1) The diagrams below show cross sections of exposed bedrock. Which cross section shows the least evidence of crustal movement?

A) ![Diagram A]

B) ![Diagram B]

C) ![Diagram C]

D) ![Diagram D]

2) A seismograph station $3 \times 10^3$ kilometers from an epicenter received $P$-waves at 3:33:00 in the afternoon. What was the origin time of the earthquake? [Refer to the Earth Science Reference Tables.]

A) 3:38:40 p.m.  
B) 3:28:40 p.m.  
C) 3:27:20 p.m.  
D) 3:03:00 p.m.

3) Which is the best evidence that the Earth's crust has been uplifted?

A) shallow-water fossils found at great ocean depths  
B) marine fossils found at high elevations above sea level  
C) younger fossils above older fossils in layers of rock  
D) marine fossils found in horizontal sedimentary layers

4) Many scientists believe that convection currents in the mantle between South America and Africa caused the separation of the two continents and the formation of the Mid-Atlantic Ridge. Which diagram best represents the currents described in this theory?

A) ![Diagram A]

B) ![Diagram B]

C) ![Diagram C]

D) ![Diagram D]

Questions 5 through 7 refer to the following:

The map below shows the location of the Peru-Chile Trench.

![Map of Peru-Chile Trench]
5) In which diagram do the arrows best represent the motions of Earth's crust at the Peru-Chile Trench?

A) 
B) 
C) 
D) 

6) Which observation provides the best evidence of the pattern of crustal movement at the Peru-Chile Trench?
A) the mineral composition of samples of mafic mantle rock
B) comparison of the rates of sediment deposition
C) the direction of flow of warm ocean currents
D) the locations of shallow-focus and deep-focus earthquakes

7) The Peru-Chile Trench marks the boundary between the
A) Caribbean Plate and the Scotia Plate
B) North American Plate and the Cocos Plate
C) Pacific Plate and the Antarctic Plate
D) Nazca Plate and the South American Plate

8) The map below shows the western part of the United States.

Which observation made at Salt Lake City would allow seismologists to determine that an earthquake had occurred somewhere along the circle shown on the map?
A) the difference in the direction of vibration of the P-waves and S-waves
B) the density of the subsurface bedrock through which the P-waves and S-waves travel
C) the relative strength of the P-waves and S-waves
D) the time interval between the arrival of the P-waves and S-waves
9) Which graph best represents the relationship between the differences in arrival times of P-waves and S-waves for locations at varying distances from an earthquake?

A) ![Graph A]

B) ![Graph B]

C) ![Graph C]

D) ![Graph D]

10) An earthquake occurred at 5:00:00 a.m. According to the Earth Science Reference Tables, at what time would the P-wave reach a seismic station 3,000 kilometers from the epicenter?

A) 5:10:15 a.m.  
B) 5:05:40 a.m.  
C) 5:01:40 a.m.  
D) 5:04:30 a.m.

11) The diagram below shows a portion of the Earth's crust.

The movements indicated by the arrows represent the process of

A) metamorphism  
B) faulting  
C) folding  
D) volcanism

12) The study of how seismic waves change as they travel through Earth has revealed that

A) seismic waves travel more slowly through the mantle because it is very dense
B) Earth’s outer core is liquid because S-waves are not transmitted through this layer
C) P-waves travel more slowly than S-waves through Earth’s crust
D) Earth’s outer core is solid because P-waves are not transmitted through this layer

Questions 13 through 15 refer to the following:

The diagram below is a block section of central New York State that extends deep into the Earth's interior. Points A and B represent reference points within the Earth.

13) According to the Earth Science Reference Tables, the inferred average density of the rock in the region around point B is most likely

A) 2.7 g/cm³  
B) 11.5 g/cm³  
C) 9.2 g/cm³  
D) 3.5 g/cm³
14) Which graph best represents the relationship between pressure and depth from point A to point B?

A)  
B)  
C)  
D)  

15) Which two zones of the Earth's interior are represented in the diagram?
A) outer core and inner core  
B) crust and mantle  
C) crust and outer core  
D) mantle and outer core

16) A seismograph station records a difference in arrival time between the S- and P-wave of 4 minutes. About how far away is the earthquake epicenter? (Refer to the Earth Science Reference Tables.)
A) 5,200 km  
B) 2,600 km  
C) 1,900 km  
D) 1,000 km

17) Earthquakes generate compressional waves (P-waves) and shear waves (S-waves). Compared to the speed of shear waves in a given earth material, the speed of compressional waves is
A) always faster  
B) sometimes faster and sometimes slower  
C) always slower  
D) always the same

18) The composition of some meteorites supports the inference that the Earth's core is composed of
A) magnesium and potassium  
B) aluminum and calcium  
C) iron and nickel  
D) silicon and oxygen

19) An earthquake's P-wave arrived at a seismograph station at 02 hours 40 minutes 00 seconds. The earthquake's S-wave arrived at the same station 2 minutes later. What is the approximate distance from the seismograph station to the epicenter of the earthquake?
A) 1,100 km  
B) 2,400 km  
C) 3,100 km  
D) 4,000 km

20) Folded sedimentary rock layers are usually caused by
A) deposition of sediments in folded layers  
B) differences in sediment density during deposition  
C) crustal movement occurring after deposition  
D) a rise in sea level after deposition

21) Which evidence does not support the theory that Africa and South America were once part of the same large continent?
A) correlation of fossils on opposite sides of the Atlantic Ocean  
B) correlation of living animals on opposite sides of the Atlantic Ocean  
C) correlation of rocks on opposite sides of the Atlantic Ocean  
D) correlation of coastlines on opposite sides of the Atlantic Ocean

22) The diagram below shows a portion of Earth's interior. Point A is a location on the interface between layers.

The arrows shown in the asthenosphere represent the inferred slow circulation of the plastic mantle by a process called
A) radiation  
B) insolation  
C) convection  
D) conduction

23) The fact that S-waves are unable to travel through the Earth's outer core supports the inference that the outer core is
A) in the solid state of matter  
B) hotter than the rock's melting point  
C) composed of iron and nickel  
D) more dense than the inner core

24) According to the Earth Science Reference Tables, as the depth within the Earth's interior increases, the
A) density, temperature, and pressure decrease  
B) density, temperature, and pressure increase  
C) density increases, but temperature and pressure decrease  
D) density and temperature increase, but pressure decreases

25) According to the Earth Science Reference Tables, if a seismograph recording station located 5,700 kilometers from an epicenter receives a P-wave at 4:45 p.m., at which time did the earthquake actually occur at the epicenter?
A) 4:56 p.m.  
B) 4:36 p.m.  
C) 4:24 p.m.  
D) 4:29 p.m
26) The thinnest section of the Earth's crust is found beneath  
A) mountain regions  
B) desert regions  
C) oceans  
D) coastal plains  

27) Compared to the continental crust of central North America, the oceanic crust of the Mid-Atlantic Ridge is  
A) thicker  
B) younger  
C) more felsic  
D) less dense  

Questions 28 and 29 refer to the following:  

The diagram below of the Earth shows the observed pattern waves recorded after an earthquake.  

28) The lack of S-waves in zone 3 can best be explained by the presence within the Earth of  
A) a solid inner core  
B) a liquid outer core  
C) mantle convection cells  
D) density changes  

29) The location of the epicenter of the earthquake that produced the observed wave pattern most likely is in the  
A) crust in zone 3  
B) mantle in zone 2  
C) crust in zone 1  
D) core of the Earth  

30) Theories about the composition of the Earth’s core are supported by meteorites that are composed primarily of  
A) aluminum and iron  
B) aluminum and oxygen  
C) oxygen and silicon  
D) iron and nickel  

31) According to the “Inferred Position of Earth Landmasses” information shown in the Earth Science Reference Tables, on what other landmass would you most likely find fossil remains of the late Paleozoic reptile called Mesosaurus shown below?  

A) Antarctica  
B) Africa  
C) North America  
D) Eurasia  

32) Which is suggested by the occurrence of higher than average temperature below the surface of the Earth in the area of the Mid-Atlantic Ridge?  
A) the existence of a thinner crust under mountains  
B) the presence of heat due to orographic effect  
C) a high concentration of magnetism in the mantle  
D) the existence of convection cells in the mantle  

33) Which statement best explains why the P-wave of an earthquake arrives at a seismic station before the S-wave?  
A) The P-wave originates from the earthquake epicenter.  
B) The P-wave has a greater velocity than the S-wave.  
C) The S-wave decreases in velocity as it passes through a liquid.  
D) The S-wave originates from the earthquake focus.  

34) According to the Earth Science Reference Tables, what is the approximate total distance traveled by an earthquake’s P-wave in its first 9 minutes?  
A) 5,600 km  
B) 12,100 km  
C) 7,600 km  
D) 2,600 km  

35) To get a sample material from the mantle, drilling will be done through the oceanic crust rather than through the continental crust because oceanic crust is  
A) thinner than continental crust  
B) younger than continental crust  
C) more dense than continental crust  
D) softer than continental crust
36) A sandstone layer is found tilted at an angle of 75° from the horizontal. What probably caused this 75° tilt?
   A) Nearly all sandstone layers are formed from wind-deposited sands.
   B) The sediments that formed this sandstone layer were originally deposited at a 75° tilt.
   C) This sandstone layer has recrystallized due to contact metamorphism.
   D) This sandstone layer has changed position due to crustal movement.

37) The epicenter of an earthquake is located near Massena, New York. According to the Earth Science Reference Tables, the greatest difference in arrival times of the P- and S-waves for this earthquake would be recorded in
   A) Binghamton, New York
   B) Plattsburgh, New York
   C) Utica, New York
   D) Albany, New York

38) The best evidence of crustal uplift would be provided by
   A) sediment in the Gulf of Mexico
   B) igneous rock deep within the Earth
   C) marine fossils in the Rocky Mountains
   D) trenches in the Pacific Ocean floor

39) Two geologic surveys of the same area, made 50 years apart, showed that the area had been uplifted 5 centimeters during the interval. If the rate of uplift remains constant, how many years will it take for this area to be uplifted a total of 70 centimeters?
   A) 700 years
   B) 250 years
   C) 350 years
   D) 500 years

40) According to the Earth Science Reference Tables, during which geologic time period were the continents of North America, South America, and Africa closest together?
   A) Carboniferous
   B) Tertiary
   C) Cretaceous
   D) Triassic

41) A seismograph recording station located 2,000 kilometers from the epicenter of an earthquake receives an S-wave at 11:30:00 p.m. According to the Earth Science Reference Tables, when did the earthquake occur?
   A) 11:26:00 p.m.
   B) 11:22:40 p.m.
   C) 11:33:20 p.m.
   D) 11:37:20 p.m.

42) The fine-grained texture of most of the igneous rock formed on the surface of Iceland is due to
   A) rapid cooling of the molten rock
   B) high pressure under the island
   C) high density of the molten rock
   D) numerous faults in the island’s bedrock

43) The youngest bedrock is most likely found at which location?
   A) A
   B) B
   C) C
   D) D

44) The inference that the inner core of the Earth is solid is based on analysis of
   A) crustal rock
   B) seismic data
   C) radioactive data
   D) meteorite composition
45) The newspaper article shown below was taken and adapted from the Los Angeles Times.

**VOLCANIC BLAST SHAPED EARTH**

*Study finds eruption split an ancient continent, creating Atlantic Ocean*

The largest volcanic eruption in Earth's history so powerful it split an ancient supercontinent and created the Atlantic Ocean spewed millions of square miles of searing lava that extinguished much of life on ancient Earth.

