

- 20) Which type of convergence will result in a volcanic island arc? 20) _____
 A) Oceanic-oceanic B) Continental-continental C) Oceanic-continental
- 21) Where are the majority of transform faults located? 21) _____
 A) Radiating from convergent boundaries as stress fractures
 B) Southern California
 C) On the ocean floor offsetting segments of oceanic ridge
 D) Along mountain ranges that have been thrust up due to collision
- 22) What is a mantle plume? 22) _____
 A) An upwelling of hot material from the Earth's interior that is cylindrical in shape
 B) Material rising up from a subducting plate going through partial melting
 C) A form of batholith composed of ferromagnesian materials
 D) The magma that rises up from the mantle at a divergent plate boundary
- 23) _____ occurs when magnetic minerals in lavas align their magnetic fields with magnetic north, preserving a record of that pole's location at that moment in time. 23) _____
 A) A mantle plume B) Seafloor spreading
 C) Magnetic reversal D) Paleomagnetism
- 24) A typical rate of seafloor spreading in the Atlantic Ocean is _____. 24) _____
 A) 2 centimeters per year B) 20 feet per year
 C) 0.1 inches per year D) 2 meters per year
- 25) All of the following offer additional evidence supporting the theory of plate tectonics except for _____. 25) _____
 A) measurements of plate motions
 B) changes in the Moon's orbit due to shifting plates
 C) hot spots
 D) ocean floor sediment cores
- 26) Where is the top of the asthenosphere closest to Earth's surface? 26) _____
 A) Along a transform fault B) Along a mid-ocean ridge
 C) Above a deep mantle plume D) Along a subduction zone
- 27) Which of the following statements best describes the tectonic setting for Mount St. Helens and the other Cascade volcanoes? 27) _____
 A) Old, deeply eroded volcanoes built before the Pacific Ocean existed
 B) Young, deeply eroded, basaltic volcanoes built when western North America was over the present-day site of the Hawaiian hot spot
 C) A chain of young, active volcanoes built on a continental margin above a sinking slab of oceanic lithosphere
 D) A chain of old, inactive volcanoes built while western North America moved over a mantle plume
- 28) How did researchers in the mid-twentieth century obtain ocean floor samples in order to determine the age of the seafloor? 28) _____
 A) Satellite image images B) Hydraulic vacuum tubes
 C) Drilling ships D) Deep-diving manned submersibles
- 29) Samples from the seafloor around the Mid-Atlantic Ridge and the East Pacific Rise show that both areas have been creating new material in the last five million years. Samples from the East Pacific show 29) _____
 Pacific show

the 29) _____
five-milli _____
on-year-
old
seafloor
is three
times as
wide as
similarly
aged
material
from the
Mid-Atla
ntic
Ridge.
What
does this
say
about the
rate of
seafloor
spreadin
g in the
East
Pacific?

- A) The seafloor at the Mid-Atlantic is growing more slowly.
- B) The seafloor at the Mid-Atlantic is growing more quickly.
- C) The seafloor at the East Pacific Rise is growing more slowly.
- D) The seafloor at both sites is growing at the same rate.

30) What two pieces of information would researchers need to have in order to calculate the rate of plate motion for seafloor spreading? 30) _____

- A) Distance from the rift and age of seafloor sample
- B) Age of the seafloor sample and age of the continent
- C) Age of the continent and depth of the water
- D) Type of rock and distance from the rift

31) How can GPS receivers and satellites be used to monitor plate motion? 31) _____

- A) Satellites send lasers to measure the distance to continents.
- B) Satellites track seafloor spreading.
- C) GPS receivers send signals to each other to see if the units are getting closer together.
- D) GPS receivers are placed on landmasses to track their locations.

32) How can the orientation of transform faults provide information about the direction of plate motion? 32) _____

- A) Transform faults are parallel to the direction of plate motion.
- B) Transform faults are oriented perpendicular to the direction of plate motion.
- C) Transform faults are parallel to convergent boundaries.
- D) Transform faults radiate out from the rift zone located in the center.

33) Which is denser: a 100-million-year-old oceanic lithosphere near a convergent boundary, a 15-million-year-old oceanic lithosphere near a rift, or the upper part of the asthenosphere? 33) _____

- A) A 15-million-year-old oceanic lithosphere
- B) Upper asthenosphere
- C) 100-million-year-old oceanic lithosphere
- D) They all have the same density.

