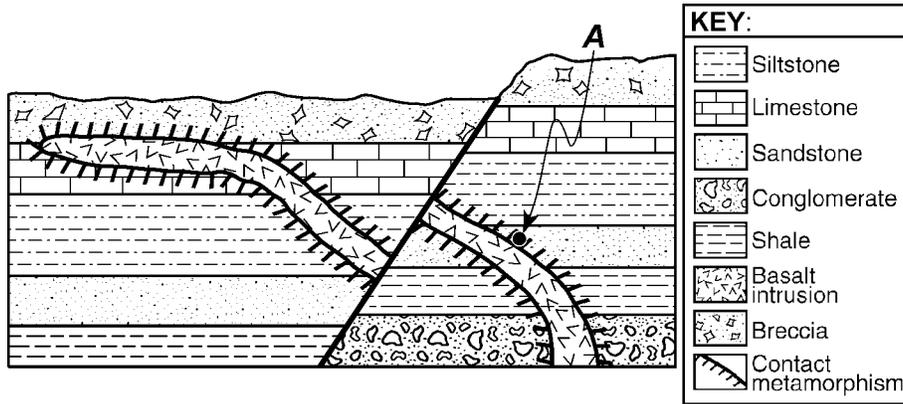


Name: _____

Questions 1 and 2 refer to the following:

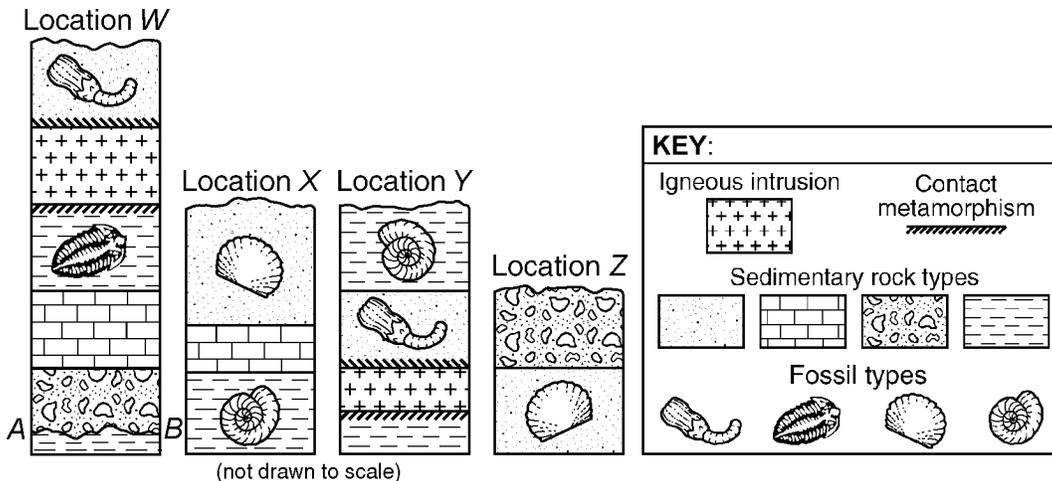
In the geologic cross section below, the rock layers have not been overturned. Point A is located in the zone of contact metamorphism.



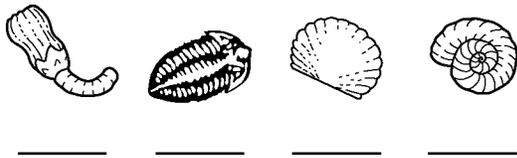
- 1) State the evidence shown by the cross section that supports the inference that the fault is *younger* than the basalt intrusion.
- 2) Based upon the cross section shown, list basalt, limestone, and breccia in the order in which they were formed.

Questions 3 through 5 refer to the following:

The cross sections below show widely separated outcrops at locations W, X, Y, and Z. The rock layers have not been overturned. Line AB in the cross section at location W represents an unconformity. Fossils are shown in some of the layers.



3) Determine the relative geologic age of the four fossils by correlating the rock layers between the outcrops shown in the cross section. Number the fossils below from 1 to 4 in order of relative age, with 1 as the *oldest* and 4 as the *youngest*.

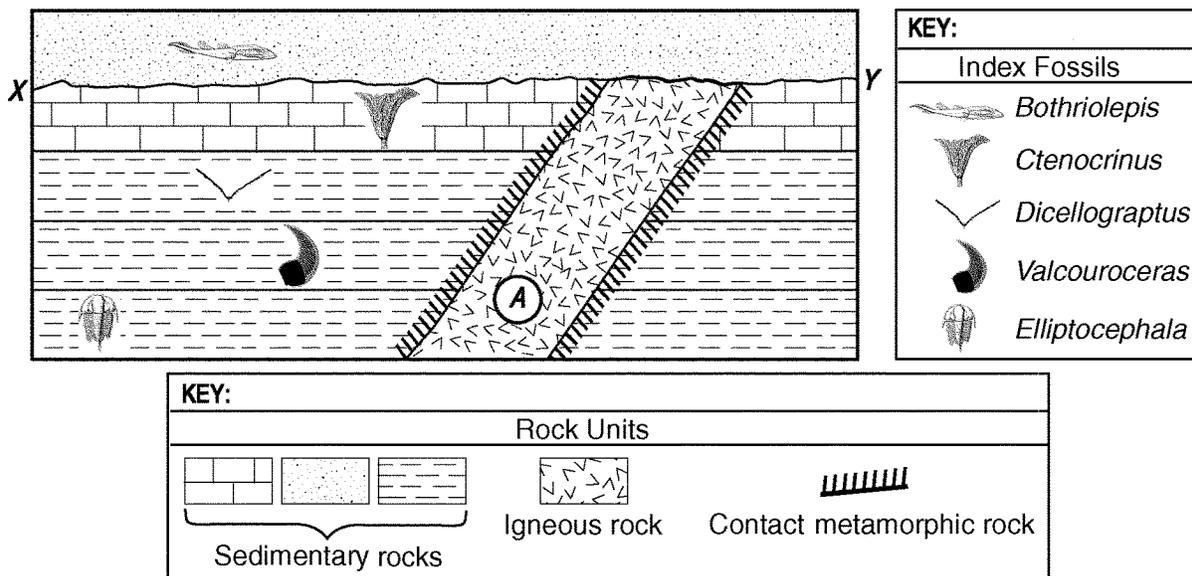


4) Identify *two* of the processes involved in the formation of the unconformity represented by line *AB* in the cross section at location *W*.

5) Based on the given cross section, what evidence shown in the outcrop at location *W* suggests that the igneous intrusion occurred after *both* fossils were deposited at location *W*?

Questions 6 through 10 refer to the following:

The geologic cross section below shows New York State index fossils in rock layers that have not been overturned. Rock unit *A* is an igneous intrusion and line *XY* represents an unconformity.



6) Identify one piece of evidence in the cross section shown that indicates that the igneous intrusion, *A*, is *older* than the sandstone layer.

7) Describe the type of depositional environment in which the fossilized organisms shown lived.

- 8) Based on fossil evidence, determine the geologic period during which the unconformity shown in the cross section formed.