From hundreds of basalt outcrops that rim the Atlantic coasts, scientists have pieced together evidence of the titanic eruption 200 million years ago. Researchers said that the eruption set the fractured landmasses adrift and, by wedging them apart, gradually opened the gulf that created the Atlantic giving the map of the world the form it has today.

"This is one of the biggest things that has ever happened in Earth's history. This is a gigantic, igneous event and it all seems to have occurred in an amazingly brief amount of time."

To reconstruct the ancient catastrophe, a team of scientists analyzed basalt dikes, sills, and lavas from the New Jersey Palisades, the Brazilian Amazon, Spain, and West Africa.

By studying the chemical composition and dating the residual radioisotopes in the basaltic rocks, the researchers determined that the rocks all originated from the same eruption. Once they realized the outcrops were linked, they were able to determine that, in the distant past, the rocks all had been located together at the center of an immense continent called Pangea that once stretched, unbroken, from pole to pole.

Basaltic outcrops are not the only evidence of this ancient continental splitting. Describe another piece of evidence that supports the idea that the present-day continents were once part of the large ancient continent, Pangea, that split apart.

46) According to the *Earth Science Reference Tables*, during which geologic period were the continents all part of one landmass, with North America and South America joined to Africa?

A) Cretaceous  
B) Triassic  
C) Carboniferous  
D) Tertiary

47) The difference in arrival times for *P*- and *S*-waves from an earthquake is 5.0 minutes. According to the *Earth Science Reference Tables*, how far away is the epicenter of the earthquake?

A) $8.1 \times 10^3$ km  
B) $2.6 \times 10^3$ km  
C) $1.3 \times 10^3$ km  
D) $3.5 \times 10^3$ km

48) According to the *Earth Science Reference Tables*, in which part of the Earth is a rock temperature of 2,000°*C* most likely to occur?

A) asthenosphere (plastic mantle)  
B) continental crust  
C) stiffer mantle  
D) outer core

49) A seismic station in a small town recorded the arrival of the first *P*-wave at 1:30:00 (1 hour, 30 minutes, 00 seconds) and the first *S*-wave from the same earthquake at 1:34:30.

(a) Determine the distance, in kilometers, from the town to the epicenter of this earthquake.

(b) State what additional information is needed to determine the location of the epicenter of this earthquake.

50) The structure of the Earth's interior is *best* inferred by

A) analyzing worldwide seismic data  
B) determining crustal density differences  
C) measuring crustal temperature ranges  
D) observing rock samples from surface bedrock

51) Which best describes a major characteristic of both volcanoes and earthquakes?

A) They are located in the same geographic areas.  
B) They are restricted to the Southern Hemisphere.  
C) They are centered at the poles.  
D) They are related to the formation of glaciers.

52) Most of the oceanic crust is composed of rock material similar to

A) sandstone  
B) granite  
C) limestone  
D) basalt

53) According to the *Earth Science Reference Tables*, the rock between 2,900 kilometers and 5,200 kilometers below the Earth's surface is inferred to be

A) a silicate-rich solid  
B) an iron-rich liquid  
C) a silicate-rich liquid  
D) an iron-rich solid

54) A seismic station receives a *P*-wave at 12:07 a.m. and an *S*-wave at 12:12 a.m. The station's distance from the epicenter is approximately

A) 8,800 km  
B) 2,600 km  
C) 3,400 km  
D) 4,000 km
55) The diagram below represents the seismogram recorded at a seismograph station as a result of an earthquake. Based on the data provided by the seismogram, what is the approximate distance between the station and the earthquake epicenter? [Refer to the Earth Science Reference Tables.]

- [Diagram of P-Wave and S-Wave]

A) 2,600 km  
B) 1,300 km  
C) 3,400 km  
D) 5,200 km

56) The composition of the Earth's core is thought to be the same as the composition of

A) most basalts  
B) most granites  
C) certain meteorites  
D) volcanic ash

57) Why do geologists infer that the Earth's outer core is a liquid?

A) S-waves do not pass through the outer core of the Earth.  
B) P-waves can travel through the core of the Earth.  
C) Instruments indicate that the Earth's temperature increases with depth.  
D) S-waves travel faster than P-waves in the outer core.

58) Where on the Earth can the best evidence of past magnetic field reversals be found?

A) in water molecules in the oceans  
B) in sediments being deposited in the oceans  
C) in folded metamorphic rocks on the continental shelves  
D) in igneous rocks on the floor of the oceans

59) A seismic station is 2,000 kilometers from an earthquake epicenter. According to the Earth Science Reference Tables, how long does it take an S-wave to travel from the epicenter to the station?

A) 3 minutes 20 seconds  
B) 4 minutes 10 seconds  
C) 5 minutes 10 seconds  
D) 7 minutes 20 seconds

60) What is the relationship between the velocity of compressional waves (P-waves) and the velocity of the shear waves (S-waves) as they travel through the same material?

A) S-waves have a greater velocity.  
B) P-waves and S-waves have the same velocity.  
C) P-waves have a greater velocity.

61) The analysis of seismic data from an earthquake shows that some locations received both P-waves and S-waves, but other locations received only P-waves. What is the best inference that can be made from these observations?

A) Some seismographs are more sensitive than others.  
B) Iron in some rocks prevents S-waves from traveling.  
C) A zone of liquid rock exists within the Earth.  
D) S-waves are very weak.

62) Shallow-water fossils are found in rock layers that are deep beneath the ocean floor. This suggests that

A) the surface water cooled off, killing the organisms  
B) shallow-water organisms always migrate to the deeper waters to die  
C) parts of the ocean floor have subsided  
D) parts of the ocean floor have been uplifted

63) The time that an earthquake occurs can be inferred by knowing the

A) epicenter distance and arrival time of the P-waves  
B) arrival time of P-waves  
C) distances between seismograph stations  
D) travel time of the S-waves

64) Which evidence supports the theory of ocean floor spreading?

A) In the ocean floor, rocks near the mid-ocean ridge are cooler than rocks near the continents.  
B) The pattern of magnetic orientation of rocks is similar on both sides of the mid-ocean ridge.  
C) The density of oceanic crust is greater than the density of continental crust.  
D) The rocks of the ocean floor and the continents have similar origins.

65) A P-wave reaches a seismograph station 2,600 kilometers from an earthquake epicenter at 12:10 p.m. According to the Earth Science Reference Tables, at what time did the earthquake occur?

A) 12:01 p.m.  
B) 12:05 p.m.  
C) 12:15 p.m.  
D) 12:19 p.m.
66) The circles on the map below show the distances from three seismic stations, X, Y, and Z, to the epicenter of an earthquake.

Which location is closest to the earthquake epicenter?
A) A  C) C
B) B  D) D

67) As evidence accumulates, the support for the theory that the present continents were at one time a single, large landmass
A) increases  C) remains the same
B) decreases

Questions 68 through 71 refer to the following:

The map below shows the crustal plate boundaries located along the Pacific coastline of the United States. The arrows show the general directions in which some of the plates appear to be moving slowly.

68) The best way to find the direction of crustal movement along the San Andreas fault is to
A) match displaced rock types from opposite sides of the fault
B) measure gravitational strength on opposite sides of the fault
C) observe erosion along the continental coastline
D) study the Earth's present magnetic field

69) What would a study of the East Pacific rise (a mid-ocean ridge) indicate about the age of the basaltic bedrock in this area?
A) The bedrock is youngest at the ridge.
B) The bedrock at the ridge is the same age as the bedrock next to the continent.
C) The bedrock at the ridge is the same age as the bedrock at the San Andreas fault.
D) The bedrock is oldest at the ridge.

70) Geologic studies of the San Andreas fault indicate that
A) the subduction zone is the boundary at which the crustal plates are drifting apart
B) the North American plate and the Pacific plate are locked in dynamic equilibrium
C) many earthquakes occur along the San Andreas fault
D) the age of the bedrock increases as distance from the fault increases
71) Which features are most often found at crustal plate boundaries like those shown on the map?
   A) plains and plateaus
   B) geysers and glaciers
   C) meandering rivers and warm-water lakes
   D) faulted bedrock and volcanoes

72) Which evidence best supports the inference that the Earth's outer core possesses liquid characteristics?
   A) The velocities of both primary and shear waves increase through the outer core.
   B) Both primary waves and shear waves pass through the outer core.
   C) The primary wave velocity decreases, while the shear wave velocity increases in the outer core.
   D) Primary waves pass through the outer core but shear waves do not.

73) An observer discovers shallow-water marine fossils in rock strata at an elevation of 5,000 meters. What is the best explanation for this observation?
   A) The level of the ocean was once 5,000 meters higher.
   B) Crustal uplift has occurred in the area.
   C) Marine organisms have evolved.
   D) Violent earthquakes caused crustal subsidence.

74) The photograph below shows an outcrop of sedimentary rock layers that have been tilted and slightly metamorphosed.

[Image of tilted rock structure]

The tilted rock structure shown in the photograph is most likely the result of the
   A) collision of crustal plates
   B) reversal of past magnetic poles
   C) deposition of rock fragments on a mountain slope
   D) passage of seismic waves

75) Which inference is supported by a study of the Earth's magnetic rock record?
   A) The Earth's magnetic poles appear to have changed location over time.
   B) The Earth's magnetic poles are usually located at 0° latitude.
   C) The Earth's magnetic field is only 2 million years old.
   D) The Earth's magnetic field is 50 times stronger now than in the past.

76) Hot springs on the ocean floor near the mid-ocean ridges provide evidence that
   A) meteor craters are found beneath the oceans
   B) marine fossils have been uplifted to high elevations
   C) convection currents exist in the asthenosphere
   D) climate change has melted huge glaciers

77) Which seismic information is needed to find the distance from an observer to an earthquake epicenter?
   A) depth of the earthquake focus
   B) P-wave and S-wave arrival times
   C) origin time of the earthquake
   D) P-wave and S-wave refractions

78) A seismograph station records a travel time difference of 7 minutes between P-waves and S-waves of an earthquake. Approximately how far is the seismograph station from the epicenter of the earthquake? [Refer to the Earth Science Reference Tables.]
   A) 1.9 x 10^3 km
   B) 2.9 x 10^3 km
   C) 4.0 x 10^3 km
   D) 5.5 x 10^3 km

Questions 79 through 83 refer to the following:

An earthquake originated in New York State. The P-wave travel time for this earthquake was recorded in the data table below for four widely separated seismic stations, A, B, C, and D.