- 34) What generates the heat necessary for convection in the Earth? 34) _____
A) Chemical reactions between geologic materials and hydrothermal fluids
B) Friction between moving slabs
C) Decay of radioactive materials
D) Volcanic eruptions
- 35) What is slab pull? 35) _____
A) Warmer oceanic lithosphere is pulled below colder asthenosphere.
B) Cold continental lithosphere is pulled below warmer asthenosphere.
C) Cold oceanic lithosphere is pulled below warmer asthenosphere.
D) Cold continental lithosphere is pulled below warmer oceanic lithosphere.
- 36) Along which tectonic boundary is ridge push going to be most important in helping to drive plate motion? 36) _____
A) Divergent boundary B) Convergent boundary C) Transform boundary
- 37) Which factor contributes the most toward plate motion at a convergent boundary? 37) _____
A) Ridge push B) Mantle drag C) Friction D) Slab pull
- 38) In which layer of the Earth does the convection necessary for plate motion occur? 38) _____
A) Outer core B) Mantle C) Crust D) Inner core
- 39) Which model of convection describes how the interior is divided into several levels of convection cells? 39) _____
A) Differentiation model B) Plume model
C) Layer cake model D) Whole-mantle convection
- 40) In the whole-mantle convection model, what feature balances the deeply descending lithosphere by transporting hot material toward the surface? 40) _____
A) Mantle plumes B) Rift zones
C) Decompression melting D) Kimberlites
- 41) During what time period did scientists first notice the jigsaw puzzle fit of the southern continents? 41) _____
A) 1600s B) 1910s C) 1800s D) 1750s
- 42) Which of the following best explains the global distribution of plant species, such as the *Glossopteris*, during the Mesozoic? 42) _____
A) Seeds were ingested by animals and later deposited in scat.
B) Seeds were small, so they could be carried by the wind.
C) The landmasses were joined and the plant had a large geographic extent.
D) Oceans that transgressed on the continents carried the seeds to different locations.
- 43) Where is oceanic lithosphere thickest and why? 43) _____
A) In the middle of the tectonic plate as it has not been scraped off during subduction
B) Close to the subduction zone boundary because continental material is added to it
C) Furthest from the spreading center because the older oceanic crust is cooler

D) Along oceanic ridges because it is newest there

- 44) The lithosphere is broken into _____ major plates and many minor plates. 44) _____
A) nine B) seven C) fifteen D) twelve
- 45) Which of the following statements regarding the global oceanic ridge system is correct? 45) _____
A) The ridge system has an extensive submarine canyon system.
B) The ridge system marks the locations of most mantle plumes in the mantle.
C) The ridge system marks the deepest locations on the Earth's surface.
D) The ridge system is the longest topographic feature on the Earth's surface.
- 46) Another name for a _____ boundary is a destructive boundary. 46) _____
A) divergent B) convergent C) transform
- 47) Which of the following makes it possible for oceanic crust created at divergent boundaries to be carried to the sites of destruction at convergent boundaries? 47) _____
A) Magma plutons weighing the crust down at convergent boundaries, pulling the slab
B) Alignment of magnetic fields in iron particles
C) Seawater seeping into plate fractures to lubricate the rocks
D) Transform boundaries that accommodate plate motion
- 48) Which of the following plate boundaries is not usually associated with volcanism? 48) _____
A) Convergent B) Transform C) Divergent
- 49) A convergent boundary is usually associated with which physical features? 49) _____
A) Volcanic arcs and submarine trenches
B) Submarine trenches
C) Rift valleys
D) Horizontally displaced rocks
E) Volcanic arcs
- 50) Which two continents did Wegener cite as having the best evidence of a close coastline fit? 50) _____
A) North America and Europe B) South America and Africa
C) India and Asia D) Europe and Africa
- 51) The _____ is a hotter, weaker region in the mantle that lies below the lithosphere and responds to forces by flowing. 51) _____
A) atmosphere
B) inner core
C) outer core
D) crust
E) asthenosphere
- 52) Which is least dense? 52) _____
A) Continental lithosphere B) Mantle
C) Asthenosphere D) Oceanic lithosphere
- 53) _____ is the name of the process by which new seafloor is generated at mid-ocean ridges. 53) _____
A) Melting B) Seafloor spreading
C) Convection D) Subduction
- 54) _____ and _____ drive water from the pores of a subducted oceanic plate, which leads to partial

melting. 54)

- A) Air; heat
- C) Heat; pressure

- B) Salt; oil
- D) Compression; tension

55) Lava solidifying during a period of reverse polarity will align the magnetic fields of its iron particles toward the _____ pole.

- A) South
- B) West
- C) North
- D) East

55) _____

TRUE/FALSE. Write 'T' if the statement is true and 'F' if the statement is false.

56) The majority of divergent plate boundaries are associated with oceanic ridges.

56) _____

57) Subduction zones will only develop between a continental plate and an oceanic plate.

57) _____

58) An oceanic plate that has been permeated by water before subduction will trigger melting sooner than a "dry" oceanic plate.

58) _____

59) The magnetic poles roughly correspond to the locations of the geographic poles.

59) _____

MATCHING. Choose the item in column 2 that best matches each item in column 1.

Match the tectonic boundary with its direction of motion.

60) Convergent boundary

A) Two plates move toward each other

60) _____

61) Divergent boundary

B) Two plates slide past each other

61) _____

62) Transform boundary

C) Two plates pull apart from each other

62) _____

Match the tectonic boundary with the effect on the crust.

63) Convergent boundary

A) Crust is being destroyed

63) _____

64) Divergent boundary

B) Crust is being conserved

64) _____

65) Transform boundary

C) Crust is being created

65) _____

Match the tectonic boundary with the type of stress affecting it.

66) Convergent boundary

A) Tension

66) _____

67) Divergent boundary

B) Shear

67) _____

68) Transform boundary

C) Compression

68) _____

Match the convergent boundary with a real-world example.