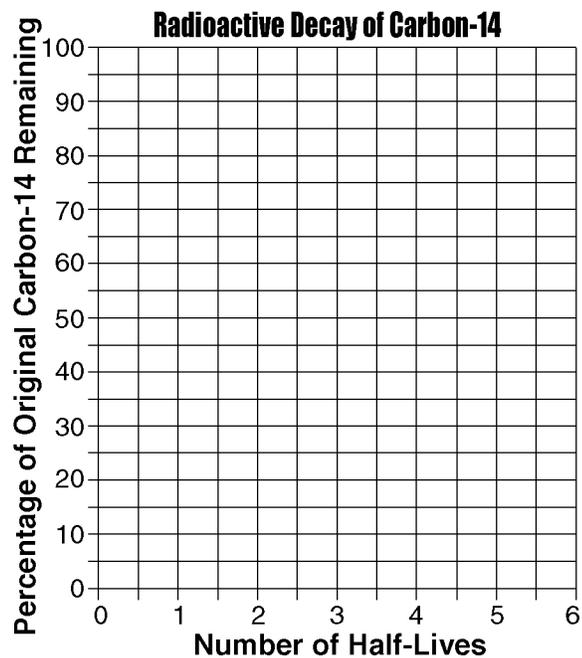
- 9) Identify the coral index fossil that would most likely be found in the same layer as the index fossil *Ctenocrinus*.

- 10) Each index fossil existed for a relatively short geologic time interval. State one other characteristic that each fossil must have to be considered an index fossil.

Questions 11 and 12 refer to the following:

The data table below shows the radioactive decay of carbon-14. The number of years required to complete four half-lives has been left blank.

Number of Half-Lives	Percentage of Original Carbon-14 Remaining	Time (years)
0	100	0
1	50	5700
2	25	11,400
3	12.5	17,100
4	6.3	
5	3.1	28,500
6	1.6	34,200



- 11) Based on the given information, how long does it take for radioactive carbon-14 to complete four half-lives?

- 12) On the grid provided, construct a graph that shows the radioactive decay of carbon-14 by plotting an **X** to show the percentage of original carbon-14 remaining after each half-life. Connect the **X**'s with a smooth, curved line.

- 13) State *one* characteristic of a good index fossil.

Questions 14 and 15 refer to the following:

The passage below describes the geologic history of the Pine Bush region near Albany, New York. The cross section below shows the bedrock and overlying sediment along a southwest to northeast diagonal line through a portion of this area. Location *A* shows an ancient buried stream channel and location *B* shows a large sand dune.

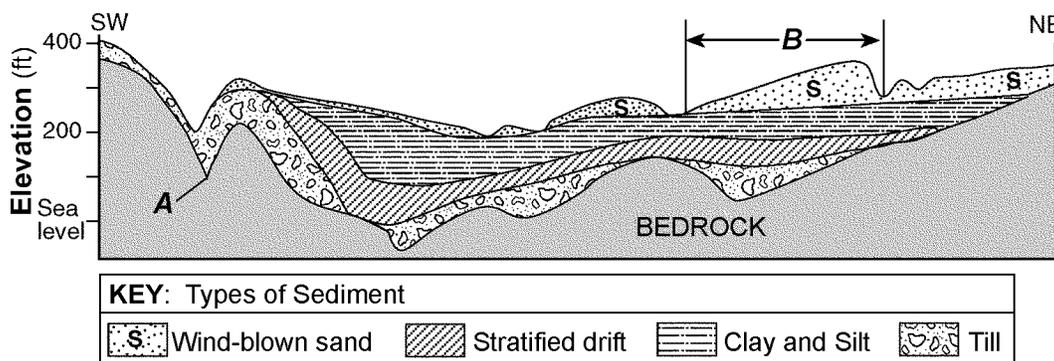
THE PINE BUSH REGION:

The Pine Bush region, just northwest of Albany, New York, is a 40-square mile area of sand dunes and wetlands covered by pitch pine trees and scrub oak bushes. During the Ordovician Period, this area was covered by a large sea. Layers of mud and sand deposited in this sea were compressed into shale and sandstone bedrock.

During most of the Cenozoic Era, running water eroded stream channels into the bedrock. One of these buried channels is shown at location *A* in the cross section. Over the last one million years of the Cenozoic Era, this area was affected by glaciation. During the last major advance of glacial ice, soil and bedrock were eroded and later deposited as till (a mixture of boulders, pebbles, sand, and clay).

About 20,000 years ago, the last glacier in New York State began to melt. The meltwater deposited pebbles and sand, forming the stratified drift. During the 5,000 years it took to melt this glacier, the entire Pine Bush area became submerged under a large 350-foot-deep glacial lake called Lake Albany. Delta deposits of cobbles, pebbles, and sand formed along the lake shorelines, and beds of silt and clay were deposited farther into the lake.

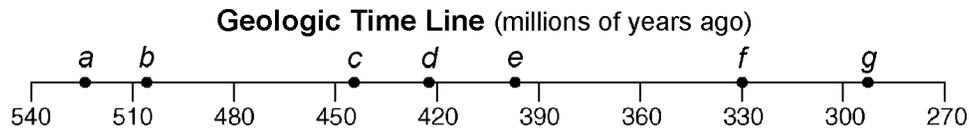
Lake Albany drained about 12,000 years ago, exposing the lake bottom. Wind and erosion created the sand dunes that cover much of the Pine Bush area today.



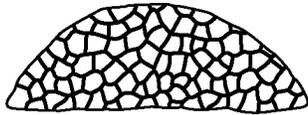
- 14) How old is the bedrock shown in the given cross section?
- 15) List, from *oldest* to *youngest*, the four types of sediment shown above the bedrock in the given cross section.

Questions 16 through 19 refer to the following:

In the geologic time line shown below, letters *a* through *g* indicate specific reference points in geologic time.



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



- 17) Identify the mountain building event (orogeny) that was occurring in eastern North America at the time represented by letter *g* in the geologic time line shown.
- 18) Letter *a* in the geologic time line shown indicates a specific time during which geologic period?
- 19) Identify *one* letter in the geologic time line shown that indicates a time for which there is *no* rock record in New York State.

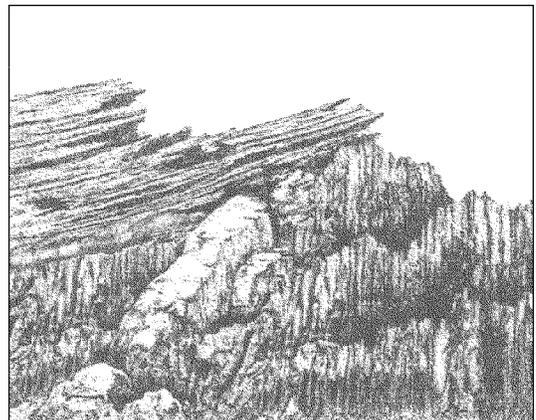
Questions 20 through 23 refer to the following:

SICCAR POINT:

The diagram below shows a unique rock formation exposed at Siccar Point, on the east coast of Scotland. The bedrock at Siccar Point shows an unconformity, which is a surface where two separate sets of rock layers that formed at different times come into contact.

The bottom rock layers are graywacke, which is a form of sandstone, formed approximately 425 million years ago when tectonic plates collided. This plate movement caused the layers of graywacke to tilt into their present vertical orientation and eventually uplifted them above sea level to form mountains.

By about 345 million years ago, these mountains had been eroded to form a plain that submerged beneath the sea. More sediment was deposited on top of the vertical graywacke layers, eventually forming the nearly horizontal layers called the Old Red Sandstone.