<table>
<thead>
<tr>
<th>Seismic Station</th>
<th>P-wave Travel Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8 min 20 sec</td>
</tr>
<tr>
<td>B</td>
<td>9 min 31 sec</td>
</tr>
<tr>
<td>C</td>
<td>12 min 18 sec</td>
</tr>
<tr>
<td>D</td>
<td>3 min 20 sec</td>
</tr>
</tbody>
</table>

79) Which seismic station could be located in New York State?
   A) C
   B) A

80) Which of the four seismic stations is located farthest from the epicenter?
   A) B
   B) C
81) If the first $P$-wave arrived at seismic station $A$ at 10hrs:22min:30sec, what was the origin time for the earthquake?
A) 02hrs:02min:30sec
B) 10hrs:14min:10sec
C) 10hrs:30min:50sec
D) 10hrs:22min:30sec

82) What is the approximate distance between the earthquake's epicenter and station $A$? [Refer to the Earth Science Reference Tables.]
A) 7,500 km
B) 1,130 km
C) 5,100 km
D) 2,400 km

83) If it takes 50 seconds for the $P$-wave to arrive at Buffalo, about how long would it take for the $S$-wave from this same earthquake to arrive at Buffalo? [Refer to the Earth Science Reference Tables.]
A) 1min40sec
B) 4min00sec
C) 0min50sec
D) 6min40sec

84) The best evidence of crustal movement would be provided by
A) dinosaur tracks found in the surface bedrock
B) ripple marks found in sandy sediment
C) marine fossils found on a mountaintop
D) weathered bedrock found at the bottom of a cliff

85) According to the Earth Science Reference Tables, the rate of temperature increase below the Earth's surface is greatest between depths of
A) 3500 and 4000 km
B) 2500 and 3500 km
C) 1500 and 2500 km
D) 250 and 500 km

86) According to the Earth Science Reference Tables, in which group are the zones of the Earth's interior correctly arranged in order of increasing average density?
A) crust, mantle, outer core, inner core
B) outer core, inner core, mantle, crust
C) crust, mantle, inner core, outer core
D) inner core, outer core, mantle, crust

87) The inference that a liquid outer core exists within the Earth is based primarily on the analysis of
A) crustal rock samples
B) seismic data
C) the Earth's revolution
D) core samples

88) At a depth of 2,000 kilometers, the temperature of the stiffer mantle is inferred to be
A) 3,500°C
B) 4,200°C
C) 6,500°C
D) 1,500°C

89) The scale below shows the age of the sea-floor crust in relation to its distance from the Mid-Atlantic Ridge.

Crust that originally formed at the Mid-Atlantic Ridge is now 37 kilometers from the ridge. Approximately how long ago did this crust form?
A) 1.8 million years ago
B) 3.0 million years ago
C) 4.5 million years ago
D) 2.0 million years ago

90) The arrival of $P$-waves and $S$-waves at a seismic station indicated that an earthquake occurred 4,000 kilometers from the station. The $P$-wave arrived at 3:32:30 p.m. When did the earthquake occur? [Refer to the Earth Science Reference Tables.]
A) 3:39:30 p.m.
B) 3:25:30 p.m.
C) 3:27:00 p.m.
D) 3:32:23 p.m.

91) Which statement best describes the relationship between the travel rates and travel times of earthquake $P$-waves and $S$-waves from the focus of an earthquake to a seismograph station? [Refer to the Earth Science Reference Tables.]
A) $S$-waves travel at a faster rate and take less time.
B) $P$-waves travel at a faster rate and take less time.
C) $P$-waves travel at a slower rate and take less time.
D) $S$-waves travel at a slower rate and take less time.

92) According to the Earth Science Reference Tables, the temperature of rock located 1,000 kilometers below the Earth's surface is about
A) 2,100°C
B) 200°C
C) 3,200°C
D) 2,800°C

93) Which observation provides the strongest evidence for the inference that convection cells exist within the Earth's mantle?
A) Displaced rock strata are usually accompanied by earthquakes and volcanoes.
B) Heat-flow readings vary at different locations in the Earth's crust.
C) Marine fossils are found at elevations high above sea level.
D) Sea level has varied in the past.
94) An earthquake occurred in Massena, New York. For which two locations would the P-wave arrival times be approximately the same? [Refer to the Earth Science Reference Tables.]
   A) Utica and Watertown
   B) Rochester and New York City
   C) Binghamton and Slide Mountain
   D) Watertown and Oswego

95) Which diagram best represents how P-waves and S-waves travel through the Earth?

   KEY:
   \[\text{P-waves} \rightarrow \text{S-waves} . . . . \rightarrow\]

   A) [Diagram A]
   B) [Diagram B]
   C) [Diagram C]
   D) [Diagram D]

96) According to the Earth Science Reference Tables, in the Earth's interior, which zone has a temperature higher than its melting point?
   A) inner core
   B) crust
   C) outer core
   D) stiffer mantle

97) The theory of continental drift suggests that the
   A) continents moved due to changes in the Earth's orbital velocity
   B) present-day continents of South America and Africa once fit together like puzzle parts
   C) continents moved due to the Coriolis effect, caused by the Earth's rotation
   D) present-day continents of South America and Africa are moving toward each other

98) A seismograph station records a difference between the arrival times of the P-wave and S-wave of 7 minutes 30 seconds. About how far away is this station from the earthquake epicenter? [Refer to the Earth Science Reference Tables.]
   A) 4,400 km
   B) 2,100 km
   C) 6,000 km
   D) 7,200 km

99) According to the Earth Science Reference Tables, which generalization about earthquake S-waves and P-waves is correct?
   A) S-waves always travel about twice as fast as P-waves.
   B) P-waves always travel faster than S-waves, regardless of the distance traveled.
   C) When the P-waves and S-waves are near the epicenter, they both travel at the same speed.
   D) The velocity of P-waves and S-waves is constant, regardless of the distance traveled.

100) Where are earthquakes most likely to take place?
   A) near the Earth's Equator
   B) where the composition of the Earth tends to be uniform
   C) along the core-mantle interface
   D) near a fault zone
101) The diagram below represents the Earth's normal magnetic field.

Which diagram best represents the inferred pattern of reversal of the Earth's magnetic poles and fields?

A)  

B)  

C)  

D)  

102) Which conclusion based on the analysis of seismic data supports the inference that the Earth's outer core is liquid?

A) P-waves are transmitted through the outer core.
B) S-waves are transmitted through the outer core.
C) P-waves are not transmitted through the outer core.
D) S-waves are not transmitted through the outer core.

103) Fossils of marine plants and animals are found in the bedrock of mountains many thousands of feet above sea level. The most likely reason for this observation is that

A) transported materials were deposited at high elevations
B) forces within the Earth caused uplift
C) the ocean level has dropped several thousand feet
D) the mountains were part of a mid-ocean ridge

104) A seismic station recorded an earthquake with an epicenter distance of 4,000 kilometers. If the origin time of the earthquake was 11:00 a.m., what time did the P-wave arrive at the seismic station?

A) 11:07 a.m.  
B) 11:05 a.m.  
C) 10:53 a.m.  
D) 11:12 a.m.

105) Evidence of crustal subsidence (sinking) is provided by

A) shallow-water fossils beneath the deep ocean
B) zones of igneous activity at mid-ocean ridges
C) heat-flow measurements on coastal plains
D) marine fossils on mountaintops

106) Igneous rock along oceanic ridges is younger than the igneous rock farther from the ridge. This evidence supports the theory that

A) volcanoes one existed on both sides of the oceanic ridges
B) the ocean floor is stable
C) oceanic ridges are areas of subsidence
D) the ocean floor is spreading

107) According to the Earth Science Reference Tables, at 4,500 kilometers below the surface of the Earth, the pressure is estimated to be

A) 3.1 million atmospheres
B) 2.0 million atmospheres
C) 2.8 million atmospheres
D) 1.4 million atmospheres

108) Igneous rocks on the ocean floor that have an alternating pattern of magnetic orientation provide evidence that

A) the Earth was struck by meteorites
B) the seafloor is spreading
C) mountains are rising
D) ocean tides are cyclic
109) At the Aleutian Trench and the Peru-Chile Trench, tectonic plates are generally
   A) moving along a transform boundary
   B) diverging
   C) moving over a mantle hot spot
   D) converging

110) The P-waves (compressional waves) from an earthquake travel through the Earth's
   A) crust, only
   B) crust, mantle, and inner core, only
   C) crust and mantle, only
   D) crust, mantle, outer core, and inner core

111) According to the Earth Science Reference Tables, what is the relationship between density, temperature, and
   pressure inside the earth?
   A) As depth increases, density and temperature increase, but pressure decreases.
   B) As depth increases, density, temperature, and pressure increase.
   C) As depth increases, density increases, but temperature and pressure decrease.
   D) As depth increases, density, temperature, and the pressure decrease.

112) In 8 minutes, an earthquake P-wave travels a total distance of
   A) 6,600 km  C) 11,300 km
   B) 4,700 km  D) 2,100 km

113) Fossils of organisms that lived in shallow water can be found in horizontal sedimentary rock layers at great
   ocean depths. This fact is generally interpreted by most Earth scientists as evidence that
   A) sunlight once penetrated to the deepest parts of the ocean
   B) organisms that live in deep water evolved from species that once lived in shallow water
   C) sections of the Earth's crust have changed their elevations relative to sea level
   D) the cold water deep in the ocean kills shallow-water organisms

114) The diagram below shows land features that have been disrupted by an earthquake.

Which type of crustal movement most likely caused the displacement of features in this area?
   A) folding of surface rock
   B) vertical lifting of surface rock
   C) down-warping of the crust
   D) movement along a transform fault

115) The primary cause of convection currents in the Earth’s mantle is believed to be the
   A) rotation of the Earth
   B) differences in densities of earth materials
   C) occurrence of earthquakes
   D) subsidence of the crust

116) The epicenter of an earthquake is 6,000 kilometers from an observation point. What is the difference in travel time for the P-waves and S-waves?
   A) 9 mm 20 sec  C) 7 mm 35 sec
   B) 13 mm 10 sec  D) 17 mm 00 sec

117) Which statement provides evidence that the seafloor is spreading out from both sides of the Mid-Atlantic Ridge?
   A) The fossils found on one side of the ridge are younger than the fossils found on the other side.
   B) Parallel strips of igneous rocks on each side of the ridge show matching reversals of magnetic polarity.
   C) The age of the rocks decreases as the distance from the ridge increases.
   D) Seafloor temperatures increase as the distance from the ridge increases.
118) The seismogram below shows the arrival times of $P$- and $S$-waves at a seismic station in hours, minutes, and seconds.

Approximately how far from the earthquake epicenter is this seismic station?
A) 1,650 km  
B) 1,900 km  
C) 4,100 km  
D) 2,200 km

119) Which of the following earthquake waves can travel through both solids and fluids?
A) $P$-waves, only  
B) $S$-waves and $P$-waves  
C) $S$-waves, only

120) A student read an article in the local newspaper stating that a major earthquake can be expected to affect the region where the student lives within the next year. The student's family plans to stay in this region. As a result, the student decides to help prepare her home and family for this expected earthquake.

State three specific actions the student could take to increase safety or reduce injury or damage from an earthquake.

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

122) Which statement correctly describes the Earth's crust?
A) It is thinnest under the center of continents.  
B) It is thicker under the poles than under the Equator.  
C) It is thinnest under the oceans.  
D) It is of uniform thickness.

123) An earthquake $P$-wave arrived at a seismograph station at 01 hour 21 minutes 40 seconds. The distance from the station to the epicenter is 3,000 kilometers. The earthquake's origin time was
A) 01 h 20 min 20 sec  
B) 01 h 27 min 20 sec  
C) 01 h 16 min 00 sec  
D) 01 h 11 min 40 sec

124) Which statement best explains why shark's teeth have been found in the bedrock of some mountainous regions?
A) Shark remains were transported great distances before being deposited.  
B) Sharks were once amphibious animals.  
C) The area was once below sea level.  
D) A type of shark existed on land in early times.

125) A large belt of mountain ranges and volcanoes surrounds the Pacific Ocean. Which events are most closely associated with these mountains and volcanoes?
A) hurricanes  
B) tornadoes  
C) earthquakes  
D) sandstorms

126) A huge undersea earthquake off the Alaskan coastline could produce a
A) thunderstorm  
B) tsunami  
C) cyclone  
D) hurricane

127) Recent volcanic activity in different parts of the world supports the inference that volcanoes are located mainly in
A) the central regions of continents  
B) the centers of landscape regions  
C) zones in late stages of erosion  
D) zones of crustal activity

128) What is the total distance that a $P$-wave will travel in 7 minutes and 20 seconds?
A) 7,200 kilometers  
B) 5,800 kilometers  
C) 2,000 kilometers  
D) 4,200 kilometers

129) Which statement best describes the materials through which earthquake waves are transmitted?
A) $P$-waves are transmitted through solids, only.  
B) $P$-waves are transmitted through liquids, only.  
C) $S$-waves are transmitted through solids and liquids.  
D) $S$-waves are transmitted through solids, only.
130) How does the oceanic crust compare to the continental crust?
   A) The oceanic crust is thinner and contains less basalt.
   B) The oceanic crust is thinner and contains more basalt.
   C) The oceanic crust is thicker and contains less basalt.
   D) The oceanic crust is thicker and contains more basalt.