69) Oceanic-continental

A) Pacific and Philippine plates

69) _____

70) Oceanic-oceanic

B) North American and Juan de Fuca plates

70) _____

71) Continental-continental

C) Indian and Eurasian P=plates

71) _____

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

- 72) Explain how geologists regarded the positions of the ocean basins and the continents prior to the advent of plate tectonics and how that perspective differs from how modern geologists regard those same features.
- 73) When continental drift was first proposed in 1912, geologists from one specific continent strongly opposed the idea. Which continent's geologists were against the idea, and why did they have difficulty accepting it? (Think about where the evidence for continental drift is very clear.)
- 74) The acceptance of plate tectonics after the initial rejection of continental drift has been described as a scientific revolution. Explain why plate tectonics was so revolutionary and what tools were used to bring it about.
- 75) Scientific research supports the existence of Alfred Wegener's proposed supercontinent, Pangaea, approximately 300 million years ago. Pangaea subsequently broke apart, and the pieces of our modern continents migrated to the positions they occupy today. Based on your knowledge of the mechanics of tectonic motion, do you think there is a likelihood of another supercontinent forming? If so, where?
- 76) Why would using the continental shelves to reassemble the continents provide a better fit than using the shorelines of the continents?
- 77) Mesosaurus is a small freshwater reptile that existed in the Permian Period. It is only found in black shale deposits in eastern South America and southwestern Africa. If the Mesosaurus is an aquatic reptile and the continents are currently separated by an ocean, evaluate why the Mesosaurus would be used as strong evidence **in favor** of continental drift rather than as evidence **against** it.
- 78) Which two aspects of continental drift were most objectionable to scientists of the early twentieth century? Why?
- 79) Explain how the shapes of polar wandering paths for Europe and North America and the locations of those continents can be used to support the existence of Pangaea.
- 80) Lava lamps are commonly used to illustrate how convection cells in the mantle convey heat from the core to the exterior of the Earth. Explain how convection works, using a lava lamp as a proxy for the Earth.
- 81) Alfred Wegener provided several pieces of evidence supporting the idea that the planet's continents were once joined in a single landmass. List three of them.
- 82) How does the temperature of the lithosphere and that of the asthenosphere affect those layers' rigidities and responses when force is applied?
- 83) There is an expression in American society that it would only take one good earthquake and the state of California would sink into the ocean. Using what you know about plate boundaries, evaluate this statement.
- 84) If there is no compositional difference between two oceanic plates, what other factor will determine which plate will become the subducted one and why? (What other factor can control density?)
- 85) If new plate material is being created at divergent plate boundaries, is the Earth growing larger? Explain why or why not.

MATCHING. Choose the item in column 2 that best matches each item in column 1.



Using the map provided, locate three continental plates and three oceanic plates. Match the correct label with the correct plate.