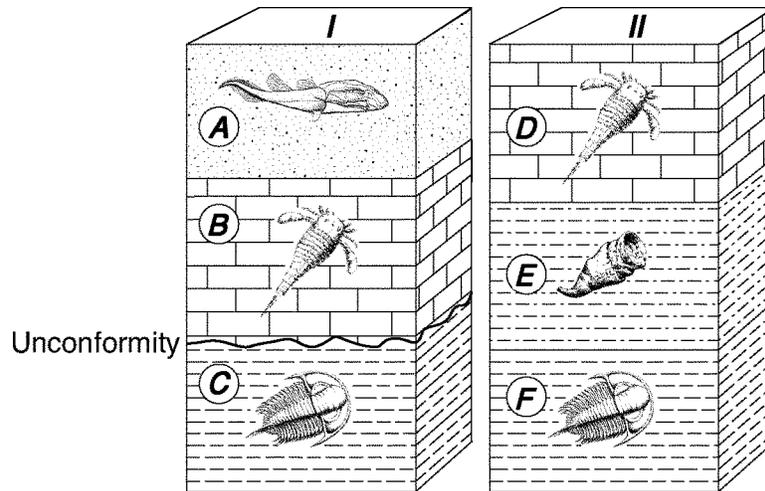
- 20) During which geologic time period did the graywacke bedrock described in the reading passage form?
- 21) Based on the given information, describe the structural evidence shown by the bedrock at Siccar Point that led geologists to conclude that the graywacke was moved by converging tectonic plates.
- 22) On the diagram following the given reading passage, draw a dark, heavy line tracing the unconformity separating the graywacke from the Old Red Sandstone.
- 23) Based on the given information, identify *two* of the processes that produced the unconformity at Siccar Point.
- 24) Explain why carbon-14 can *not* be used to find the geologic age of index fossils.
- 25) The table below shows information about Earth's geologic history. Letter *X* represents information that has been omitted.

Period	Million Years Ago	Index Fossil Found in Bedrock	Important Geologic Event
Triassic	251 to 200	<i>Coelophysis</i>	<i>X</i>

Identify *one* important geologic event that occurred in New York State that could be placed in the box at *X*.

Questions 26 and 27 refer to the following:

The diagrams below represent two bedrock outcrops, *I* and *II*, found several kilometers apart in New York State. Rock layers are lettered *A* through *F*. Drawings represent specific index fossils.



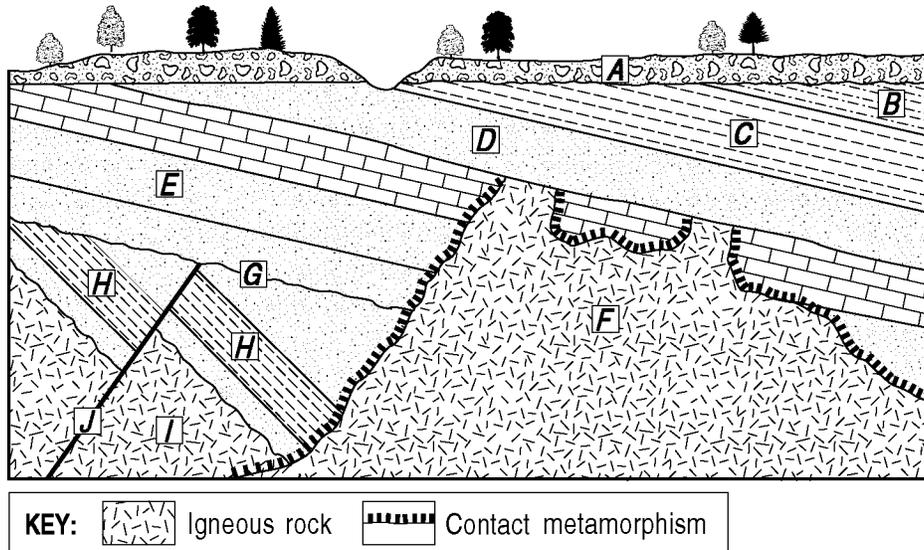
26) Identify *two* processes that produced the unconformity in outcrop *I* in the diagram shown.

27) During which geologic time period was rock layer *C* in the given diagram deposited?

28) State *one* method used by geologists to determine the age of bedrock in which an ancient mammal fossil was found.

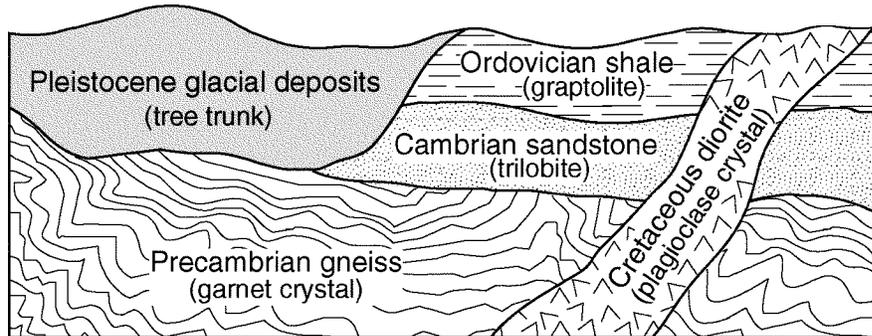
Questions 29 through 32 refer to the following:

The cross section below shows a portion of Earth's crust. Letters *A* through *J* represent rock units or geologic structures. The rock units have not been overturned.



- 29) Draw a circle around the letter of the *oldest* rock unit shown in the given cross section.
- 30) Explain why rock unit *H* in the cross section shown is *not* one continuous layer.
- 31) On the cross section shown, place an **X** to indicate a location where the rock, marble, was formed.
- 32) Describe *one* piece of evidence that suggests rock unit *D* is *younger* than rock unit *F* in the given cross section.

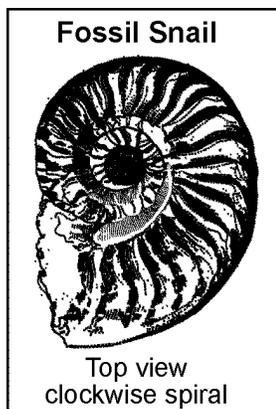
- 33) The cross section below shows part of Earth's crust. The objects in parentheses indicate materials found within each rock unit or deposit.



Which object in parentheses could be accurately dated using carbon-14? [*Explain your answer.*]

Questions 34 and 35 refer to the following:

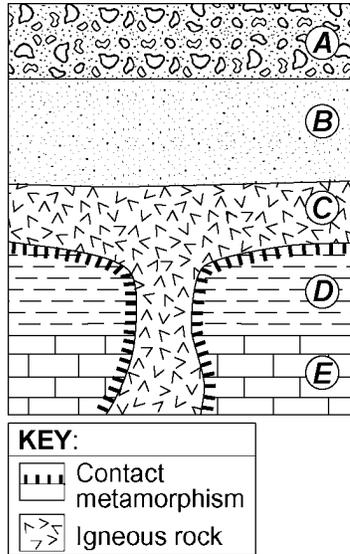
Snails have lived in most of the world's oceans over a period of hundreds of millions of years. Paleontologists discovered that in warm, tropical waters more snails have shells that, when viewed from the top, spiral outward in a *clockwise* direction. In cool or cold waters, more snails have shells that spiral outward in a *counterclockwise* direction. Both clockwise- and counterclockwise-spiraled snail fossils have been found in New York State bedrock.