131) Compared to the velocity of an earthquake's $P$-waves, the velocity of the $S$-waves in the same material is
   A) greater
   B) less
   C) the same

Questions 132 through 134 refer to the following:

The map below shows the continents of Africa and South America, the ocean between them, and the ocean ridge and transform faults. Locations $A$ and $D$ are on the continents. Locations $B$ and $C$ are on the ocean floor.

132) Which table best shows the relative densities of the crustal bedrock at locations $A$, $B$, $C$, and $D$?

<table>
<thead>
<tr>
<th>Relative Densities of Crust</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>More Dense</td>
<td>Less Dense</td>
</tr>
<tr>
<td>A)</td>
<td></td>
</tr>
<tr>
<td>C, D</td>
<td>A, B</td>
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<table>
<thead>
<tr>
<th>Relative Densities of Crust</th>
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<tr>
<td>More Dense</td>
<td>Less Dense</td>
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<tr>
<td>B)</td>
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<tr>
<td>B, C</td>
<td>A, D</td>
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<tr>
<td>C)</td>
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<tr>
<td>A, D</td>
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<tbody>
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<tr>
<td>D)</td>
<td></td>
</tr>
<tr>
<td>A, B</td>
<td>C, D</td>
</tr>
</tbody>
</table>

133) The hottest crustal temperature measurements would most likely be found at which location?
   A) $A$  C) $C$
   B) $B$  D) $D$
134) Which graph best shows the relative age of the ocean-floor bedrock from location B to location C?

A) ![Graph A]

B) ![Graph B]

C) ![Graph C]

D) ![Graph D]

135) Fossils of marine life can be found at locations higher than 200 meters above sea level in New York State. Which statement best explains this fact?

A) Much of New York State was once below sea level and has since been uplifted.
B) Much of New York State was once above sea level and has since subsided.
C) Sea level was once more than 200 meters lower than it is today.
D) Sea level was once more than 200 meters higher than it is today.

136) It is suggested that the outer core of the Earth is liquid. Which is the strongest evidence for this?

A) P-waves disappear as they move through the outer core.
B) S-waves disappear as they move through the outer core.
C) S-waves speed up as they move through the outer core.
D) P-waves are transmitted through the outer core.

137) The diagrams below represent seismograms of the same earthquake recorded in four different locations. Which seismogram was recorded closest to the epicenter of the earthquake?

A) ![Seismogram A]

B) ![Seismogram B]

C) ![Seismogram C]

D) ![Seismogram D]

138) An earthquake's P-wave traveled 4,800 kilometers and arrived at a seismic station at 5:10 p.m. At approximately what time did the earthquake occur?

A) 5:10 p.m. 
B) 5:02 p.m. 
C) 5:18 p.m. 
D) 5:08 p.m.

139) The map below shows the present-day locations of South America and Africa. Remains of Mesosaurus, an extinct freshwater reptile, have been found in similarly aged bedrock formed from lake sediments at locations X and Y.

Which one of the following statements represents the most logical conclusion to draw from this evidence?

A) The continents of South America and Africa were joined when Mesosaurus lived.
B) Mesosaurus came into existence on several widely separated continents at different times.
C) Mesosaurus migrated across the ocean from location X to location Y.
D) The present climates at locations X and Y are similar.
140) The cross sections of crust below represent two regions of sedimentary rock layers that have been altered.

The sedimentary bedrock in both regions originally formed as
A) faulted layers
B) horizontal layers
C) folded layers
D) recrystallized layers

141) Which graph best represents the relationship between volcanic activity and earthquake activity in an area?

A)

B)

C)

D)

142) At a seismograph recording station, the difference between the arrival times of an earthquake's compression wave ($P$-wave) and its shear wave ($S$-wave) is 8 minutes 20 seconds. According to the Earth Science Reference Tables, how far from the station is the epicenter?
A) 2,400 km
B) 6,800 km
C) 5,000 km
D) 4,500 km

143) According to the Earth Science Reference Tables, in which zone of the Earth's interior is the melting point of the rock inferred to be lower than the actual temperature of the rock?
A) crust
B) mantle
C) outer core
D) inner core

144) Which statement best describes the continental and oceanic crusts?
A) The continental crust is thicker and less dense than the oceanic crust.
B) The continental crust is thinner and more dense than the oceanic crust.
C) The continental crust is thinner and less dense than the oceanic crust.
D) The continental crust is thicker and more dense than the oceanic crust.

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

146) Four seismograph stations receive data from the same earthquake. The table below shows the differences in travel times for the $P$- and $S$-waves recorded at each station. Which station is closest to the epicenter of the earthquake?

<table>
<thead>
<tr>
<th>STATION</th>
<th>TRAVEL-TIME DIFFERENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4 min 32 sec</td>
</tr>
<tr>
<td>B</td>
<td>3 min 52 sec</td>
</tr>
<tr>
<td>C</td>
<td>3 min 18 sec</td>
</tr>
<tr>
<td>D</td>
<td>4 min 17 sec</td>
</tr>
</tbody>
</table>

A) B
B) A
C) C
D) D

147) According to the Earth Science Reference Tables, the border between the South American plate and the African plate is best described as
A) diverging and located at an oceanic ridge
B) converging and located at an oceanic trench
C) converging and located at an oceanic ridge
D) diverging and located at an oceanic trench

148) Which statement best explains why the direction of some seismic waves changes sharply as the waves travel through the Earth?
A) Different parts of the Earth's interior have different densities.
B) The Earth is spherical.
C) Seismic waves tend to travel in curved paths.
D) The temperature of the Earth's interior decreases with depth.
149) Where is the thickest part of the Earth's crust?
   A) under continental mountain ranges
   B) under volcanic islands
   C) at mid-ocean ridges
   D) at the edge of continental shelves

150) According to the Earth Science Reference Tables, as depth within the Earth's interior increases, the
   A) density, temperature, and pressure decrease
   B) density and temperature decrease, but pressure increases
   C) density decreases, but temperature and pressure increase
   D) density, temperature, and pressure increase

151) The presence of marine fossils at elevations high above sea level provides good evidence for
   A) volcanic eruptions
   B) continental glaciation
   C) crustal erosion
   D) crustal uplift

152) What is the average velocity of an earthquake's S-wave in its first 4 minutes of travel?
   A) 250 km/min
   B) 500 km/min
   C) 4 km/min
   D) 1 km/min

153) According to the Earth Science Reference Tables, which two elements make up the greatest volume of the Earth's crust?
   A) silicon and iron
   B) iron and nickel
   C) oxygen and potassium
   D) silicon and potassium

154) The best evidence of crustal uplift is provided by
   A) shallow-water marine fossils found in deep ocean water
   B) thick layers of sediment on the ocean floor
   C) horizontal sedimentary layers
   D) marine fossils found in the bedrock of some mountaintops

155) The diagram below shows a cutaway view of Earth in which the interior layers are visible. The paths of earthquake waves generated at point $X$ are shown. $A$, $B$, $C$, and $D$ are locations of seismic stations on Earth's surface, and point $E$ is located in Earth's interior.

Both $P$-waves and $S$-waves were received at seismic stations $A$ and $B$ in the given diagram, but only $P$-waves were received at seismic stations $C$ and $D$. Which one of the following statements best explains why this occurred?
   A) $S$-waves are much weaker than $P$-waves.
   B) The solid outer core prevents $S$-waves from traveling to seismic stations $C$ and $D$.
   C) $S$-waves travel faster than $P$-waves.
   D) The liquid outer core prevents $S$-waves from traveling to seismic stations $C$ and $D$.

156) Which part of the Earth is most likely a liquid zone?
   A) outer core
   B) inner core
   C) crust
   D) mantle

157) Compared to Earth's crust, Earth's core is believed to be
   A) less dense, cooler, and composed of more iron
   B) more dense, cooler, and composed of less iron
   C) less dense, hotter, and composed of less iron
   D) more dense, hotter, and composed of more iron
The block diagram below shows the bedrock age as measured by radioactive dating and the present location of part of the Hawaiian Island chain. These volcanic islands may have formed as the Pacific Plate moved over a mantle hot spot.

This diagram provides evidence that the Pacific Crustal Plate was moving toward the
A) south         C) east
B) northwest     D) southwest

Name one region of the United States that is likely to experience a major damaging earthquake. Explain why an earthquake is likely to occur in that region.

A part of which zone of the Earth's interior is inferred to have a density of 10.0 grams per cubic centimeter? [Refer to the Earth Science Reference Tables.]
A) outer core     C) inner core
B) crust         D) mantle

A seismographic station determines that its distance from the epicenter of an earthquake is 4,000 kilometers. According to the Earth Science Reference Tables, if the P-wave arrived at the station at 10:15 a.m., the time of the earthquake's origin was
A) 10:02 a.m.     C) 10:10 a.m.
B) 10:08 a.m.     D) 10:22 a.m.

The diagram below represents a section of the Earth's bedrock. The arrows show the direction of forces that are gradually compressing this section.

Which diagram represents the most probable result of these forces?
A)  
B)  
C)  
D)  

Approximately how long does an earthquake P-wave take to travel the first 6,500 kilometers after the earthquake occurs?
A) 6.5 min     C) 18.5 min
B) 8.0 min     D) 10.0 min
164) In the diagram below, letters A and B represent locations near the edge of a continent.

![Diagram of continental and oceanic crust with locations A and B]

A geologist who compares nonsedimentary rock samples from locations A and B would probably find that the samples from location A contain

A) the same minerals and fossils
B) more basalt
C) more fossils
D) more granite

Questions 165 through 169 refer to the following:

The table below shows some of the data collected at two seismic stations, A and B. Some data have been omitted.

<table>
<thead>
<tr>
<th>Station</th>
<th>Arrival Time of P-Wave</th>
<th>Arrival Time of S-Wave</th>
<th>Difference in Arrival Times of P and S-Waves</th>
<th>Distance to Epicenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6:02:00 p.m.</td>
<td>6:07:30 p.m.</td>
<td>5 min 30 sec</td>
<td>km</td>
</tr>
<tr>
<td>B</td>
<td>- p.m.</td>
<td>6:11:20 p.m.</td>
<td>7 min 20 sec</td>
<td>5,700 km</td>
</tr>
</tbody>
</table>

165) What is the approximate distance from the epicenter to station A?
A) 1,400 km  
B) 1,900 km  
C) 3,000 km  
D) 4,000 km

166) Which statement best describes the seismic waves received at station B?
A) The P-wave had the greatest velocity.  
B) The S-wave passed through a fluid before reaching station B.  
C) The P-wave arrived at 6:12 p.m.  
D) The S-wave arrived before the P-wave.

167) Which seismogram most accurately represents the arrival of P and S-waves at station A?

A)  
B)  
C)  
D)

168) What is the minimum number of additional stations from which scientists must collect data in order to locate the epicenter of this earthquake?
A) 3  
B) 0  
C) 1  
D) 2
169) What was the origin time of this earthquake?
A) 5:55:00 p.m.  
B) 6:11:20 p.m.  
C) 6:00:00 p.m.  
D) 6:06:00 p.m.