86) Pacific Plate

A) Oceanic Plate

86) _____

87) North American Plate

B) Continental Plate

87) _____

88) Nazca Plate

88) _____

89) Philippine Plate

89) _____

90) Eurasian Plate

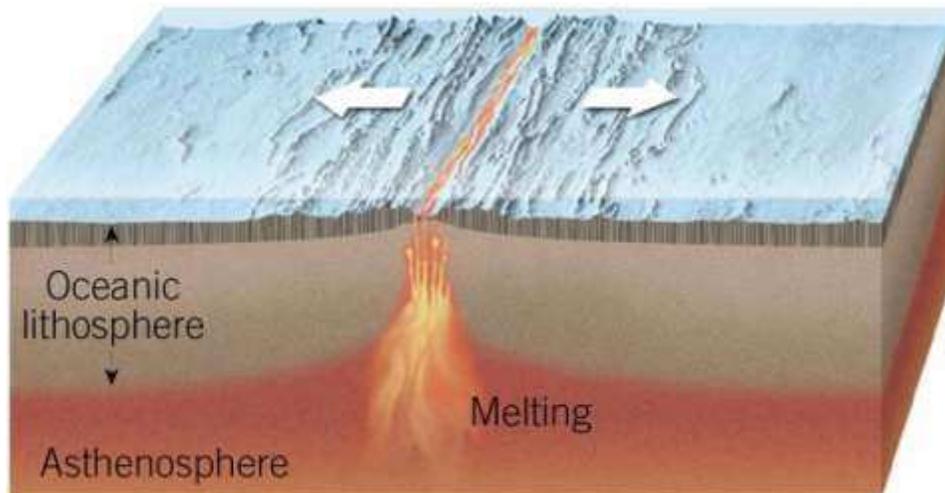
90) _____

91) African Plate

91) _____

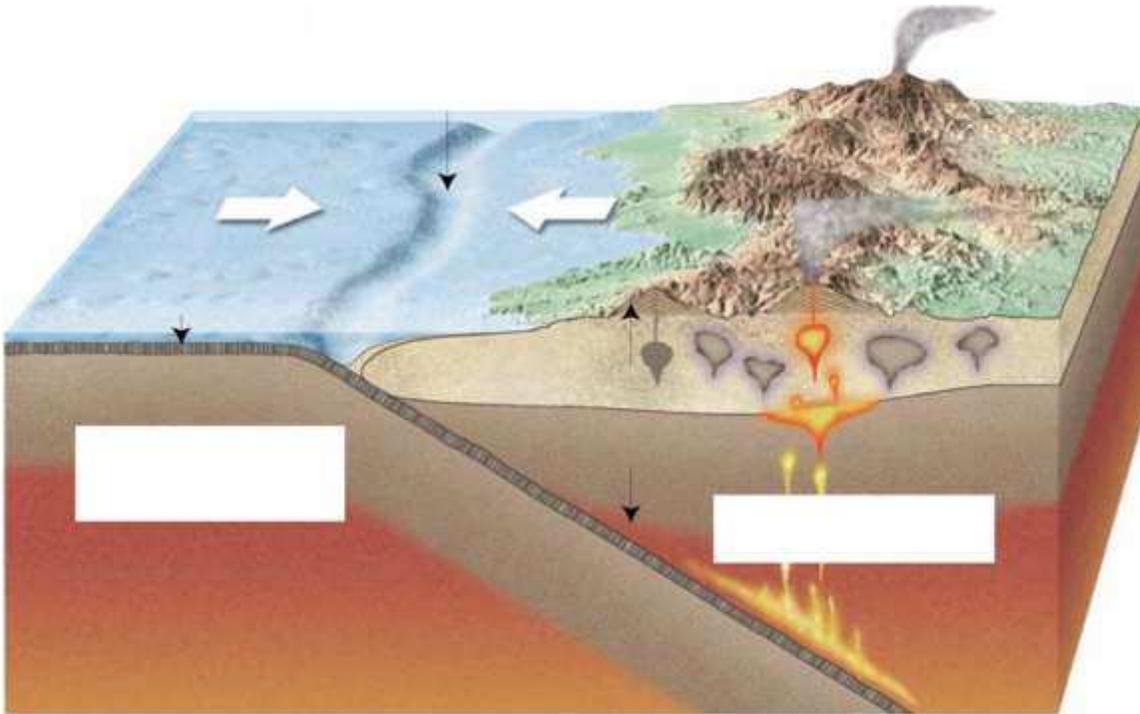
ESSAY. Write your answer in the space provided or on a separate sheet of paper.

92)



Using the block diagram provided, explain how new plate material is created at a divergent plate boundary. Make sure your answer includes a discussion on the forces at work and the generation of magma beneath the rift.

MATCHING. Choose the item in column 2 that best matches each item in column 1. Match the oceanic and continental lithospheres with their positions on the figure below.