- 34) State *one* reason bedrock that formed in tropical regions is found in New York State.
- 35) In a slab of rock that contains many fossil snails, such as the type shown, what evidence would lead geologists to conclude that the slab was formed in a tropical climate?

Questions 36 through 38 refer to the following:

The cross section below shows rock units *A* through *E* that have not been overturned.



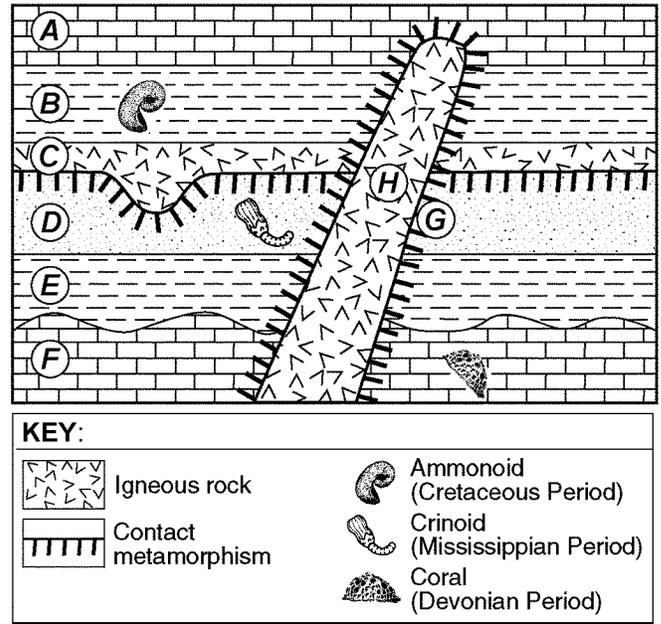
- 36) Identify *one* metamorphic rock that may be found along the boundary between rock units *C* and *E* in the given cross section.

- 37) State the diameter of a particle normally found in rock unit *B* in the given diagram.

- 38) Describe *one* piece of evidence shown in the given cross section that can be used to infer that rock unit *A* is younger than rock unit *B*.

Questions 39 through 44 refer to the following:

Rock units *A* through *H* are shown in the geologic cross section below. Several rock units contain fossils. Rock unit *G* was formed in a zone of contact metamorphism.



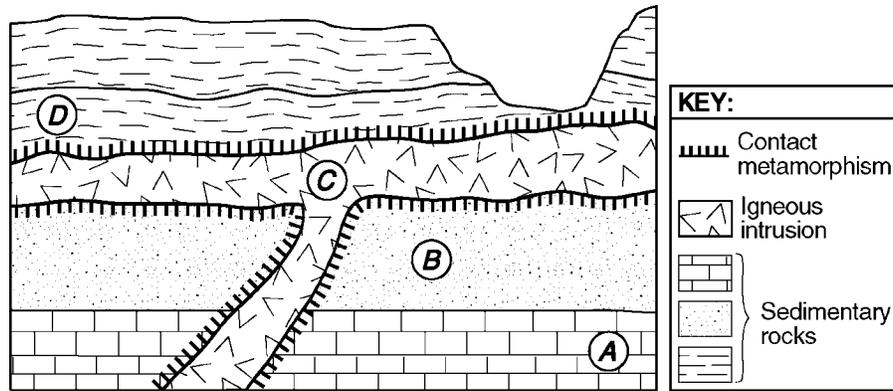
- 39) Identify *two* possible geologic periods during which the sediments that formed rock unit *E* in the given cross section could have been deposited.

- 40) Place *two* **Xs** on the cross section provided to show the locations of *two* unconformities that formed at different times in geologic history.

- 41) Describe the evidence shown in the given cross section that indicates that rock unit *C* is *younger* than rock unit *D*.

Questions 49 and 50 refer to the following:

A cross section showing a portion of Earth's crust is provided below. Letters A, B, C, and D represent rock units that have not been overturned.

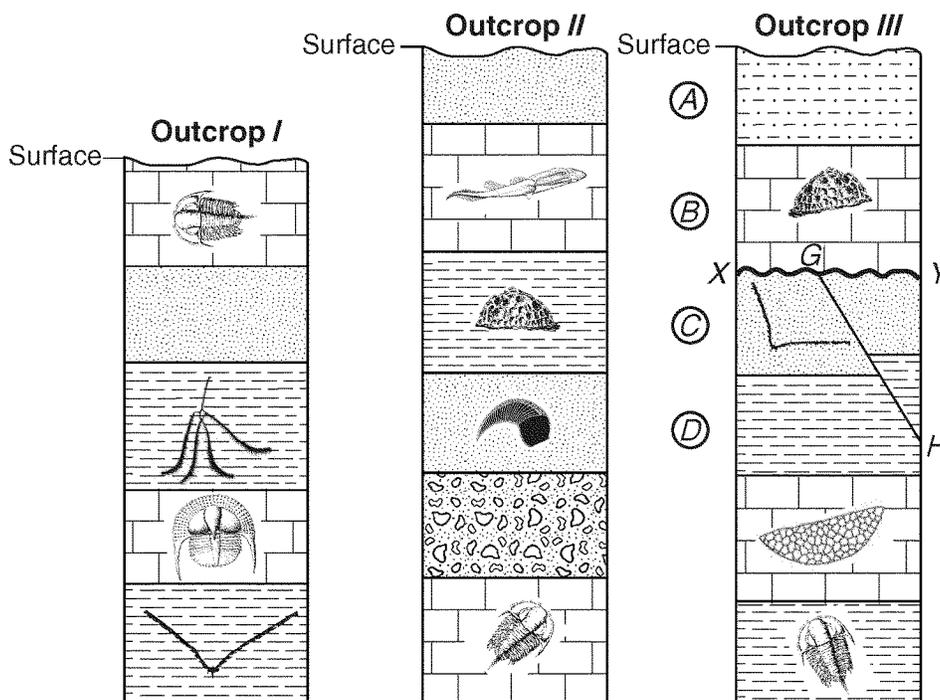


49) State *one* piece of evidence shown in the cross section that indicates that rock unit D is *older* than igneous intrusion C.

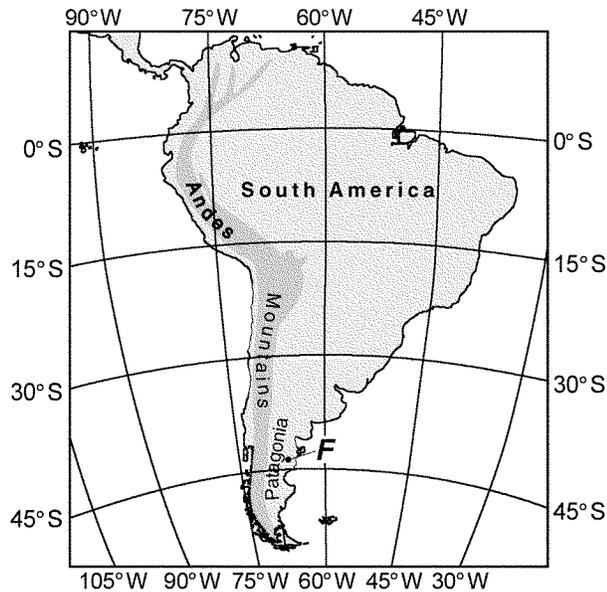
50) On the cross section provided, place an **X** where the metamorphic rock quartzite may be found.