170) One eruption of Mt. St. Helens in Washington State resulted in the movement of volcanic ash across the northwestern portion of the United States. The map shows the movement of the ash along paths at three different altitudes above sea level: path A at 1.5 km, path B at 3.0 km, and path C at 5.5 km. The lines across each path indicate the time interval between the eruption and the position of the leading edge of ash. Points X and Y are places on the Earth's surface.

According to the Earth Science Reference Tables, approximately how long would it take for an earthquake P-wave caused by the eruption to travel from Mt. St. Helens to point Y? (Use the map scale.)
A) 11 minutes  
B) 7 minutes  
C) 2 minutes  
D) 4 minutes
Questions 171 through 175 refer to the following:

Diagram I below is a map showing the location and bedrock age of some of the Hawaiian Islands. Diagram II is a cross section of an area of the Earth illustrating a stationary magma source and the process that could have formed the islands.

171) Which graph best represents the ages of the Hawaiian Islands comparing them from point A to point B?

A)  

B)  

C)  

D)  

172) Volcanic activity like that which produced the Hawaiian Islands is usually closely correlated with

A) frequent earthquake activity  
B) frequent major changes in climate  
C) nearness to the center of the ocean  
D) sudden reversals in the Earth's magnetic field

173) If each island formed as the crustal plate moved over the magma source in the mantle as shown in diagram II, where would the next volcanic island most likely form?

A) northeast of Hawaii  
B) between Hawaii and Maui  
C) northwest of Kauai  
D) southeast of Hawaii

174) Which of the Hawaiian Islands has the greatest probability of having a volcanic eruption?

A) Maui  
B) Hawaii  
C) Oahu  
D) Kauai

175) Compared to the continental crust of North America, the oceanic crust area of the Hawaiian Islands is probably

A) thicker and similar in composition  
B) thicker and different in composition  
C) thinner and different in composition  
D) thinner and similar in composition
176) The map below shows the intensity values (Earth-shaking effects observed by people) during an earthquake that occurred in New York State. The numbered areas on the map were determined from the Modified Mercalli Scale shown below. The scale is used to group locations according to the observed effects of an earthquake.

![Map of New York State with intensity values](image1)

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Observed Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Usually only detected by instruments</td>
</tr>
<tr>
<td>II</td>
<td>Felt by a few persons at rest, especially on upper floors</td>
</tr>
<tr>
<td>III</td>
<td>Hanging objects swing; vibration like a passing truck; noticeable indoors</td>
</tr>
<tr>
<td>IV</td>
<td>Felt indoors by many, outdoors by few; a sensation like a heavy truck striking a building, parked automobiles rock</td>
</tr>
<tr>
<td>V</td>
<td>Felt by nearly all; sleepers awakened; liquids disturbed; unstable objects overturned; some dishes and windows broken</td>
</tr>
<tr>
<td>VI</td>
<td>Felt by all; many frightened and run outdoors; some heavy furniture moved; glassware broken; books fall off shelves; damage slight</td>
</tr>
<tr>
<td>VII</td>
<td>Difficult to stand; noticed in moving automobiles; damage to some masonry; weak chimneys broken at roofline</td>
</tr>
<tr>
<td>VIII</td>
<td>Partial collapse of masonry; chimneys, factory stacks, columns fall; heavy furniture overturned; frame houses moved on foundations</td>
</tr>
</tbody>
</table>

At which one of the following locations in New York State could everyone feel the vibrations caused by this earthquake?

A) 42°45' N 74°00' W  
B) 41°00' N 74°00' W  
C) 43°00' N 78°30' W  
D) 43°30' N 75°30' W

Questions 177 and 178 refer to the following:

The diagram below represents a cross section of a portion of the Earth's crust. Densities in grams per cubic centimeter are shown for several points.

![Diagram of Earth's crust](image2)
177) Which graph best shows the density of the Earth along a line from point A to point B?

A)  

\[
\begin{array}{c|c}
\text{Depth (km)} & \text{Density (g/cm}^3) \\
\hline
0 & \text{A} \\
20 & \text{B} \\
40 & \text{C} \\
60 & \text{D} \\
80 & \text{E} \\
100 & \text{F}
\end{array}
\]

B)  

\[
\begin{array}{c|c}
\text{Depth (km)} & \text{Density (g/cm}^3) \\
\hline
0 & \text{A} \\
20 & \text{B} \\
40 & \text{C} \\
60 & \text{D} \\
80 & \text{E} \\
100 & \text{F}
\end{array}
\]

C)  

\[
\begin{array}{c|c}
\text{Depth (km)} & \text{Density (g/cm}^3) \\
\hline
0 & \text{A} \\
20 & \text{B} \\
40 & \text{C} \\
60 & \text{D} \\
80 & \text{E} \\
100 & \text{F}
\end{array}
\]

D)  

\[
\begin{array}{c|c}
\text{Depth (km)} & \text{Density (g/cm}^3) \\
\hline
0 & \text{A} \\
20 & \text{B} \\
40 & \text{C} \\
60 & \text{D} \\
80 & \text{E} \\
100 & \text{F}
\end{array}
\]

178) Which inference can best be made from the diagram?

A) The continental crust has a higher density than the oceanic crust.
B) The Moho is always found at the same depth below the Earth's surface.
C) The Moho is the interface between oceanic and continental crusts.
D) The continental crust is thicker than the oceanic crust.

Questions 179 through 181 refer to the following:

The map below shows the location of mid-ocean ridges and the age of some oceanic bedrock near these ridges. Letters A through D are locations on the surface of the ocean floor.

179) Rising convection currents in the asthenosphere would most likely be under location

A) A  
B) B  
C) C  
D) D

180) The age of the oceanic bedrock at location A is

A) 60 million years old  
B) 40 million years old  
C) 10 million years old  
D) 4 million years old

181) The age of the oceanic bedrock at location C is

A) 60 million years old  
B) 40 million years old  
C) 10 million years old  
D) 4 million years old
180) The age of oceanic bedrock on either side of a mid-ocean ridge is supporting evidence that at the ridges, tectonic plates are
A) being subducted
B) diverging
C) converging
D) locked in place

181) What is the most probable age, in millions of years, of the bedrock at location B?
A) 5
B) 48
C) 12
D) 62

Questions 182 and 183 refer to the following:

Seismic stations are located at the four cities shown on the map below. Letter X represents the epicenter of an earthquake determined from seismic waves recorded at all four cities.

182) At which city is there a difference of approximately 3 minutes and 20 seconds between the arrival times of the P-waves and the S-waves?
A) New York City
B) Louisville
C) New Orleans
D) Pittsburgh
183) Which map correctly shows how the location of the epicenter was determined?

A)  

B)  

C)  

D)  

184) The map below shows many of the major faults and fractures in the surface bedrock of New York State.

Most of the faults found along the New York-New Jersey border lie in which direction?

A) east to west
B) northeast to southwest
C) northwest to southwest
D) north to south
Questions 185 through 187 refer to the following:

The map below shows three circles used to locate an earthquake epicenter. Five lettered locations, A, B, C, D, and E, are shown as reference points. Epicenter distances from three locations are represented by r1, r2, and r3.

185) At which location could the seismogram below have been recorded? [Refer to the Earth Science Reference Tables.]

A) A  
B) C  
C) D  
D) B

186) At which location was the difference in time of arrival of P-waves and S-waves greatest?

A) A  
B) D  
C) C  
D) B

187) The earthquake epicenter is located at point

A) A  
B) B  
C) C  
D) E
Questions 188 through 192 refer to the following:

The diagram below represents three cross sections of the Earth at different locations to a depth of 50 kilometers below sea level. The measurements given with each cross section indicate the thickness and the density of the layers.

188) In which group are the layers of the Earth arranged in order of increasing average density?
   A) ocean water, crust, mantle
   B) mantle, crust, ocean water
   C) crust, mantle, ocean water
   D) ocean water, mantle, crust

189) Compared with the oceanic crust, the continental crust is
   A) thicker and more dense
   B) thinner and more dense
   C) thicker and less dense
   D) thinner and less dense

190) Which statement about the Earth’s mantle is confirmed by the diagram?
   A) The mantle is liquid.
   B) The mantle does not exist under continental mountains.
   C) The mantle has the same composition as the crust.
   D) The mantle is located at different depths below the Earth’s surface.

191) Which material is most likely to be found 20 kilometers below sea level at the continental mountain location? [Refer to the Earth Science Reference Tables.]
   A) limestone
   B) shale
   C) basalt
   D) granite

192) The division of the Earth’s interior into crust and mantle, as shown in the diagram, is based primarily on the study of
   A) radioactive dating
   B) gravity measurements
   C) seismic waves
   D) volcanic eruptions
Questions 193 through 195 refer to the following:

The data table below gives information collected at seismic stations A, B, C, and D for the same earthquake. [Some of the data has been deliberately omitted.]

<table>
<thead>
<tr>
<th>Seismic Station</th>
<th>P-Wave Arrival Time</th>
<th>S-Wave Arrival Time</th>
<th>Difference in Arrival Times</th>
<th>Distance to Epicenter</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>08:48:20</td>
<td>No S-waves arrived</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>08:42:00</td>
<td></td>
<td>00:04:40</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>08:39:20</td>
<td></td>
<td>00:02:40</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>08:45:40</td>
<td></td>
<td></td>
<td>6,200 km</td>
</tr>
</tbody>
</table>

193) What is the most probable reason for the absence of S-waves at station A?
A) S-waves were not generated at the epicenter.
B) S-waves cannot travel through liquids.
C) Station A was located on solid bedrock.
D) Station A was located too close to the epicenter.

194) How long did it take the P-wave to travel from the epicenter of the earthquake to seismic station D?
A) 00:09:40
B) 00:46:20
C) 00:39:20
D) 00:17:20

195) What is the approximate distance from station C to the earthquake epicenter?
A) 1,600 km
B) 2,400 km
C) 1,000 km
D) 3,200 km

Questions 196 through 199 refer to the following:

At intervals in the past, the Earth's magnetic field has reversed. The present North magnetic pole was once the South magnetic pole, and the present South magnetic pole was once the North magnetic pole. A record of these changes is preserved in the igneous rocks that formed at mid-ocean ridges and moved away from the ridges.

The diagram below represents the pattern of normal and reversed magnetic polarity in the igneous rocks composing the ocean crust on the east side of a mid-ocean ridge.

196) Approximately how many million years were required to form the material shown between A and B in the diagram?
A) 1.8
B) 1.1
C) 2.5
D) 0.7

197) The igneous material along this mid-ocean ridge was found to be younger than the igneous material farther from the ridge. This fact supports the theory of
A) crustal subsidence
B) seafloor spreading
C) superposition
D) dynamic equilibrium
198) Which diagram below best shows the pattern of normal and reversed polarity on the west side of the midocean ridge?

A)  
B)  
C)  
D)  

199) The younger extrusive igneous rocks on the ocean floor have a higher heat flow rate than older extrusive igneous rocks. Which graph best shows the relationship between heat flow rate and distance from the midocean ridge?

A)  
B)  
C)  
D)  
Questions 200 through 203 refer to the following:

The diagram below shows an enlargement of the mid-Atlantic ridge and surrounding in its position with respect to the continents. Magnetic polarity bands of igneous rock parallel to the ridge are illustrated according to the key.

