1. A whalebone that originally contained 200 grams of radioactive carbon-14 now contains 25 grams of carbon-14. How many carbon-14 half-lives have passed since this whale was alive?
   (1) 1  (2) 2  (3) 3  (4) 4

2. The diagram below represents a sample of a radioactive isotope.
   Sample before decay
   [Diagram]

   Which diagram best represents the percentage of this radioactive isotope sample that will remain after 2 half-lives?
   (1)  (2)  (3)  (4)

3. The table below shows information about the radioactive decay of carbon-14.

<table>
<thead>
<tr>
<th>Half-Life</th>
<th>Mass of Original Carbon-14 Remaining (g)</th>
<th>Number of Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>$\frac{1}{2}$</td>
<td>5700</td>
</tr>
<tr>
<td>2</td>
<td>$\frac{1}{4}$</td>
<td>11,400</td>
</tr>
<tr>
<td>3</td>
<td>$\frac{1}{8}$</td>
<td>17,100</td>
</tr>
</tbody>
</table>

   What is the amount of carbon-14 remaining after 28,500 years?
   (1) $\frac{1}{16}$ g  (3) $\frac{1}{32}$ g
   (2) $\frac{15}{16}$ g  (4) $\frac{31}{32}$ g

4. How old is a fossil that has radioactively decayed through 4 half-lives of carbon-14?
   (1) 5,700 years  (3) 22,800 years
   (2) 17,100 years  (4) 28,500 years

5. The division of Earth’s geologic history into units of time called eons, eras, periods, and epochs is based on
   (1) absolute dating techniques  (3) climatic changes
   (2) fossil evidence            (4) seismic data

6. Which event in Earth’s history was dependent on the development of a certain type of life-form?
   (1) addition of free oxygen to Earth’s atmosphere
   (2) formation of clastic sedimentary rocks
   (3) movement of tectonic plates
   (4) filling of the oceans by precipitation

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

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

9. An igneous rock contains 10 grams of radioactive potassium-40 and a total of 10 grams of its decay products. During which geologic time interval was this rock most likely formed?
   (1) Middle Archean
   (2) Late Archean
   (3) Middle Proterozoic
   (4) Late Proterozoic

10. Which geologic event occurred in New York State at approximately the same time that eurypterids were becoming extinct?
    (1) the opening of the Atlantic Ocean
    (2) the uplift of the Appalachian Mountains
    (3) the formation of the Catskill Delta
    (4) the intrusion of the Palisades Sill

11. The gases in Earth’s early atmosphere are inferred to have come primarily from
    (1) meteor showers
    (2) melting of glacial ice
    (3) volcanic eruptions
    (4) evaporation of seawater
12. The diagram at right shows a process thought to have produced Earth’s early atmosphere.

Which major component is shown as gas X?
(1) helium  (3) carbon dioxide
(2) ozone    (4) hydrogen

13. One reason Tetragraptus is considered a good index fossil is that Tetragraptus
(1) existed during a large part of the Paleozoic Era
(2) has no living relatives found on Earth today
(3) existed over a wide geographic area
(4) has been found in New York State

14. Eurypterid fossils are abundant in the Bertie dolostone, a sedimentary rock layer found in western New York State. The presence of both the eurypterids and the dolostone indicates that, during the formation of this rock layer, this region of New York State was
(1) covered by evaporating shallow seas
(2) uplifted and eroded
(3) buried beneath lava flows
(4) intensely metamorphosed

15. The presence of eurypterid fossils in New York State bedrock indicates that
(1) eurypterids lived in land environments
(2) eurypterids first appeared during the Devonian Period
(3) most of New York State was once a mountainous region
(4) areas of New York State were once covered with shallow seas

16. Which index fossil may be found in the surface bedrock near Ithaca, New York?

17. According to the fossil record, which group of organisms has existed for the greatest length of time?
(1) gastropods     (3) mammals
(2) corals     (4) vascular plants

18. What is the geologic age sequence of the surface bedrock from Ithaca, New York, to Watertown, New York?
(1) Ordovician, Taconic, Cambrian
(2) Ordovician, Tertiary, Pleistocene
(3) Devonian, Silurian, Cambrian
(4) Devonian, Silurian, Ordovician

19. Which statement is best supported by the fossil record?
(1) Fossils are found in nearly all rocks.
(2) Fossils are found only in areas that were once under water.
(3) Most early life-forms that left fossil remains are now extinct.
(4) Most early life-forms that left fossil remains still exist today.