Questions 51 and 52 refer to the following:

The cross sections below show widely separated outcrops labeled I, II, and III. Index fossils are found in some of the rock layers in the three outcrops. In outcrop III, layers A, B, C, and D are labeled. Line XY represents an unconformity. Line GH represents a fault.



- 51) List in order, from *oldest* to *youngest*, the relative age of the four rock layers, *A*, *B*, *C*, and *D*, fault *GH*, and unconformity *XY* shown in outcrop *III* in the given diagram.
- 52) On the diagram of Outcrop *II* provided, place the symbol  for an unconformity between the two rock layers where the Silurian-age bedrock has been removed by erosion.
- 53) Explain why coal deposits are *not* found in bedrock older than Silurian-age bedrock.
- 54) Point *F* on the map below shows the location where an unusual mammal fossil was found.



FOSSIL JAW OF MAMMAL FOUND IN SOUTH AMERICA:

Paleontologists working in Patagonia have found the tiny fossil jaw that may be the first evidence of early mammals in South America.

The fossil, which measures less than a quarter-inch long, is believed to be from the middle or late Jurassic Period. Researchers said it suggests that mammals developed independently in the Southern Hemisphere.

The fossil, named *Asfaltomylos patagonicus*, was discovered in a shale formation in Patagonia. Dinosaurs were the dominant land animal at that time. Mammals were tiny, and hunted insects in the dense tropical vegetation. The now-arid region also has yielded some remarkable dinosaur fossils from the same period in a vast ancient boneyard covering hundreds of square miles.

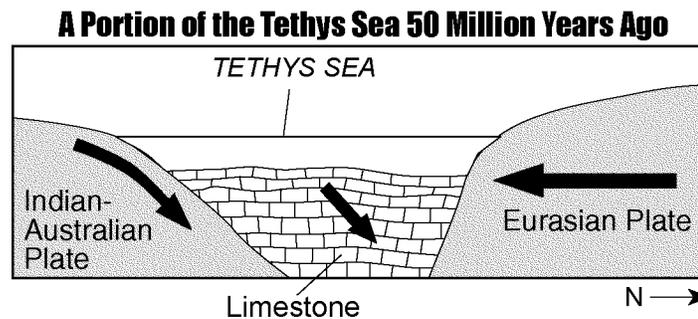
Based on the reading passage, what other life-form first appeared on Earth during the geologic period when *Asfaltomylos patagonicus* existed?

- 55) The passage and cross section below explain how some precious gemstones form. The cross section shows a portion of the ancient Tethys Sea, once located between the Indian-Australian Plate and the Eurasian Plate.

PRECIOUS GEMSTONES:

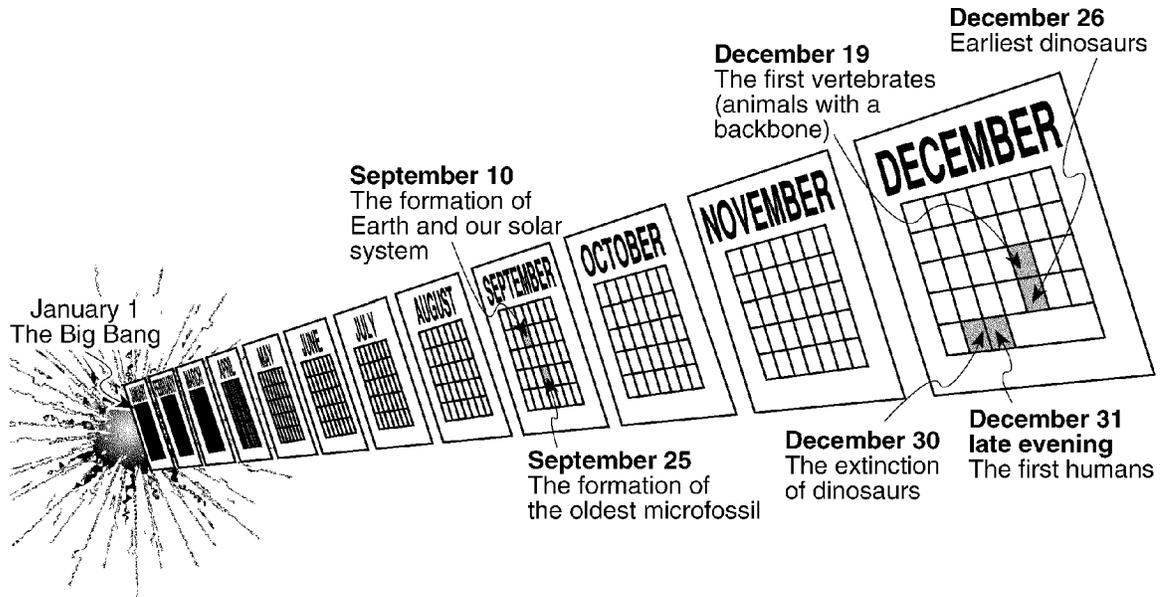
Some precious gemstones are a form of the mineral corundum, which has a hardness of 9. Corundum is a rare mineral made up of closely packed aluminum and oxygen atoms, and its formula is Al_2O_3 . If small amounts of chromium replace some of the aluminum atoms in corundum, a bright-red gemstone called a ruby is produced. If traces of titanium and iron replace some aluminum atoms, deep-blue sapphires can be produced.

Most of the world's ruby deposits are found in metamorphic rock that is located along the southern slope of the Himalayas, where plate tectonics played a part in ruby formation. Around 50 million years ago, the Tethys Sea was located between what is now India and Eurasia. Much of the Tethys Sea bottom was composed of limestone that contained the elements needed to make these precious gemstones. The Tethys Sea closed up as the Indian-Australian Plate pushed under the Eurasian Plate, creating the Himalayan Mountains. The limestone rock lining the seafloor underwent metamorphism as it was pushed deep into Earth by the Indian-Australian Plate. For the next 40 to 45 million years, as the Himalayas rose, rubies, sapphires, and other gemstones continued to form.



During which geologic epoch did the events shown in the given cross section of the Tethys Sea occur?

56) The calendar model below shows the inferred history of the universe. The 12-month time line begins with the Big Bang on January 1 and continues to the present time, which is represented by midnight on December 31. Several inferred events and the relative times of their occurrence have been placed in the appropriate locations on the time line.



How many million years of Earth's geologic history elapsed between the event that occurred on September 10 and the event that occurred on September 25 in the model shown?

57) **ASTERIODS:**

Most known asteroids are found orbiting the Sun approximately halfway between the orbits of Mars and Jupiter, in a vast ring known as the Asteroid Belt. Occasionally, though, an asteroid leaves this orbit belt and moves into a more eccentric orbit that brings it into the inner solar system. This sudden change may be caused by an impact with another asteroid or by the gravitational pull of Jupiter or Mars.

The closest known near-Earth collision was in 1994, when asteroid 1994 XL1 came within the Moon's orbit at a distance of 100,000 kilometers from Earth. Earth had missed hitting this asteroid by a mere 52 minutes. This asteroid was only about 15 hours away from Earth when it was first noticed. Only 30 feet in diameter, 1994 XL1 was 100,000 times fainter than an object that could be seen with the naked eye. Each year other asteroids are spotted coming close to Earth.