93) Oceanic Plate

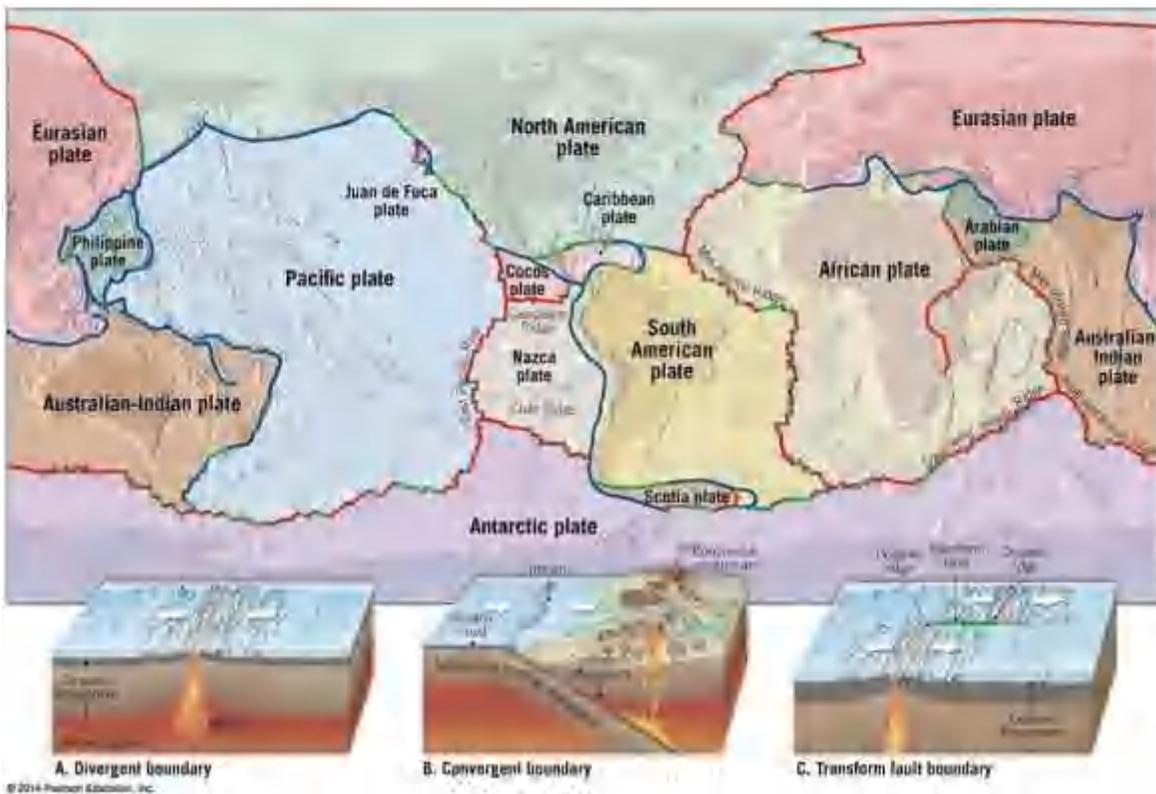
A) on the left

93) _____

94) Continental Plate

B) on the right

94) _____



A. Divergent boundary

B. Convergent boundary

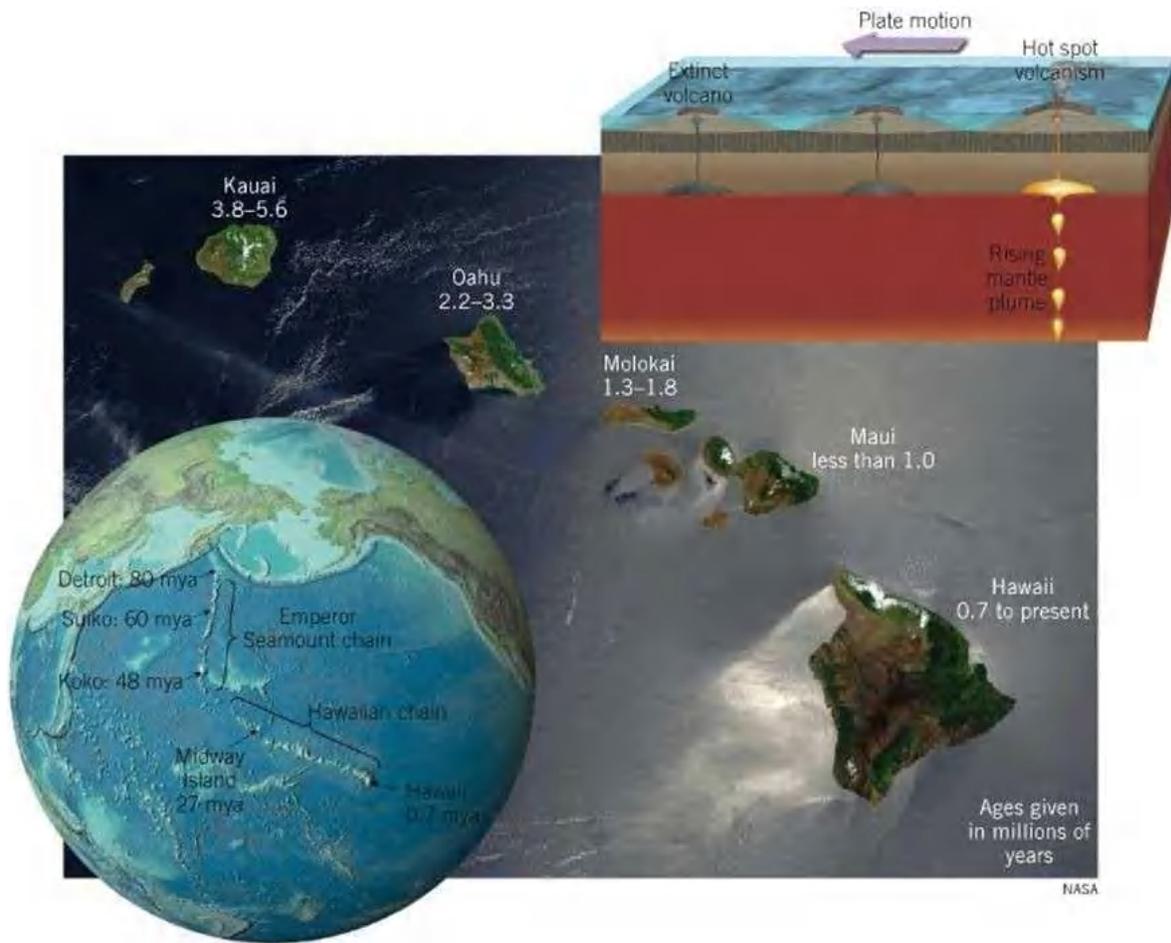
C. Transform fault boundary

Using the figure above, indicate which boundaries are convergent, divergent, and transform.

- | | | |
|---------------------------------------|---------------|------------|
| 95) Pacific/North American boundary | A) Divergent | 95) _____ |
| 96) Nazca/South American boundary | B) Transform | 96) _____ |
| 97) Pacific/Antarctic boundary | C) Convergent | 97) _____ |
| 98) African/South American boundary | | 98) _____ |
| 99) Caribbean/North American boundary | | 99) _____ |
| 100) African/Eurasian boundary | | 100) _____ |

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

- 101) _____



The Hawaiian mantle plume has left a chain of volcanic islands and seamounts stretching back for ~70 million years. Although the mantle plume has remained relatively stationary, the Pacific plate above it has moved. Use the figure to answer the following question.

What direction was the Pacific plate moving between 65 and 43 million years ago?