20. Which geologic event occurred during the same geologic period as the first appearance of modern corals in Earth’s oceans?
(1) Grenville Orogeny
(2) Acadian Orogeny
(3) intrusion of the Palisades Sill
(4) formation of the Catskill Delta

21. Which sequence of New York State index fossils shows the order in which the organisms appeared on Earth?

22. Which graph best represents human existence on Earth, compared with Earth’s entire history?
23. According to the fossil record, which sequence correctly represents the evolution of life on Earth?
(1) fish → amphibians → mammals → soft-bodied organisms
(2) fish → soft-bodied organisms → mammals → amphibians
(3) soft-bodied organisms → amphibians → fish → mammals
(4) soft-bodied organisms → fish → amphibians → mammals

24. The lower layers of sediment found in sandstone C were deposited 520 million years ago. During which period of geologic time did this deposition occur?
(1) Cambrian
(2) Ordovician
(3) Silurian
(4) Triassic

25. After the metamorphism of rock D, which sequence of events most probably formed unconformity AB?
(1) flooding → deposition → erosion → uplift
(2) uplift → erosion → flooding → deposition
(3) deposition → flooding → uplift → erosion
(4) erosion → flooding → uplift → deposition

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

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

27. When these rocks were deposited as sediments, this area was most likely
(1) under the ocean
(2) a desert between high mountains
(3) repeatedly covered by lava flows
(4) glaciated several times

28. Both organisms that formed the fossils found in rock layers 3 and 4
(1) lived during the same period of geologic time
(2) lived in polar regions
(3) are members of the same group of organisms
(4) are still alive today

29. Evidence best indicates that rock layers 4 and 8 were deposited during the same geologic period because both layers
(1) contain the same index fossil
(2) are composed of glacial sediments
(3) contain index fossils of the same age
(4) are found in the same area

30. The graph below shows the extinction rate of organisms on Earth during the last 600 million years. Letters A through D represent mass extinctions.

Which letter indicates when dinosaurs became extinct?
(1) A  (2) B  (3) C  (4) D
Base your answers to questions 31 and 32 on the diagrams below. Diagram 1 is a drawing of a seafloor environment during the Carboniferous Period. Diagram 2 is a drawing of a Carboniferous swamp-forest environment. Two organisms are labeled A and B.

31. If the fish labeled A in diagram 1 are placoderms, the diagram represents conditions during which geologic epoch?
(1) Early Mississippian  (3) Early Pennsylvanian
(2) Late Mississippian  (4) Late Pennsylvanian

32. In which type of rock would fossils of organisms A and B most likely be found?
(1) felsic igneous  (3) clastic sedimentary
(2) vesicular igneous  (4) nonfoliated metamorphic

33. During which two geologic time periods did most of the surface bedrock of the Taconic Mountains form?
(1) Cambrian and Ordovician  (2) Silurian and Devonian
(3) Pennsylvanian and Mississippian  (4) Triassic and Jurassic

34. The geologic cross section below shows a complex structure containing a granite intrusion.
If the granite intrusion occurred 24 million years ago, what are the most probable ages of the schist and shale, in millions of years?
(1) schist – 25; shale – 23  (3) schist – 23; shale – 25
(2) schist – 25; shale – 26  (4) schist – 23; shale – 20

35. The cross section below shows rock layers A, B, C, D, and fault F. The rock layers have not been overturned.

36. Which characteristic of the granite intrusion provides the most evidence that it solidified deep underground?
(1) very hard  (3) light color
(2) coarse texture  (4) felsic composition

37. Which event occurred sometime after the formation of the unconformity?
(1) formation of rock unit 3  (2) tilting of rock unit 5
(3) deposition of the sediments that formed rock unit 8  (4) intrusion of rock unit 7

38. Which rock most probably formed in the contact metamorphic zone within rock unit 6?
(1) marble  (3) quartzite
(2) basalt  (4) hornfels
39. The cross section below shows a rock sequence that has not been overturned.