Evidence on Earth indicates that some asteroids have come close enough to be drawn into Earth by gravitational attraction. A 110-mile-wide crater discovered by oil geologists under the Yucatan Peninsula and the Gulf of Mexico is one such piece of evidence. This crater is closely linked to the extinction of the dinosaurs. Some scientists estimate that a 10-mile-wide asteroid caused this crater.

Some scientists believe an asteroid impact on Earth caused the extinction of the last of the dinosaurs. How many million years ago did this asteroid impact occur?

Questions 58 and 59 refer to the following:

RADIOCARBON DATING

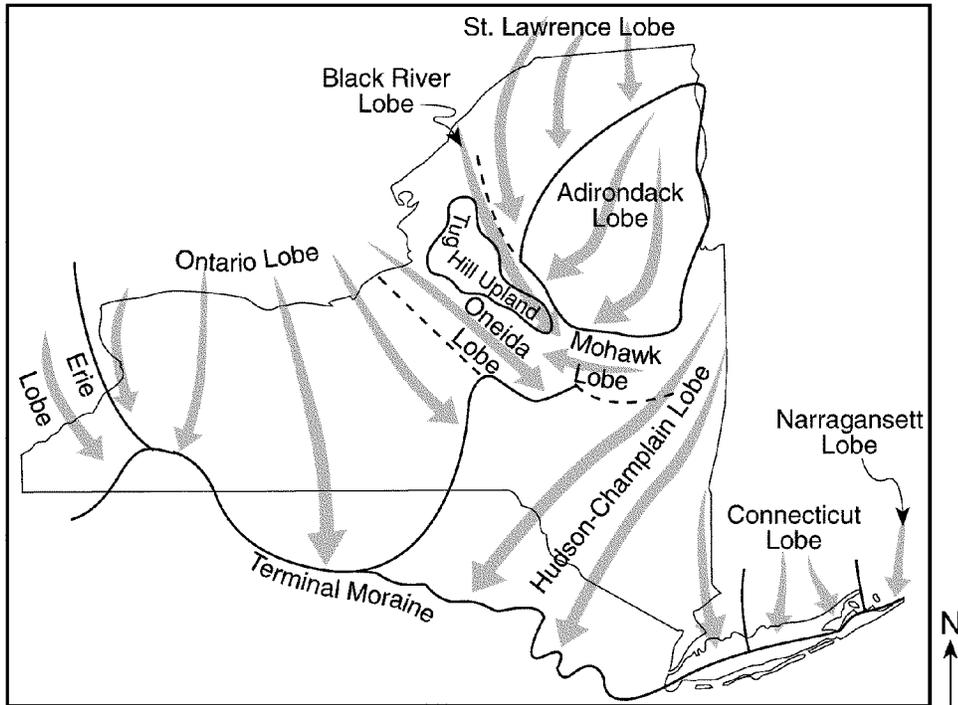
Radioactive carbon-14 (C^{14}), because of its short half-life, is used for the absolute dating of organic remains that are less than 70,000 years old.

Carbon-14 is an isotope of carbon that is produced in Earth's upper atmosphere. High-energy cosmic rays from the Sun hit nitrogen-14 (N^{14}), producing radioactive C^{14} . This C^{14} is unstable and will eventually change back into N^{14} through the process of radioactive decay. The proportions of C^{14} and ordinary C^{12} in Earth's atmosphere remain approximately constant.

Radioactive C^{14} , just like ordinary C^{12} , can combine with oxygen to make carbon dioxide. Plants use CO_2 during photosynthesis. The proportion of C^{14} to C^{12} in the cells and tissues of living plants is the same as the proportion of C^{14} to C^{12} in the atmosphere. After plants die, no new C^{14} is taken in because there is no more photosynthesis. Meanwhile, the C^{14} in the dead plant keeps changing back to N^{14} , so there is less and less C^{14} . The longer the plant has been dead, the less C^{14} is found in the plant. The age of organic remains can be found by comparing how much C^{14} is still in the organic remains to how much C^{14} is in a living organism.

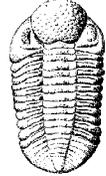
- 58) State *one* difference between dating with the radioactive isotope C^{14} and dating with the radioactive isotope uranium-238 (U^{238}).
- 59) Radioactive C^{14} was used to determine the geologic age of old wood preserved in a glacier. The amount of C^{14} in the old wood is half the normal amount of C^{14} currently found in the wood of living trees. What is the geologic age of the old wood?

60) The map below shows the different lobes (sections) of the Laurentide Ice Sheet, the last continental ice sheet that covered most of New York State. The arrows show the direction that the ice lobes flowed. The terminal moraine shows the maximum advance of this ice sheet.



During which geologic epoch did the Laurentide Ice Sheet shown in the map advance over New York State?

Questions 61 and 62 refer to the following:

Table of Index Fossils		
		
Eospirifer	Manticoceras	Phacops

61) During what geologic time period did the *oldest* index fossil shown in the table exist?

62) Based on the index fossils shown, complete the classification table below by filling in the general fossil group name for *each* index fossil.

Fossil Classification

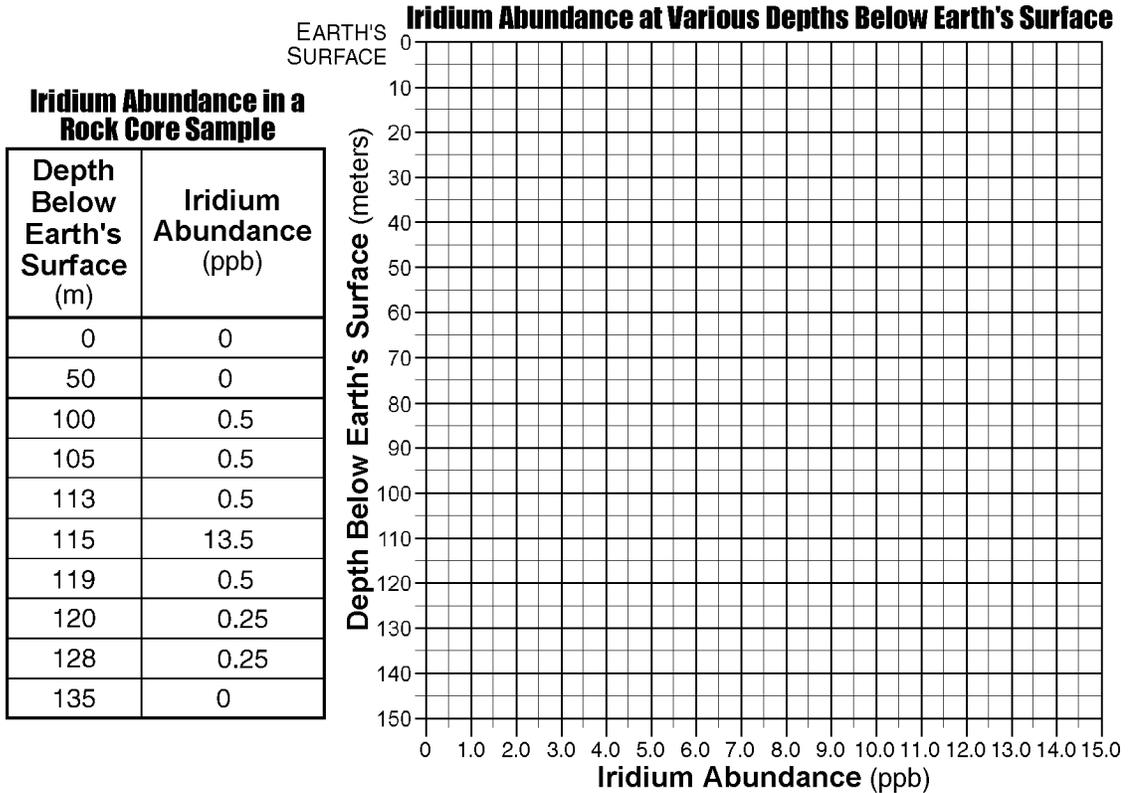
Index Fossil	<i>Eospirifer</i>	<i>Manticoceras</i>	<i>Phacops</i>
General Fossil Group			

63) Antarctica's ice sheet has an average thickness of 6,600 feet and holds approximately 70% of Earth's freshwater. Ice layers in Antarctica preserve information about Earth's history. Fossil evidence found in the bedrock of this continent shows that Antarctica was once tropical and is a potential source of untapped natural resources. Antarctica is now a frozen desert with very little snowfall.

