

Base your answers to questions 1 through 6 on the information below and on your knowledge of Earth and Space Sciences.

Modeling Earth's Interior

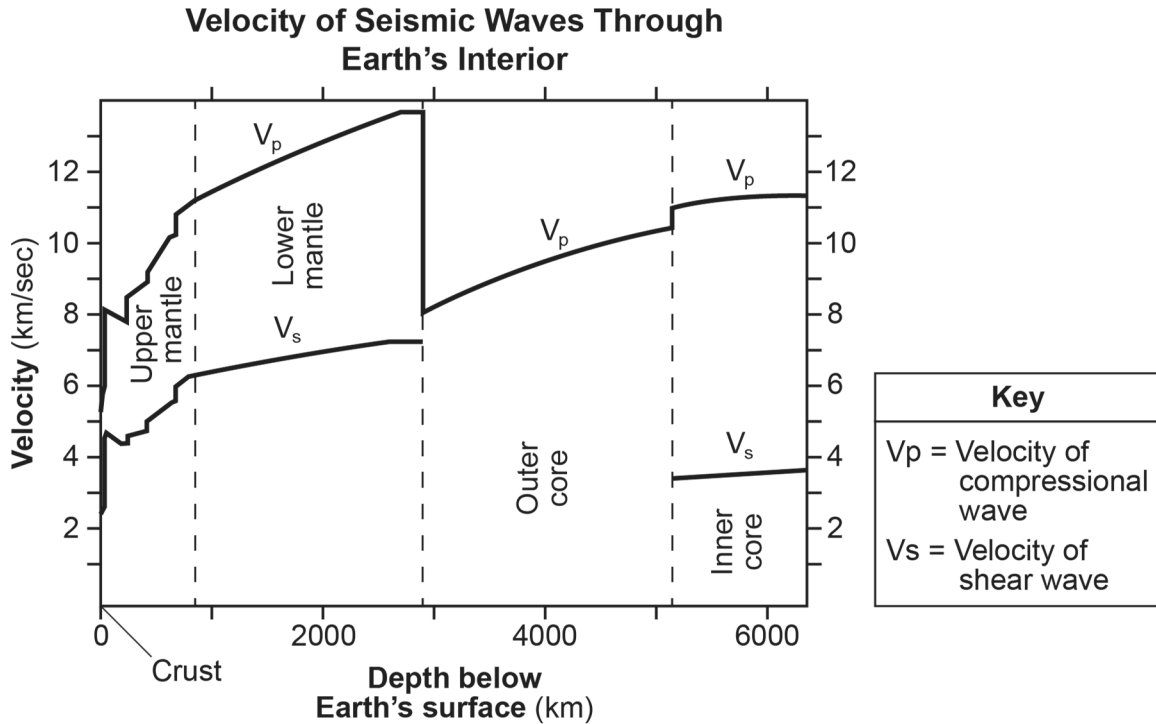
While other planets experience tectonic deformation in the form of volcanic activity, Earth is the only planet currently known to exhibit active plate tectonics involving multiple plates. To gain a better understanding of Earth's interior, scientists have developed models using seismic waves, rock samples, and laboratory experiments. These models assist scientists in the visualization of Earth's complex interior and crustal dynamics.

Conditions within Earth's interior cause different substances to be found at different depths. The table below shows regions within Earth's interior where some substances are found.

Substances Found in Earth's Interior

| Region (depths) | Substances |
|------------------------------|---|
| inner core (6371-5150 km) | solid, stable iron |
| outer core (5150-2891 km) | liquid iron |
| lower mantle (2891-670 km) | magnesium and iron-bearing silicates |
| transition zone (670-410 km) | structures with both SiO_4 and SiO_6 groups (e.g., majorite garnet) |
| upper mantle (410-40 km) | olivine, pyroxene, garnet, spinel |
| crust (average depth 40 km) | feldspar, quartz |

The graph below shows some information about the velocity of seismic waves as the waves travel through Earth's interior.



- 1 Which row in the table below correctly describes the substance(s) found in Earth's interior and the characteristic of that interior layer of Earth?

| Row | Substance(s) in Earth's Interior | Characteristics of Earth's Interior |
|-----|----------------------------------|--|
| A | liquid iron | found in a layer where compressional velocity is greatest in Earth's interior |
| B | solid, stable iron | found in a layer where compressional wave velocity is approximately 11.2 km/sec |
| C | pyroxene and quartz | found only at a depth of 500 kilometers |
| D | magnesium silicates | found in a layer where shear wave velocity is greater than compressional wave velocity |

- (1) Row A
 (2) Row B
 (3) Row C
 (4) Row D

- 2 Seismic wave information was used by scientists to infer the depth of Earth's interior layers and the states of matter found in these layers. For each piece of evidence (*A* and *B*) below, place an **X** in the appropriate box to indicate the characteristic that can be inferred *and* explain how this evidence changes and is used to determine this characteristic. [1]