Which event occurred last at this location?
(1) Shale was deposited.
(2) Glacial till was deposited.
(3) Basaltic lava flows solidified.
(4) Glossopteris flourished and then became extinct.

Base your answers to questions 41 through 43 on the cross section below, which shows the bedrock of a portion of the Helderberg Escarpment, located in Thacher State Park near Albany, New York. The rock formations are identified by name.

40 Which time line most accurately indicates when this sequence of events in Earth’s history occurred?

41. Which formations appear to be the most resistant to weathering?
(1) Esopus and Oriskany
(2) Onondaga and Coeymans
(3) Schoharie, and Marcellus and Hamilton
(4) New Scotland, and Schenectady and Indian Ladder beds

42. What is the main factor that causes the bedrock to weather at different rates?
(1) elevation above sea level     (3) age of rock layers
(2) mineral composition             (4) environment of formation

43. The Manlius layer formed during the early Devonian Period. What type of fossils could possibly be found in the Manlius layer?
(1) earliest birds            (3) Tetragraptus
(2) earliest reptiles        (4) Ctenocrinus

44. On the map below, the darkened areas represent locations where living corals currently exist. The arrow points to a location where coral fossils have been found in Devonian-age bedrock in New York State.

Devonian-age coral fossils found in some New York State bedrock are not located in the same general region that present-day corals are living because during the Devonian Period
(1) corals migrated to New York State
(2) corals lived everywhere on Earth
(3) New York State was closer to the equator
(4) New York State had a colder climate
Fossils and the History of Earth’s Rotation

Data from coral fossils support the hypothesis that Earth’s rotation rate has been slowing down by about 2.5 seconds per 100,000 years. Scientists believe this is due to the frictional effects of ocean tides. This slowing rotation rate decreases the number of days in the year. Scientists have discovered that corals produce a thin layer of shell every day, resulting in growth rings. These daily layers are separated by yearly ridges. The Devonian coral fossil, Pleurodictyum, has approximately 400 growth rings between each yearly ridge, which suggests that there were about 400 days in a year during the Devonian Period. Supporting this hypothesis, scientists have found coral from the Pennsylvanian Period that have about 390 growth rings per year, while present-day corals have about 365 growth rings per year.

45. Approximately how many fewer Earth days per year are there today than there were during the Devonian Period?
   (1) 10  (2) 25  (3) 35  (4) 40

46. What inference can be made about the number of growth rings per year for a coral from the Permian Period and Ordovician Period compared to the number of growth rings per year for the Devonian coral, Pleurodictyum?
   (1) Ordovician coral would have fewer, but Permian coral would have more.
   (2) Ordovician coral would have more, but Permian coral would have fewer.
   (3) Both Ordovician and Permian coral would have fewer.
   (4) Both Ordovician and Permian coral would have more.

47. The evidence of the fossil Pleurodictyum found in surface bedrock in the Finger Lakes region of New York State suggests that this region was once
   (1) covered by a glacial ice sheet  (3) located in a desert area
   (2) covered by a warm, shallow sea  (4) located in a tropical rain forest

Geologic History B2 - C

Base your answers to questions 1 through 4 on the cross section below which shows a portion of Earth’s crust. Letters A through J represent rock units or geologic structures. The rock units have not been overturned.