What evidence is preserved in Antarctica that provides information about the Earth's past climates mentioned in the reading passage?

64) Describe *one* characteristic necessary for a fossil to be classified as an index fossil.

65) Iridium is an element rarely found in Earth's lithosphere but commonly found in asteroids. The data table below shows the abundance of iridium, in parts per billion (ppb), found in a rock core sample taken in Carlsbad, New Mexico.

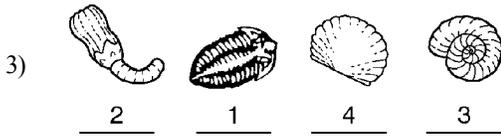


- (a) The high concentration of iridium in the rock core sample described has been matched to rock layers that have been dated to the geologic time when dinosaur extinction from an asteroid impact may have occurred. Between which two geologic time periods did this inferred extinction occur?

- (b) Other than iridium in the rock layers, what surface feature was most likely created when this asteroid impacted Earth's crust?

1) SAMPLE ANSWERS: The fault displaced the intrusion. OR The fault has cut across the preexisting basalt intrusion.

2) limestone → breccia → basalt



4) SAMPLE ANSWERS: uplifting OR weathering OR erosion OR submergence OR deposition OR burial

5) SAMPLE ANSWERS: contact metamorphism OR Contact metamorphism is shown in both the sandstone and shale layers. OR An igneous intrusion is younger than the bedrock it intrudes.

6) SAMPLE ANSWERS: There is no contact metamorphism between rock unit A and the sandstone. OR An unconformity exists between the igneous intrusion and sandstone layer.

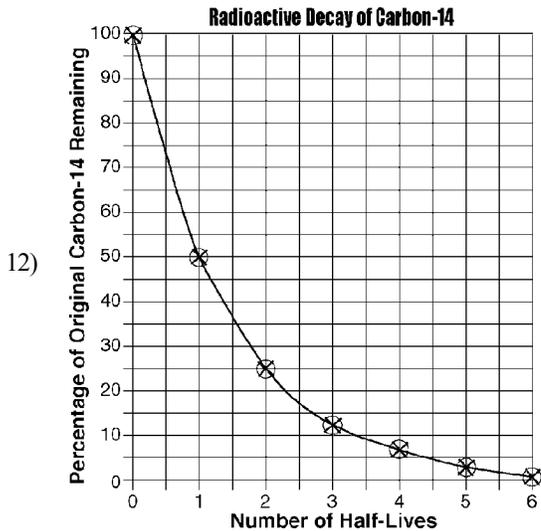
7) SAMPLE ANSWERS: The organisms lived in a shallow sea. OR They lived in a marine environment.

8) Devonian Period

9) *Pleurodictyum*

10) SAMPLE ANSWER: widespread geographic distribution

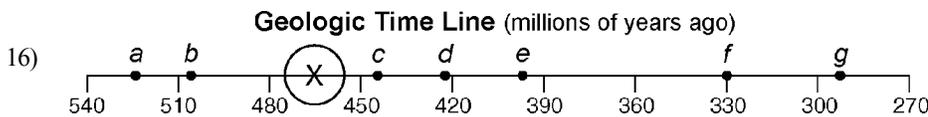
11) 22,800 yr



13) SAMPLE ANSWERS: existed for a short geologic time OR widespread geographically

14) 490 to 443 million years

15) 1 — till, 2 — stratified drift, 3 — clay and silt, 4 — wind-blown sand



17) SAMPLE ANSWERS: Appalachian Orogeny OR Alleghanian Orogeny

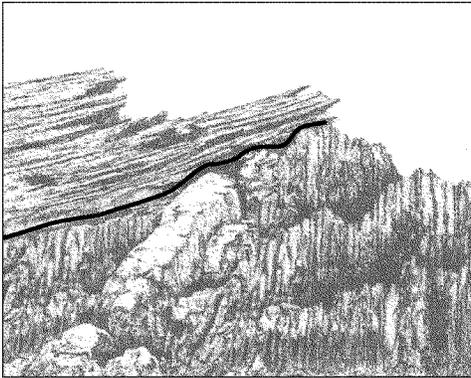
18) Cambrian Period

19) SAMPLE ANSWERS: *f* OR *g*

20) Silurian Period

21) SAMPLE ANSWERS: The graywacke layers are tilted. OR The layers are now vertical. OR The unconformity indicates that the graywacke layers were uplifted and eroded.

22)



23) SAMPLE ANSWERS: uplift OR weathering OR erosion OR tilting OR submergence OR burial OR deposition

24) SAMPLE ANSWERS: Carbon-14's half-life is too short. OR Not enough carbon-14 is left to measure. OR The fossils are too old.

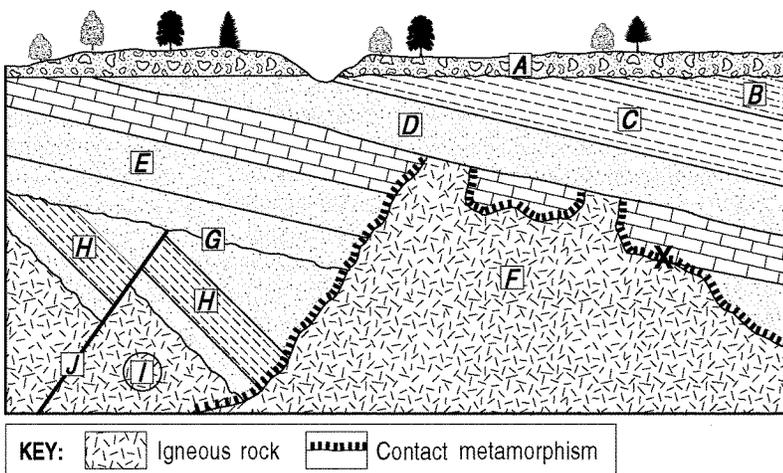
25) SAMPLE ANSWERS: intrusion of the Palisades sill OR breakup of Pangaea

26) SAMPLE ANSWERS: uplift OR erosion OR weathering OR subsidence OR deposition OR burial

