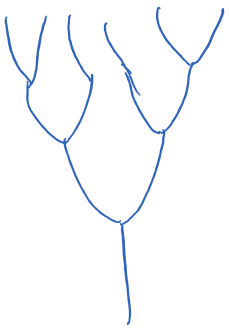
1. Divergence – the separation of single species into two or more groups exploring different habitats



2. Convergence – two or more groups of different species experience similar selective (survival) needs, thus become alike in some traits or features.



3. Adaptive Radiation - Adaptation is the adjustment that a population makes to its environment over a period of time.



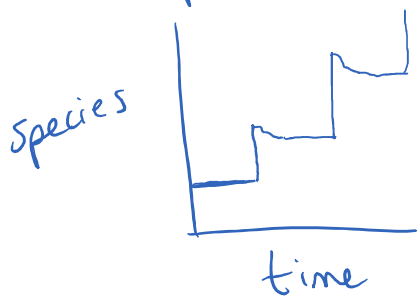
- when members of a single population undergo evolutionary divergence (successive generations become less and less alike) this is adaptive radiation

4. Natural Selection - survival of those organisms best suited to their environment

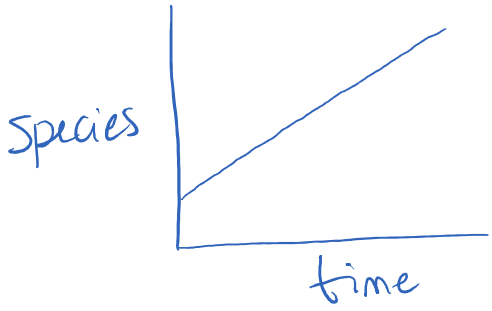
5. Extinction - species that can't adapt die out
   - the extinction of intermediate species helps explain the wide separation between the major groups of animals.

6. Punctuated Equilibrium - a model of the mechanism of evolutionary change that proposed that long periods of no change (status) are punctuated by periods of rapid formation of new species (speciation), followed by natural selection acting on the species.

the species.



7. Gradualism – approaching a desired end by gradual stages



* Difficult to decide between punc. eq. and grad. because many changes occur in the soft parts (muscles, tendons, etc) which don't fossilize easily.

Ch8 + Fossils Test

May 4, 2016 9:36 AM

45 mc
10 marks written

- fossils best in shale (fine sediments)
- unconformity
- relative dating
- radiometric dating (inc. graph to get half life)
- index fossil defn
- fossil recognition
- fossilization methods
- trace fossils
- timescale
- uniformitarianism *
- effective dating ranges. (see chart of isotope pairs)
- "up" direction
- evolution

W: how rad. dating works ... parent/daughter/h.l./Age ...
soft parts fossilization conditions
disconformity vs angular conformity
Solar System formation --- Earth ---

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January 28, 2017 5:15 PM

Notes: Buried Lava Flow vs Sill

Did the igneous intrusion flow on the surface and then get buried by the sandstone later? (Buried Lava Flow)
Or did the ig. intrusion squeeze between the sandstone and shale layers? (Sill)

Clues to look for:

Buried Lava Flow	Sill
- vesicles near top	- no vesicles
- contact metamorphism on rock below only	- contact meta of rocks above and below
- included fragments from rock below only	- inc. fragments from rocks above and below.
- possible erosion surface on top	- no erosion (never exposed at surface)