- A) Northwest B) North C) West D) Southeast E) East

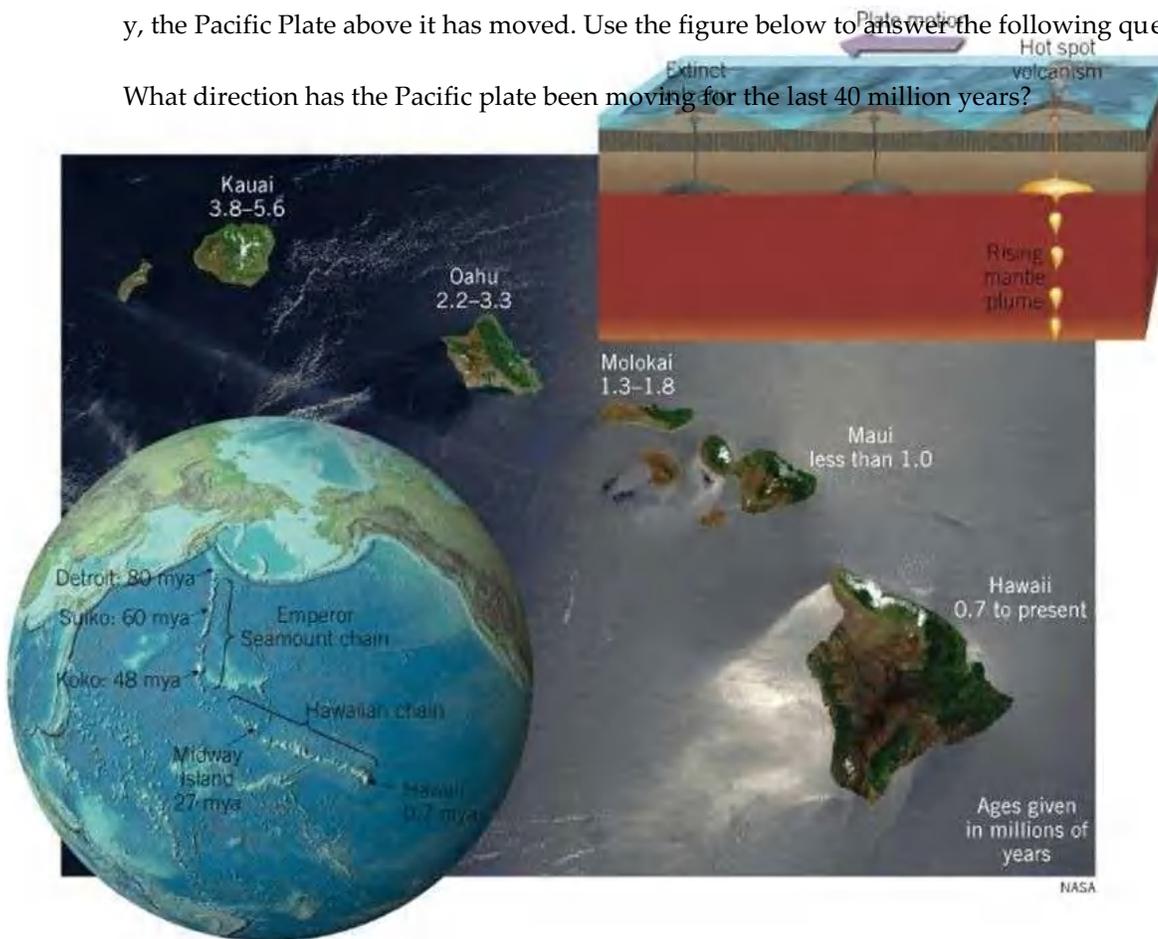
t

- 102)

y, the Pacific Plate above it has moved. Use the figure below to answer the following question.

102) _____

What direction has the Pacific plate been moving for the last 40 million years?



The Hawaiian mantle plume has left a chain of volcanic islands and seamounts stretching back for ~70 million years. Although the mantle plume has remained relatively stationary

A) North

B) Northwest

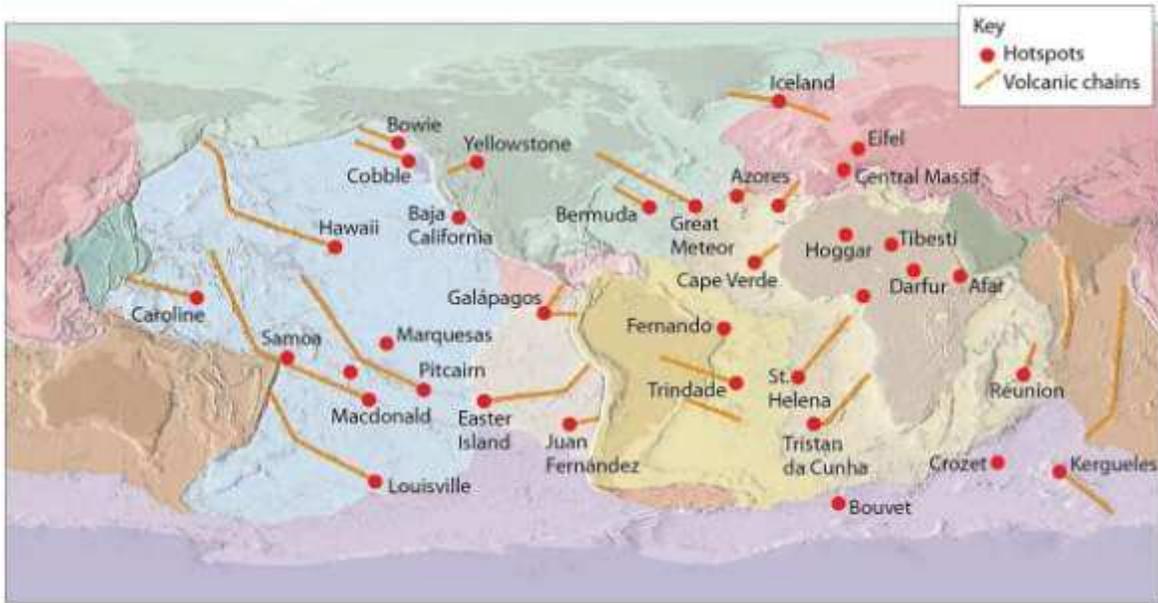
C) Northeast

D) Southeast

E) West

103)