1. On the cross section, draw a circle around the letter of the oldest rock unit shown. [1]

2. On the same cross section, place an X to indicate a location where the rock, marble, was formed. [1]

3. Describe one piece of evidence shown in the cross section that suggests rock unit D is younger than rock unit F. [1]
   ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

4. Explain why rock unit H is not one continuous layer. [1]
   ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

   ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Base your answers to questions 5 through 7 on the cross section below, which shows rock units A through E that have not been overturned.

5. Identify one metamorphic rock that may be found along the boundary between rock units C and E. [1] 

6. Describe one piece of evidence shown in the cross section that can be used to infer that rock unit A is younger than rock unit B. [1]

7. State the diameter of a particle normally found in rock unit B. [1] _______________________________

Base your answers to questions 8 through 10 on the data table below, which shows the radioactive decay of carbon-14. The number of years required to complete four half-lives has been left blank.

8. On the grid below, 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 Xs with a smooth, curved line. [1]

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

9. How long does it take for radioactive carbon-14 to complete four half-lives? [1] _______________________

10. 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. [1]
11. The table below shows information about Earth’s geologic history. Letter X represents information that has been omitted. Identify one important geologic event that occurred in New York State that could be placed in the box at X. [1]

<table>
<thead>
<tr>
<th>Period</th>
<th>Million Years Ago</th>
<th>Index Fossil Found in Bedrock</th>
<th>Important Geologic Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triassic</td>
<td>251 to 200</td>
<td>Coelophysis</td>
<td>X</td>
</tr>
</tbody>
</table>

Base your answers to questions 12 through 14 on the map below, which shows the inferred position of Earth’s landmasses at a particular time in Earth’s history. The Taconic Mountains are shown near a subduction zone where they formed after the coast of Laurentia collided with a volcanic island arc, closing the western part of the Iapetus Ocean.

12. On the map place an X to show the approximate location of the remaining part of the Iapetus Ocean. [1]

13. On the map draw an arrow on the Laurentia landmass to show its direction of movement relative to the subduction zone. [1]

14. Identify the geologic time period represented by the map.
[1]____________________________________

Base your answers to questions 15 through 17 on the cross sections below, which 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.

15. Describe one characteristic necessary for a fossil to be classified as an index fossil. [1]
______________________________________________
______________________________________________
______________________________________________

16. On outcrop II place the symbol for an unconformity between the two rock layers where the Silurian-age bedrock has been removed by erosion. [1]

17. 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. [1]

Oldest ___________________________ ___________________________ ___________________________ ___________________________ ___________________________ Youngest

____________________________________
Base your answers to questions 18 through 22 on the passage and map below. Point F on the map 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 bone yard covering hundreds of square miles.

18. State the latitude and longitude of point F, to the nearest degree, where the fossil Asfaltomylos patagonicus was discovered. Include the correct units and compass directions in your answer. [1]

__________________________________________________________________________

19. State the name of the dominant sediment particle that was compacted to form the shale in which this fossil was found. [1]

____________________________________________________________________

20. What other life-form first appeared on Earth during the geologic period when Asfaltomylos patagonicus existed? [1]

________________________________________________________________________

21. State one method used by geologists to determine the age of the bedrock in which this ancient mammal fossil was found. [1]

__________________________________________________________________________

22. Explain how the uplift of the Andes Mountains changed eastern Patagonia’s climate from a wet tropical forest at the time Asfaltomylos patagonicus lived to the arid conditions of today. [1]

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Siccar Point

The diagram 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.

23. On the diagram draw a dark, heavy line tracing the unconformity separating the graywacke from the Old Red Sandstone.

24. During which geologic time period did the graywacke bedrock form? [1] ___________________________

25. 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. [1]

26. Identify two of the processes that produced the unconformity at Siccar Point. [1]

Base your answers to questions 27 through 29 on the sequence of diagrams below, which shows four stages in coal formation.

27. Which type of rock is forming above the coal material during stages 2 and 3? [1] ______________________________

28. State the form of coal which normally has the highest density and explain why. [1]___________________________

29. Explain why coal deposits are not found in bedrock older than Silurian-age bedrock. [1]___________________________