200) Ocean floor rock found 20 kilometers west of the ocean ridge would have an approximate age of
   A) 30 million years  
   B) 2.0 million years  
   C) 1.6 million years  
   D) 15 million years

201) What are two characteristics of ocean floor rock found at location C?
   A) normal polarity, oceanic composition  
   B) reverse polarity, continental composition  
   C) normal polarity, continental composition  
   D) reverse polarity, oceanic composition

202) Which of the cross-sectional diagrams below best represents a model for the movement of rock material below the crust along the mid-Atlantic ridge?

   A)  
   B)  
   C)  
   D)  

   A Crust, Mantle  
   B Crust, Mantle  
   C Crust, Mantle  
   D Crust, Mantle
203) Along the line from position A to position B, the comparative age of the rock
   A) increases from A to the mid-Atlantic ridge and then decreases to B
   B) decreases from A to the mid-Atlantic ridge and then increases to B
   C) continuously increases from A to B
   D) continuously decreases from A to B

204) A series of dots is shown on the world map below.

![World Map](image)

The dots represent the locations of
   A) previous magnetic poles
   B) fossil trilobites, eurypterids, and echinoderms
   C) prehistoric glacial rivers and lakes
   D) plate boundaries, earthquakes, and volcanoes

Questions 205 through 209 refer to the following:

The diagram below shows the magnetic orientation of igneous rock on the seafloor on the east (right) side of a mid-ocean ridge. The pattern on the west (left) side of the ridge has been omitted. The age of the igneous rock and its distance from the ridge center are shown.
205) According to the diagram, what is the approximate rate of seafloor spreading?
   A) 2 km/million years  
   B) 1 km/million years  
   C) 40 km/million years  
   D) 50 km/million years

206) The occurrence of high-heat flows at the ridge center provides evidence of the
   A) destruction of oceanic crust  
   B) destruction of continental crust  
   C) existence of ancestral mountains  
   D) existence of rising mantle convection currents

207) Which diagram below best represents the pattern of magnetic orientation in the seafloor on the west (left) side of the ocean ridge?

208) As distance from the center of the ridge increases, the age of the rocks
   A) increases  
   B) decreases  
   C) remains the same

209) Which inference can best be made from the diagram?
   A) The amount of fossil material preserved in the igneous rock has changed with time.  
   B) The size of the continents has changed with time.  
   C) The orientation of the Earth's magnetic field has reversed with time.  
   D) The elevation of sea level has changed with time.
Questions 210 and 211 refer to the following:

210) How many additional seismic stations *must* report seismogram information in order to locate this earthquake?
A) one  
B) two  
C) three  
D) four

211) When did the *first* P-waves arrive at this seismic station?
A) 3 minutes after an earthquake occurred 2,600 km away  
B) 9 minutes after an earthquake occurred 3,500 km away  
C) 5 minutes after an earthquake occurred 2,600 km away  
D) 11 minutes after an earthquake occurred 3,500 km away

212) The drawing below represents the ocean floor between North America and Africa.

Which graph best represents the age of the bedrock in the ocean floor along line AB?

A) 
B) 
C) 
D)
Questions 213 through 217 refer to the following:

The map below shows how the epicenter of an earthquake is located using observations at seismograph stations 1, 2, and 3 in New York State. Station 4 is a seismograph station located in Canada.

213) How would the difference in arrival times of the $P$-waves and $S$-waves at station 4 compare with the difference in arrival times of these waves at station 3?
   A) The difference would be the same at both stations.
   B) The difference would be greater at station 4.
   C) The difference would be greater at station 3.

214) Station 3 is approximately 400 kilometers from the epicenter of this earthquake. According to the Earth Science Reference Tables, approximately how much time did the $P$-wave take to travel to station 3?
   A) 5 minutes
   B) 50 seconds
   C) 2 seconds
   D) 1 minute 40 seconds

215) Which statement about the arrival times of the seismic waves at station 2 is correct?
   A) Only the $S$-wave arrived.
   B) The $P$-wave arrived first.
   C) The $S$-wave arrived first.
   D) The $P$-wave and $S$-wave arrived at the same time.

216) Using the seismic reading received at station 1 only, an observer would be able to determine
   A) both the distance and the direction of the epicenter from station 1
   B) the distance of the epicenter from station 1, only
   C) neither the distance nor the direction of the epicenter from station 1
   D) the direction of the epicenter from station 1, only

217) Another seismograph station in the United States recorded the difference in arrival times between $P$-waves and $S$-waves as 6 minutes. According to the Earth Science Reference Tables, approximately how far from the epicenter would this station be located?
   A) $4.4 \times 10^3$ km
   B) $1.6 \times 10^3$ km
   C) $9.2 \times 10^3$ km
   D) $3.3 \times 10^3$ km
Questions 218 and 219 refer to the following:

The isolines on the isoseismal map below connect points of equal earthquake intensity. Letters A through H represent locations near an earthquake epicenter. The Modified Mercalli Intensity Scale below measures the strength of an earthquake in terms of the effects it produces.

![Isoseismal Map](image)

<table>
<thead>
<tr>
<th>Modified Mercalli Intensity Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity Level</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
<tr>
<td>IV</td>
</tr>
<tr>
<td>V</td>
</tr>
<tr>
<td>VI</td>
</tr>
</tbody>
</table>

218) Which state probably had the least damage from the earthquake?

A) South Dakota  
B) Nebraska  
C) Colorado  
D) Utah

219) At which location would the probability of earthquake damage to windows and dishes be greatest?

A) G  
B) A  
C) E  
D) H

220) The diagram below represents a cross section of a portion of the Earth's crust and mantle. Letters A, B, C, D, and X identify locations within the crust.

![Cross Section Diagram](image)

The age of oceanic crust increases along a line between location X and location

A) A  
B) B  
C) C  
D) D
Questions 221 through 223 refer to the following:

The map below shows the locations of deep-sea core drilling sites numbered 1 through 4. The approximate location of the East Pacific Ridge is shown by a dashed line. Point A is located on the East Pacific Ridge.

221) Compared to the thickness and density of the continental crust of South America, the oceanic crust of the Pacific floor is
   A) thinner and more dense
   B) thicker and more dense
   C) thinner and less dense
   D) thicker and less dense

222) At point A, the East Pacific Ridge is the boundary between the
   A) South American Plate and the Nazca Plate
   B) Pacific Plate and the South American Plate
   C) Cocos Plate and the North American Plate
   D) Pacific Plate and the Nazca Plate

223) At which drilling site would the oldest igneous bedrock most likely be found?
   A) 1
   B) 2
   C) 3
   D) 4

224) The landscape shown in the diagram below is an area of frequent earthquakes.

This landscape provides evidence for
   A) density differences in the rocks of the mantle
   B) differential erosion of hard and soft rocks of the crust
   C) converging convection cells within the rocks of the mantle
   D) movement and displacement of the rocks of the crust
Questions 225 through 228 refer to the following:

The diagram below shows three seismograms of the same earthquake recorded at three different seismic stations, X, Y, and Z. The distances from each seismic station to the earthquake epicenter have been drawn on the map. A coordinate system has been placed on the map to describe locations. [The map scale has not been included.]

![Seismograms and map diagram]

225) Approximately how far away from station Y is the epicenter?
   A) 1,300 km
   B) 5,200 km
   C) 3,900 km
   D) 2,600 km

226) The S-waves from this earthquake that travel toward Earth's center will
   A) be totally reflected off the crust-mantle interface
   B) be deflected by Earth's magnetic field
   C) reach the other side of Earth faster than those that travel around Earth in the crust
   D) be absorbed by the liquid outer core

227) Seismic station Z is 1,700 kilometers from the epicenter. Approximately how long did it take the P-wave to travel to station Z?
   A) 6 min 30 sec
   B) 2 min 50 sec
   C) 3 min 30 sec
   D) 1 min 50 sec

228) On the map, which location is closest to the epicenter of the earthquake?
   A) E-5
   B) G-1
   C) H-8
   D) H-3

Questions 229 and 230 refer to the following:

The small dots on the map represent earthquake epicenters. The letters on the map represent locations. [Earthquake epicenters map diagram]
229) Where do most of these earthquakes occur?
A) in the centers of the continents  
B) randomly throughout the mantle  
C) along the core-mantle interface  
D) in specific belts within the crust  

230) At which location do rocks, minerals, and fossils most closely match those at location D?
A) E  
B) F  
C) H  
D) B

231) The block diagram below shows a section of the Earth's crust. The rock layers have not been overturned. I, II, III, IV, and V are locations on the Earth's surface.

The deformed rock strata in the block diagram above are primarily the result of
A) faulting  
B) folding  
C) ground water  
D) volcanism

232) The three cross-sectional diagrams below represent the splitting apart of the former supercontinent Pangaea.

Which rock labeled in diagram III is the youngest?
A) A  
B) B  
C) C  
D) D
Questions 233 through 237 refer to the following:

The dots on the map below indicate the locations of epicenters of major earthquakes over a five-year period. Points A through G are locations on the map.

![World Map of Earthquake Epicenters](image)

233) The crust of the Earth is most likely thickest at which location?
   A) A  
   B) E  
   C) B  
   D) C

234) Where do most major earthquakes occur?
   A) at the mantle-core boundary  
   B) in specific earthquake belts within the crust  
   C) in the continental interiors  
   D) randomly over the Earth's surface

235) Continental growth (formed from the deposition of land-derived sediments) would most likely occur at which location?
   A) G  
   B) D  
   C) A  
   D) B

236) How would a map showing the location of active volcanoes compare to the map showing the location of earthquake epicenters?
   A) A large percentage of volcano locations would be in the same regions as the epicenters.  
   B) There would be no match between the locations of the volcanoes and the epicenters.  
   C) Only a small percentage of volcano locations would be in the same regions as the epicenters.  
   D) The location of the volcanoes and the epicenters would only match in the ocean regions.

237) Rising mantle convection currents would most likely be located at which location on the map?
   A) G  
   B) B  
   C) A  
   D) C
238) The map below shows the position of the north magnetic pole at various times in the past.

These positions have most likely been determined by using
A) seismic waves traveling through the Earth's interior
B) compass readings on various continents today
C) magnetic properties of rocks formed during various geologic times
D) fossils found in bedrock formed during various geologic times

239) The diagram below is a seismogram of the famous San Francisco earthquake of 1906, recorded at a seismic station located 6,400 kilometers from San Francisco.

Which time scale best represents the arrival-time difference between $P$-waves and $S$-waves at this station?

A) ![Time scale A](image)
B) ![Time scale B](image)
C) ![Time scale C](image)
D) ![Time scale D](image)
240) The darkest areas on the world map below represent an earth scientist’s data. These dark areas most likely represent zones of frequent
A) hurricane paths           C) air-mass origin
B) fossil correlations       D) crustal activity

241) The world map below shows the distribution of major earthquakes during a 10-year period. The dots represent earthquake epicenters. This map would be most useful in finding the location of
A) the Moho
B) crustal-plate boundaries
C) the interface between the mantle and the outer core
D) former ocean basins

242) Tectonic plate boundaries may be classified as divergent, convergent, or transform. For each location listed in the data table below, place an X in the proper column to indicate the type of plate boundary at that location.

<table>
<thead>
<tr>
<th>Location</th>
<th>Type of Plate Boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Pacific Ridge</td>
<td>Divergent</td>
</tr>
<tr>
<td>Aleutian Trench</td>
<td>Convergent</td>
</tr>
<tr>
<td>West side of the South American Plate</td>
<td>Transform</td>
</tr>
<tr>
<td>San Andreas Fault</td>
<td></td>
</tr>
</tbody>
</table>
243) The diagram below represents a partial cross section of a model of the Earth. The arrows show inferred motions within the Earth.