103) _____



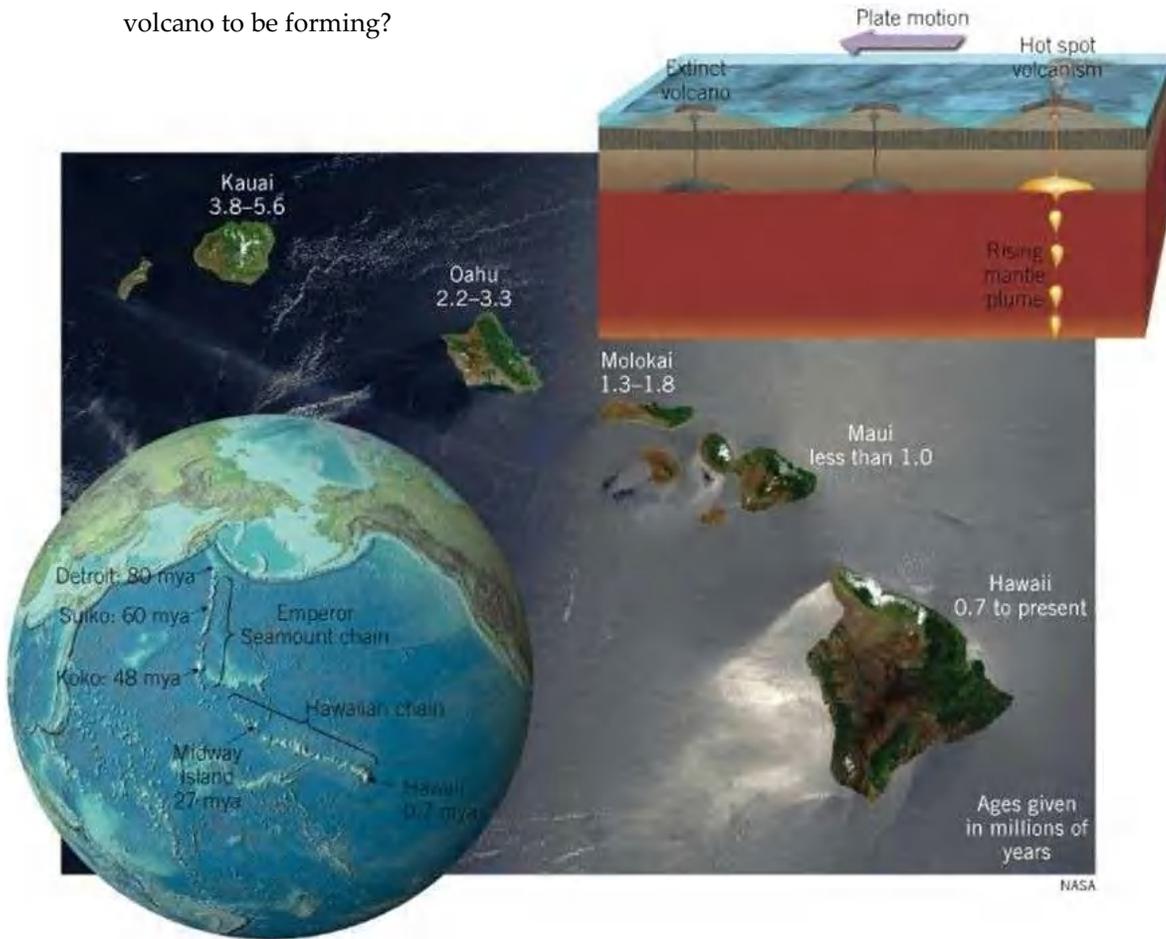
The Hawaiian mantle plume is a classic example of a long-lived mantle plume being used to demonstrate how the motion of a tectonic plate has changed over time. Which hot spot would be an even better indicator of the Pacific plate's motion over time?

- A) Cape Verde mantle plume
- B) Yellowstone
- C) Easter Island
- D) Pitcairn
- E) Caroline

104)

volcano to be forming?