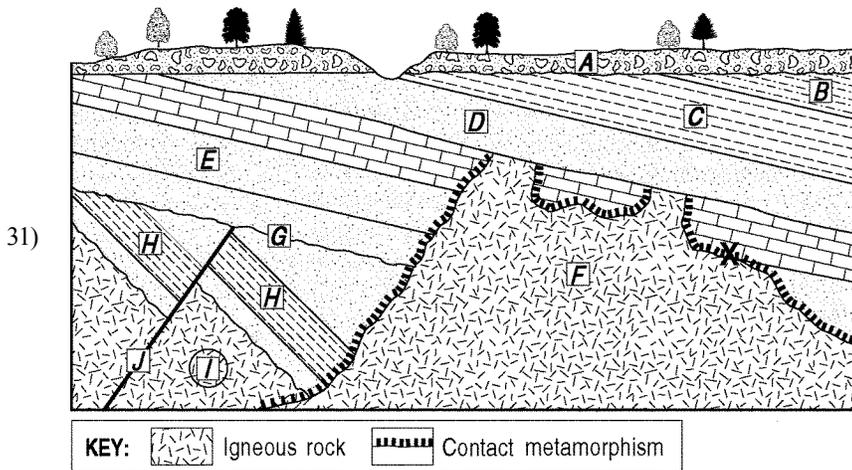
27) Cambrian Period

28) SAMPLE ANSWERS: radioactive dating OR identifying an index fossil in the layer containing this fossil OR correlating rock layers or fossils

29)



30) SAMPLE ANSWERS: Rock unit *H* was displaced by movement along a fault. OR Rock unit *H* was broken when an earthquake occurred.



32) SAMPLE ANSWERS: There is no contact metamorphism shown in rock unit *D*. OR Rock unit *F* was eroded, then rock unit *D* was formed. OR There is a buried erosional surface between *F* and *D*. OR Rock unit *D* is on top of rock unit *F*.

33) tree trunk
 SAMPLE ANSWERS: The tree trunk is a recent organic remain. OR Carbon-14 is used to date recent remains.

34) SAMPLE ANSWERS: New York State experienced a warmer climate when it was located closer to the Equator. OR The North American Plate has drifted northward from the equator region over time. OR New York State used to be in the tropics.

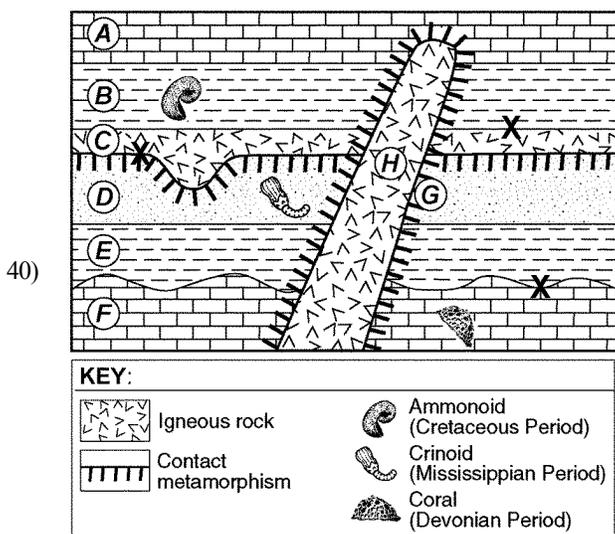
35) SAMPLE ANSWERS: Clockwise spiral snail shells are found in greater numbers. OR more clockwise fossil shells than counterclockwise

36) SAMPLE ANSWERS: marble OR hornfels

37) 0.006 to 0.2 cm

38) SAMPLE ANSWERS: Rock unit *A* is above rock unit *B*. OR Older sedimentary rock unit *B* is found beneath younger sedimentary rock unit *A*.

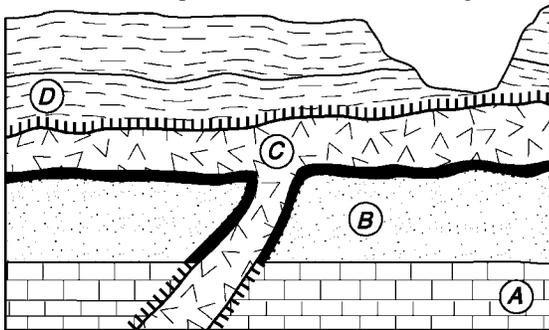
39) SAMPLE ANSWERS: Devonian Period and Mississippian Period OR Devonian Period and Carboniferous Period



41) SAMPLE ANSWERS: *C* is on top of *D*. OR *C* metamorphosed *D*.

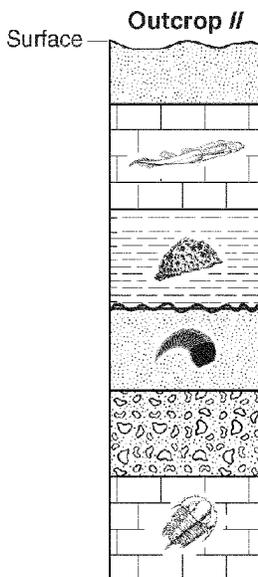
42) *G*

- 43) SAMPLE ANSWERS: The fossils are too old for ^{14}C dating. OR Carbon-14 has a very short half-life.
- 44) SAMPLE ANSWERS: Cretaceous Period OR Paleogene Period OR Neogene Period OR Quaternary Period
- 45) SAMPLE ANSWERS: widespread geographic distribution OR short existence in geologic time
- 46) SAMPLE ANSWERS: The basalt intrusion cuts across the fault. OR The intrusion is not displaced by the fault. OR The fault does not cut across the basalt intrusion.
- 47) SAMPLE ANSWERS: The fossil is too old. OR ^{14}C dating is inaccurate because very little ^{14}C is present. OR ^{14}C has a short half-life.
- 48) Ordovician Period
- 49) SAMPLE ANSWERS: Intrusions are younger than any rock they metamorphose. OR Contact metamorphism can be seen between rock layer *D* and the igneous intrusion.
- 50) An X should be placed with its center falling within the blackened zone of contact metamorphism shown in the diagram below.



- 51)

<i>D</i>	<i>C</i>	<i>fault GH</i>	<i>unconformity</i> <i>XY</i>	<i>B</i>	<i>A</i>
Oldest → Youngest					



- 53) SAMPLE ANSWERS: Earliest land plants did not occur until the Silurian. Extensive coal-forming forests didnt exist until the Carboniferous Period.
- 54) SAMPLE ANSWERS: earliest birds OR birds

- 55) Eocene Epoch
- 56) 1,300 (± 200) million years
- 57) 65 million yr
- 58) SAMPLE ANSWERS: U^{238} has a longer half-life. OR U^{238} can be used to date older geologic events. OR C^{14} is used to date organic remains while U^{238} is not.
- 59) SAMPLE ANSWERS: 5,700 years OR 5.7×10^3 years
- 60) Pleistocene Epoch
- 61) Silurian Period

Fossil Classification

62)	Index Fossil	<i>Eospirifer</i>	<i>Manticoceras</i>	<i>Phacops</i>
	General Fossil Group	Brachiopod	Ammonoid	Trilobite

- 63) SAMPLE ANSWERS: fossils OR volcanic dust OR pollen OR trapped gases OR microbes
- 64) SAMPLE ANSWERS: wide geographic distribution OR existed for a short period of geologic time
- 65) SAMPLE ANSWERS: (a) Cretaceous Period and Tertiary Period OR Paleogene Period and Cretaceous Period; (b) crater OR large ocean waves OR impact crater OR large hole