Which property of the oceanic crust in regions F and G is a result of these inferred motions?
A) The age of the igneous rock increases as distance from the mid-ocean ridge increases.
B) The crystal size of the rock decreases constantly as distance from the mid-ocean ridge increases.
C) The temperature of the basaltic rock increases as distance from the mid-ocean ridge increases.
D) Heat-flow measurements steadily increase as distance from the mid-ocean ridge increases.

244) The diagram below represents a cross section of a portion of the Earth's crust.

Which past activity in this region is suggested by the shape of these sedimentary rock layers?
A) widespread volcanic activity  C) glacial deposition
B) horizontal sorting          D) crustal movements

Questions 245 and 246 refer to the following:

The dots on the map below show the distribution of major earthquake epicenters. The shaded circle labeled A represents a location on Earth's surface.
245) Which one of the following conclusions can best be inferred from the data shown on the given map?
   A) Most earthquakes occur west of the Prime Meridian and north of the Equator.
   B) Most earthquakes are concentrated in zones along plate boundaries.
   C) Earthquakes generally are evenly distributed over the surface of Earth.
   D) Most earthquakes occur on continents.

246) Location A in the given diagram is best described as an area that is
   A) within a rift valley at a mid-ocean ridge
   B) above a mantle hot spot near the center of a crustal plate
   C) within a deep-sea trench between two converging plates
   D) at the boundary between two diverging plates

Questions 247 through 251 refer to the following:

The diagram below represents a cross section of the Earth showing the paths of earthquake waves from a single source. Seismograph stations are located on the Earth’s surface at points A through F, and they are all located in the same time zone.

247) At which station is the difference in time between the arrival of P- and S-waves the greatest?
   A) B  C) D  
   B) A  D) C

248) Station E did not receive P-waves or S-waves from this earthquake because the P-waves and S-waves
   A) are changed to sound energy
   B) are bent, causing shadow zones
   C) are converted to heat energy
   D) cancel each other out

249) What explanation do scientists give for the reason station F did not receive S-waves?
   A) S-waves do not have enough energy to pass completely through the Earth.
   B) The Earth's outer core is liquid, which does not allow S-waves to pass.
   C) The Earth's inner core is so dense that S-waves cannot pass through.
   D) S-waves become absorbed by the Earth's crust.

250) Seismograph station B recorded the arrival of P-waves at 2:10 p.m. and the arrival of S-waves at 2:15 p.m. Approximately how far is station B from the epicenter? [Refer to the Earth Science Reference Tables.]
   A) 3400 km  C) 2400 km
   B) 1400 km  D) 4400 km
251) Seismograph station D is 7,700 kilometers from the epicenter. If the P-wave arrived at this station at 2:15 p.m., at approximately what time did the earthquake occur? [Refer to the Earth Science Reference Tables.]
   A) 2:04 p.m.    C) 2:00 p.m.
   B) 2:08 p.m.    D) 1:56 p.m.

Questions 252 and 253 refer to the following:

The three cross-sectional diagrams below represent the splitting apart of the former supercontinent Pangaea.

![Diagram of Pangaea splitting into continents](image)

252) The Moho shown in the three diagrams is the boundary between
   A) Western Hemisphere continents and Eastern Hemisphere continents
   B) crust and mantle rock
   C) sedimentary rock and igneous rock
   D) oceanic crust and continental crust

253) Compared to the crust at B, the crust at A is
   A) thicker and less dense
   B) thinner and less dense
   C) thinner and more dense
   D) thicker and more dense

254) A seismogram recorded at a seismic station is shown below.

![Seismogram](image)

Which information can be determined by using this seismogram?
   A) the distance to the earthquake's epicenter
   B) the direction to the earthquake's focus
   C) the depth of the earthquake's focus
   D) the location of the earthquake's epicenter
Questions 255 and 256 refer to the following:

The map below shows the location of major islands and coral reefs in the Hawaiian Island chain. Their ages are given in millions of years.

The islands of the Hawaiian chain formed from the same source of molten rock, called a hot plume. The movement of the Pacific Plate over the Hawaiian hot plume created a trail of extinct volcanoes that make up the Hawaiian Islands. The island of Hawaii (lower right) is the most recent island formed. Kilauea is an active volcano located over the plume on the island of Hawaii.

![Map of Hawaiian Islands](image)

255) Approximately how far has the Pacific Plate moved since Necker Island was located over the hot plume at X?

A) 1,200 km  
B) 1,900 km  
C) 300 km  
D) 2,600 km
256) Which graph shows the general relationship between the age of individual islands in the Hawaiian chain and their distance from the hot plume?

A) 

B) 

C) 

D) 

257) The diagram below shows some of the surface features and inferred motions of a portion of the Earth.

What does the diagram indicate about the Earth's crust?

A) It has zones of frequent crustal activity.

B) It remains stable and unchanging over time.

C) It is neither created nor destroyed.

D) It becomes thickest in the region of oceanic ridges.
258) The map below shows the Atlantic Ocean divided into zones A, B, C, and D. The Mid-Atlantic Ridge is located between zones B and C.

Which graph best represents the geologic age of the surface bedrock on the ocean bottom?

Questions 259 and 260 refer to the following:

The map below shows three circles used to locate an earthquake epicenter. Five lettered locations, A, B, C, D, and E, are shown as reference points. Epicenter distances from three locations are represented by $r_1$, $r_2$, and $r_3$. 
259) Location D is about 3,500 kilometers from the epicenter. What was the $S$-wave travel time to location $D$? [Refer to the Earth Science Reference Tables.]
   A) 6 minutes 20 seconds
   B) 7 minutes 40 seconds
   C) 11 minutes 30 seconds
   D) 5 minutes 10 seconds

260) On another day, location $A$ records the arrival of compression waves ($P$-waves), but not shear waves ($S$-waves), from a distant earthquake. Which statement best explains why shear waves were not received?
   A) Shear waves are transmitted through all parts of the Earth.
   B) Shear waves are not transmitted through the Earth’s outer core.
   C) Shear waves are stopped by the iron and nickel inner core.
   D) Shear waves are faster than compression waves.

Questions 261 through 265 refer to the following:

The diagrams below represent four kinds of plate movements that occur in the Earth’s crust. The arrows in the diagrams show the relative motions of the crustal plates at each boundary.

261) At location $C$, the movement of the crustal plates is a direct cause of
   A) magnetic reversals
   B) the formation of continental crust
   C) the formation of oceanic crust
   D) folded mountain ranges

262) Which diagram best represents the kind of boundary that occurs in the Atlantic Ocean between Africa and South America?
   A) $A$
   B) $B$
   C) $C$
   D) $D$

263) How do the average thickness and composition of continental crust differ from those of oceanic crust?
   A) Continental crust is thinner and is granitic in composition.
   B) Continental crust is thicker and is basaltic in composition.
   C) Continental crust is thicker and is granitic in composition.
   D) Continental crust is thinner and is basaltic in composition.

264) Which equation could be used to determine the rate of crustal movement that has occurred at $B$ over a period of time?
   A) rate of crustal movement = \( \frac{\text{amount of horizontal movement}}{\text{time}} \)
   B) rate of crustal movement = \( \text{amount of horizontal movement} \times \text{time} \)
   C) rate of crustal movement = \( \frac{\text{amount of horizontal movement} - \text{time}}{\text{time}} \)
   D) rate of crustal movement = \( \frac{\text{amount of horizontal movement}}{\text{time}} \)

265) At present, the western part of California is moving northward relative to the rest of the State. Which diagram best represents this kind of plate boundary?
   A) $A$
   B) $B$
   C) $C$
   D) $D$
Questions 266 and 267 refer to the following:

The map below shows the epicenters and intensities of earthquakes within New York State. The State has been subdivided into four regions (A, B, C, D). In the key, VIII represents the most intense earthquakes and IV represents the least intense.

266) Which city is most likely to experience an earthquake at some future time? [Refer to the locations map of New York State in the Earth Science Reference Tables.]
   A) Elmira
   B) Massena
   C) Jamestown
   D) Utica

267) Which levels of earthquake intensity have occurred most frequently in New York State?
   A) VI and VII
   B) V and VII
   C) IV and VIII
   D) IV and V
Questions 268 through 272 refer to the following:

The seismograms were recorded at earthquake recording stations A, B, and C. The letters P and S on each seismogram indicate the arrival times of the compressional (primary) and shear (secondary) seismic waves.

268) The epicenter distance from station A was calculated to be 7,600 kilometers. Approximately how long did the P-wave take to get to station A? [Refer to the Earth Science Reference Tables.]
   A) 11 minutes   C) 9 minutes
   B) 12 minutes   D) 10 minutes

269) Approximately how far from station B is the earthquake epicenter located? [Refer to the Earth Science Reference Tables.]
   A) 4,300 km   C) 5,300 km
   B) 3,500 km   D) 6,300 km

270) At what time did the S-wave arrive at station A?
   A) 08:16:00   C) 08:21:00
   B) 08:30:00   D) 08:27:00

271) A fourth station recorded the same earthquake. The P-wave arrived, but the S-wave did not arrive. The best explanation for the absence of the S-wave is that the
   A) S-wave stopped when it reached a liquid part of the Earth's interior
   B) S-wave stopped when it reached a solid part of the Earth's interior
   C) S-wave was never transmitted by the earthquake
   D) S-wave traveled only on the Earth's surface and did not penetrate the Earth's interior
The radius of each circle on the maps below represents the distance from each seismograph recording station to the epicenter. Which map correctly illustrates the position of the three recording stations relative to the location of the earthquake epicenter?

A)  

B)  

C)  

D)
Questions 273 through 277 refer to the following:

The map below shows the travel time of seismic sea waves (tsunamis) from locations around the Pacific Ocean to the Hawaiian Islands. For example, an earthquake at any location on the line labeled "6 h" could produce a tsunami that would arrive in Honolulu, Hawaii, 6 hours later. A tsunami is a sea wave caused by an earthquake.

![Tsunami Travel Times to Hawaii Map](image)

273) The most likely reason for collecting this Pacific Ocean data is that Honolulu is
A) the site of a major tide station
B) an equal distance from many seismic stations
C) surrounded by earthquake-prone zones
D) the site of frequent major earthquakes

274) Which reporting station is not located on the Pacific tectonic plate?
A) Honolulu  
B) Tahiti  
C) Hong Kong  
D) Midway

275) From which location would a tsunami arrive at Honolulu in the shortest time?
A) La Jolla  
B) Tahiti  
C) Kodiak  
D) Wake Island

276) Locations in this region where major earthquakes occur are most closely associated with areas of
A) magnetic field reversal
B) volcanic eruptions
C) mid-continental folding
D) P-wave absorption

277) Approximately how fast do seismic sea waves travel from Midway to Honolulu, Hawaii?
A) 500 miles per hour
B) 1,500 miles per hour
C) 1 miles per hour
D) 3,000 miles per hour
278) The diagram below shows a cross section of a landscape and a nearby sea. Letters A and B indicate locations on the landscape surface. The geologic age of three of the rock types is shown.

![Cross section diagram](image)

The structural feature shown in the bedrock between locations A and B is a
A) glacial moraine    B) volcano    C) fault    D) plateau

Questions 279 through 281 refer to the following:

The diagram below shows a model of the relationship between Earth's surface and its interior.