104) _____



As the island of Hawaii continues to move away from the mantle plume, a new submarine volcano will be created. Off which coast would you expect the new submarine

- A) Southeast coast
- C) Southwest coast

- B) North coast
- D) Northeast coast

- 1) B
- 2) D
- 3) B
- 4) C
- 5) A
- 6) D
- 7) D
- 8) C
- 9) D
- 10) B
- 11) C
- 12) B
- 13) D
- 14) A
- 15) B
- 16) A
- 17) B
- 18) A
- 19) B
- 20) C
- 21) C
- 22) A
- 23) D
- 24) A
- 25) B
- 26) B
- 27) C
- 28) C
- 29) A
- 30) A
- 31) C
- 32) A
- 33) C
- 34) C
- 35) C
- 36) A
- 37) D
- 38) B
- 39) C
- 40) A
- 41) A
- 42) C
- 43) C
- 44) C
- 45) D
- 46) B
- 47) D
- 48) B
- 49) A
- 50) B
- 51) E

- 52) A
- 53) B
- 54) C
- 55) A
- 56) TRUE
- 57) FALSE
- 58) TRUE
- 59) TRUE
- 60) A
- 61) C
- 62) B
- 63) A
- 64) C
- 65) B
- 66) C
- 67) A
- 68) B
- 69) B
- 70) A
- 71) C
- 72) Prior to the 1960s, geologists viewed the ocean basins and continents as fixed features: they neither grew nor moved. They also believed both were incredibly old. However, after the development of the theory of plate tectonics in the 1960s, geologists realized that the continents do migrate across the globe, a process that changes the size and shape of the ocean basins. As a result, some ocean basins are much younger than was previously believed.
- 73) Geologists from North America were strongly against the idea of continental drift. Part of the reason behind their reluctance was that the strongest evidence to support it was found in the southern continents (Africa, South America, and Australia), the geology of which was not as well known to North American scientists.
- 74) Scientists initially held onto the belief that the continents and ocean basins were fixed objects, both of which dated back to the earliest days of the Earth. When continental drift was proposed, which challenged this belief, scientists had difficulty accepting it because the evidence was not as clear outside the southern continents. After World War II, modern tools like sonar, ocean drilling, and magnetometers were used to gather evidence about the age and bathymetry of the seafloor. This evidence (seafloor spreading and paleomagnetism) was used to support continental drift and develop the modern theory of plate tectonics.
- 75) The break-up of Pangaea led to the creation of the Atlantic Ocean. The divergent plate boundary that exists today is still spreading, enlarging the basin and pushing North America, South America, Europe, and Africa farther apart. As this basin grows, the Pacific Ocean basin shrinks due to the convergent plate boundaries around the margins of the Pacific plate. Recent studies indicate that the North American and Eurasian continents will meet over the North Pole (<http://www.nature.com/nature/journal/v482/n7384/full/nature10800.html>), though it would be reasonable for students to suggest that the next supercontinent would form in the Northern Pacific.
- 76) The shorelines are continuously eroded by waves or are being built out by longshore currents, fluvial deposition, and so on. These processes change the shapes of the continents over time. The continental shelves are currently several hundred feet below the erosive power of the waves, so they are left relatively untouched.
- 77) First, Mesosaurus is a freshwater reptile. It would not have been able to survive the trip across the southern Atlantic Ocean. Second, if it were able to swim such great distances as to be able to cross an ocean, it would be reasonable to assume Mesosaurus remains would be more widespread.
- 78) - Mechanism for continental drift: Wegener proposed that gravitational forces from the Sun and Moon that produce tides could gradually move the continents. However, if those forces were strong enough to move continents, the Earth's rotation would also have ceased.
- Continental rocks versus oceanic rocks: Wegener proposed that the continental landmasses broke through the thinner oceanic crust like an ice breaker. However, there was no evidence at the time to suggest such a feat was possible without severe deformation of the continents.
- 79) For the first 300 million years, the polar wandering paths for both continents were similar in shape and direction to

the were separated by several thousand miles. Starting in the middle of the Mesozoic, both paths began to converge on pole the North Pole. If these two continents are joined, these polar wandering paths overlap, supporting a unified but supercontinent.

- 80) The bulb at the base of the lamp warms the wax in the lamp. The thermal energy from the absorbed heat causes the atoms of the wax to move farther apart, making the wax less dense and allowing it to rise. Once at the top, the wax begins to cool, losing thermal energy. The atoms of wax move closer together, making the wax denser and forcing it to sink. Once the wax gets near the bulb again, it begins to warm again and the process starts all over.
- 81) Answers will vary but can include any three of the following:
 - Jigsaw puzzle fit of the southern continents
 - Matching fossils of multiple continents
 - Matching mountain ranges across multiple continents
 - Matching rock types across multiple continents
 - Matching glacial debris on multiple continents
- 82) The lithosphere is cooler and more rigid, so will bend or break when force is applied. The asthenosphere is warmer and more pliable, so will flow when force is applied.
- 83) The largest plate boundary in California is a transform boundary, which primarily moves horizontally, not vertically.
- 84) Temperature, which is a function of age. - Colder plates are denser and therefore will become the subducted plate.
- 85) No. The Earth is remaining the same size because although new plate material is being created, old plate material is being destroyed at convergent boundaries.
- 86) A
- 87) B
- 88) A
- 89) A
- 90) B
- 91) B
- 92) Tensional stress pulls the plates apart, creating a rift between them. The creation of the rift means that there is not as much force (the weight of the overlying plates) pushing down on that part of the mantle, which results in decompression melting that generates magma. Magma is less dense than the surrounding rock and rises up, filling the gap between the two plates. However, the plates are still being pulled apart, so the new material is also pulled apart, with part of it adhering to each plate.
- 93) A
- 94) B
- 95) C
- 96) C
- 97) A
- 98) A
- 99) B
- 100) B
- 101) B
- 102) B
- 103) D
- 104) A