![Model diagram](image)

279) The motion of the convection currents in the mantle beneath the Atlantic Ocean appears to be mainly making this ocean basin
A) narrower    B) wider    C) deeper    D) shallower

280) Mid-ocean ridges (rifts) normally form where tectonic plates are
A) stationary    B) sliding past each other    C) converging    D) diverging

281) According to the diagram, the deep trench along the west coast of South America is caused by movement of the oceanic crust that is
A) sinking at the Mid-Atlantic ridge    B) uplifting over the continental crust    C) colliding with the Atlantic oceanic crust    D) sinking beneath the continental crust
Questions 282 and 283 refer to the following:

**HUGE QUAKE POSSIBLE IN OREGON VALLEY**

Scientists have warned for years that a magnitude 8 or 9 earthquake could strike about 30 miles off the Oregon coast, causing huge tsunamis (large ocean waves) and tremendous damage.

Now scientists say these earthquakes could be centered much farther inland and cause severe damage to a larger area, including cities in Oregon such as Portland, Salem, and Eugene.

Geologic evidence suggests that strong quakes in this area occur about every 400 years, plus or minus 200 years. The last one, believed to be a magnitude 9, occurred 300 years ago. A magnitude 8 quake can cause tremendous damage. The San Francisco quake of 1906 has been estimated at 7.9. The Mexico City quake of 1985 that left thousands dead was measured at 8.1.

282) The cross section below shows the lithosphere and asthenosphere between points A and B on the map.

(a) On the cross section below, draw an arrow in the Juan de Fuca Plate to indicate the direction of the relative movement of the plate.

(b) Identify the type of tectonic plate boundary that exists at the Juan de Fuca Ridge.

(c) Identify the name of the plate in the cross section labeled x.

(d) How does the average earthquake depth beneath the Oregon coastline compare to the average earthquake depth beneath Mt. Hood?
283) An emergency management specialist in Portland, Oregon, is developing a plan that would help save lives or prevent property damage in the event of a future earthquake. Describe two actions or ideas that should be included in the plan.

Questions 284 through 286 refer to the following:

The small dots on the map represent earthquake epicenters. The letters on the map represent locations.

![Earthquake Epicenters Map](image)

284) At which location did earthquakes occur as a result of the Nazca plate sliding under the South American plate?
   A) A  
   B) B  
   C) C  
   D) D

285) Which processes normally occur in association with the plotted earthquakes?
   A) glaciation and erosion  
   B) deposition and sedimentation  
   C) fossilization and evolution  
   D) volcanism and mountain building

286) Locations H and K are found at tectonic plate boundaries referred to as
   A) ridges  
   B) rift zones  
   C) trenches  
   D) divergent zones
287) The diagram below shows one side of an oceanic ridge and a portion of the ocean floor.

Which graph best illustrates the age of the basalt as the distance from an oceanic ridge increases?

A) ![Graph A]
B) ![Graph B]
C) ![Graph C]
D) ![Graph D]

288) The seismogram below shows the arrival times of an earthquake's P-wave and S-wave recorded at a seismic station in Portland, Oregon.

What was the distance from Portland to the earthquake's epicenter?

A) 1,800 km  
B) 2,500 km  
C) 4,100 km  
D) 3,200 km
The passage below provides some information about the sediments under Portland, Oregon, and the map shows where Portland is located.

**BAD SEISMIC COMBINATION UNDER PORTLAND: EARTHquake FAULTS AND JIGGLY SEDIMENT**

"Using a technique called seismic profiling, researchers have found evidence of ancient earthquake faults under Portland, Oregon. The faults may still be active, a USGS [United States Geological Survey] seismologist will announce tomorrow. The research also turned up a 250-foot deep layer of silt and mud, deep under the city, which may have been caused by a catastrophic ice dam break some 15,000 years ago.

The two findings could together mean bad news, as soft sediment is known to amplify ground shaking during strong earthquakes. In the 1989 San Francisco earthquake, much of the damage to buildings was caused by liquefaction, a shaking and sinking of sandy, water-saturated soil along waterways...."

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Robert Roy Britt, excerpted from "Bad seismic combination under Portland: Earthquake faults and jiggly sediment", explorezone.com, 05/03/99

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289) What type of tectonic plate boundary is shown at the San Andreas Fault?

290) Describe one precaution that can be taken to prevent or reduce property damage in preparation for a future earthquake in Portland.

291) Why is the presence of a layer of silt and mud deep under the city a danger to Portland?

292) Explain why Portland is likely to experience a major earthquake.
Questions 293 through 297 refer to the following:

The map below shows mid-ocean ridges and trenches in the Pacific Ocean. Specific areas A, B, C, and D are indicated by rectangles.

293) According to the *Earth Science Reference Tables*, which map best shows the direction of movement of the oceanic crustal plates in the vicinity of the East Pacific Rise (ridge)?

A) ![Map A](image1)
B) ![Map B](image2)
C) ![Map C](image3)
D) ![Map D](image4)

294) Movement of the crustal plates shown in the diagram is most likely caused by

A) shifting of the Earth's magnetic poles
B) the erosion of the Earth's crust
C) convection currents in the Earth's mantle
D) the revolution of the Earth
295) Mid-ocean ridges such as the East Pacific Rise and the Oceanic Ridge are best described as
   A) mountains containing folded sedimentary rocks
   B) sections of the ocean floor that are the remains of a submerged continent
   C) mountains containing fossils of present-day marine life
   D) sections of the ocean floor that contain the youngest oceanic crust

296) The crust at the mid-ocean ridges is composed mainly of
   A) granite   B) limestone   C) basalt   D) shale

297) The cross section below represents an area of the Earth's crust within the map region.

Which rectangular area on the map does this cross section represent?
   A) Area A   B) Area B   C) Area C   D) Area D

298) The diagram below shows some features of Earth's crust and upper mantle.

Which model most accurately shows the movements (arrows) associated with the surface features shown in the diagram?
The cross-sectional diagram below of the Earth shows the paths of seismic waves from an earthquake. Letter $X$ represents the location of a seismic station.

Which statement best explains why station $X$ received only $P$-waves?

A) $P$-waves and $S$-waves are refracted by the Earth's core.
B) $S$-waves traveled too slowly for seismographs to detect them.
C) A liquid zone within the Earth stops $S$-waves.
D) Station $X$ is too far from the focus for $S$-waves to reach.
Questions 300 through 302 refer to the following:

The map below shows the locations of volcanic islands and seamounts that erupted on the seafloor of the Pacific Plate as it moved northwest over a stationary mantle hotspot beneath the lithosphere. The hotspot is currently under Kilauea. Island size is not drawn to scale. Locations X, Y, and Z are on Earth's surface.

**DATA TABLE: Age of Volcanic Features**

<table>
<thead>
<tr>
<th>Volcanic Feature</th>
<th>Distance from Kilauea (km)</th>
<th>Age (millions of years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kauai</td>
<td>545</td>
<td>5.6</td>
</tr>
<tr>
<td>Nihoa</td>
<td>800</td>
<td>6.9</td>
</tr>
<tr>
<td>Necker</td>
<td>1,070</td>
<td>10.4</td>
</tr>
<tr>
<td>Midway</td>
<td>2,450</td>
<td>16.2</td>
</tr>
<tr>
<td>Suiko seamount</td>
<td>4,950</td>
<td>41.0</td>
</tr>
</tbody>
</table>

300) Which lithospheric plate boundary features are located at Y and Z?

A) secondary plates created by volcanic activity within the Pacific Plate  
B) rift valleys created by seafloor spreading of the Pacific Plate  
C) mid-ocean ridges created by faulting below the Pacific Plate  
D) trenches created by the subduction of the Pacific Plate

301) According to the data table, what is the approximate speed at which the island of Kauai has been moving away from the mantle hotspot, in kilometers per million years?

A) 10  
B) 1  
C) 1,000  
D) 100

302) Approximately how far has location X moved from its original location over the hotspot?

A) 1,800 km  
B) 20 km  
C) 2,500 km  
D) 3,600 km
303) The diagram below represents the Acadian Orogeny (mountain-building) that resulted from a collision between the North American Plate and the European Plate.

ACADIAN MOUNTAIN-BUILDING

Which geologic processes most likely caused the uplift of the Acadian Mountains?
A) burial and cementation  
B) weathering and erosion  
C) subsidence and deposition  
D) faulting and folding

304) The diagram below represents a cross section of a portion of the Earth's lithosphere.

Which statement about the Earth's crust is best supported by the diagram?
A) The continental crust is thicker than the oceanic crust.  
B) The crust is thicker than the mantle.  
C) The crust is composed primarily of sedimentary rock.  
D) The crust is composed of denser rock than the mantle.
305) The isolines on the isoseismal map below connect points of equal earthquake intensity. Letters A through H represent locations near an earthquake epicenter. The *Modified Mercalli Intensity Scale* below measures the strength of an earthquake in terms of the effects it produces.

![Isoseismal Map](image1)

The *greatest* difference between the arrival times of P-waves and S-waves was at location

A) H  B) F  C) G  D) E

306) The diagrams below show demonstrations that represent the behavior of two seismic waves, A and B.

![Wave A and Wave B](image2)

Which statement concerning the demonstrated waves is correct?

A) Wave A represents shear waves in the crust, and wave B represents shear waves in the mantle.
B) Wave A represents compressional waves in the crust, and wave B represents compressional waves in the mantle.
C) Wave A represents a compressional wave, and wave B represents a shear wave.
D) Wave A represents a shear wave, and wave B represents a compressional wave.
Questions 307 through 310 refer to the following:

The map below shows the present-day relative positions of South America and Africa and the age of the rocks composing the two continents. Letters A-H indicate specific rock units. The apparent close correlation between rocks on the two continents provided early evidence for the theory of continental drift.

307) Compared to the age of the rocks composing these continental landmasses, the age of the oceanic crust between them is mostly
   A) older
   B) younger
   C) approximately the same

308) Which model best indicates the overall direction of movement of the African landmass relative to the position of South America during this time of continental drift?
   A) 
   B) 
   C) 
   D) 

309) What present-day Atlantic Ocean feature is part of the evidence that these two continents are still drifting apart?
   A) a mid-ocean ridge
   B) land sediments
   C) a magnetic pole
   D) a deep ocean trench

310) Which Precambrian rock unit in South America is most probably a former section of rock unit F in present-day Africa?
   A) unit A
   B) unit C
   C) unit B
   D) unit D
Diagrams I and II show the same region of the Earth's surface at two different times in the geologic past.

Which statement best explains the basic cause of the changes that occurred in this region?

A) Climate changes caused flooding.
B) Mantle convection currents caused crustal movement.
C) Temperature changes caused melting of polar ice caps.
D) Meteor impact on the crust caused widening of the valley.

Questions 312 through 315 refer to the following:

The diagram below represents the age of the basaltic ocean crust in the Atlantic Ocean between the United States and Africa. Line AB is drawn for reference purposes only.
312) Which diagram most closely represents the cross section of the ocean floor along line AB?

A) ![Diagram A]

B) ![Diagram B]

C) ![Diagram C]

D) ![Diagram D]

313) Which statement is best supported by the diagram?

A) The ocean crust is the same age along line AB.

B) Most of the ocean crust along line AB formed in the Paleozoic Era.

C) The age of the ocean crust increases from point A to point B.

D) The oldest ocean crust is located near the continents.

314) According to the diagram, the width of the Cretaceous rock east of the mid-Atlantic Ridge along line AB is approximately

A) 1,000 km

B) 4,000 km

C) 1,600 km

D) 1,200 km

315) The age of formation of the ocean crust along line AB suggests that the United States and Africa are moving

A) westward

B) closer together

C) farther apart

D) eastward

316) The diagram below represents the Acadian Orogeny (mountain-building) that resulted from a collision between the North American Plate and the European Plate.

![Diagram of Acadian Orogeny]

The crust of these two colliding continents was mostly composed of

A) limestone

B) sandstone

C) granite

D) gneiss