Evidence from Graph

Characteristics of Earth's Interior Layers

A Sudden change in velocity

Change in Density

Change in Magnetism

Explanation 1: _____

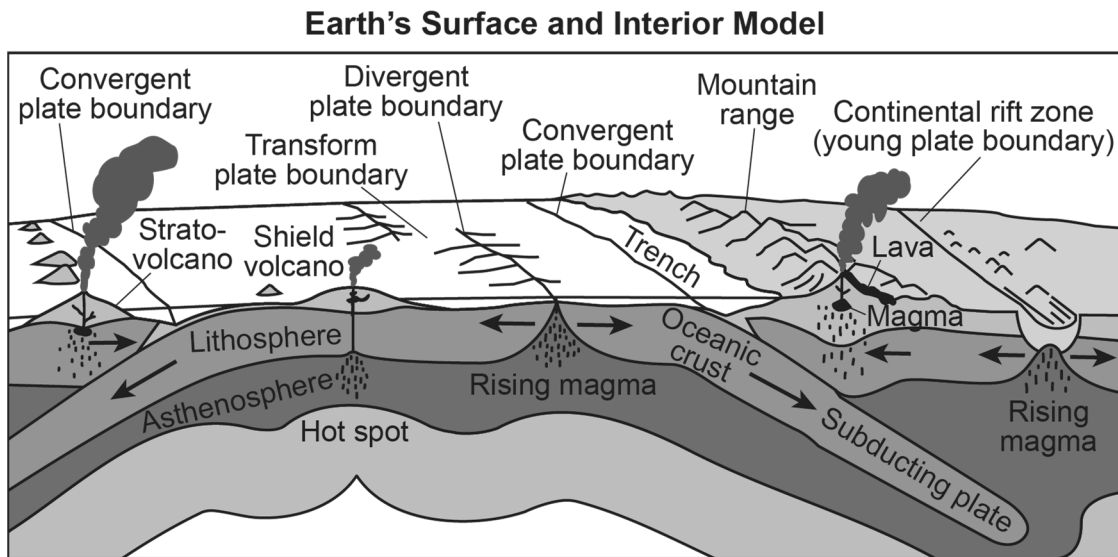
B Presence of certain types
of seismic waves

Depth

State of Matter

Explanation 2: _____

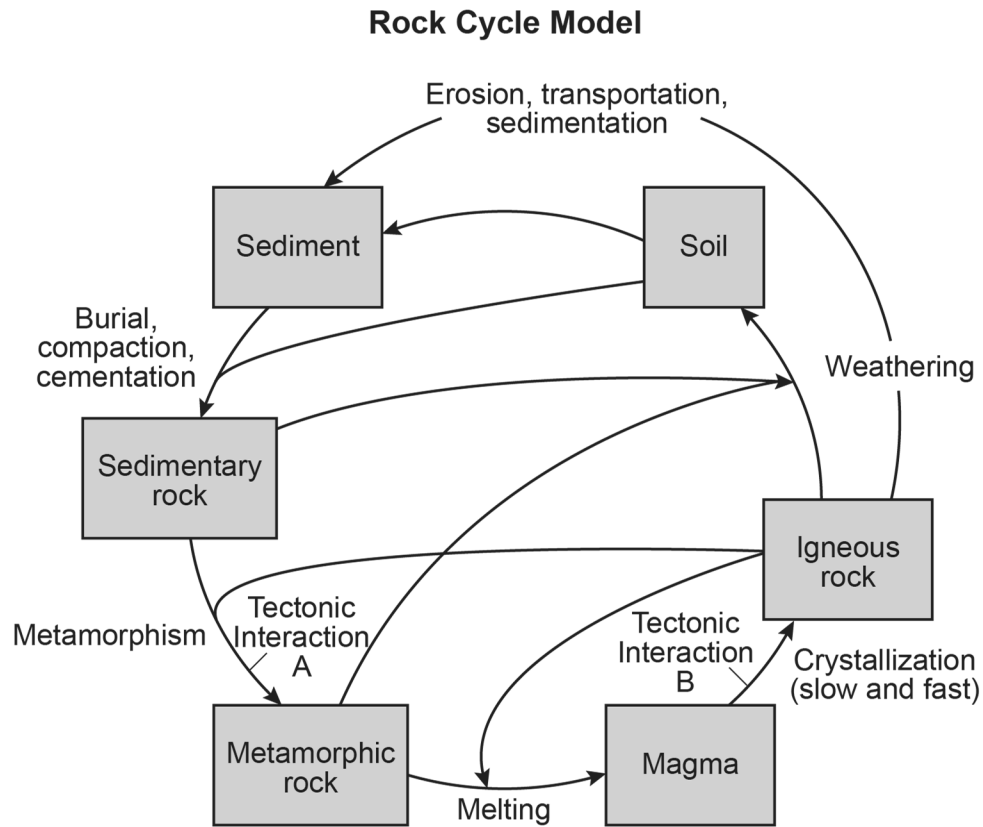
Tectonic processes are responsible for the formation of many types of rocks and minerals found on Earth. The model below shows some information about different tectonic plate interactions found on and below Earth's surface.



All models of Earth's interior depend on indirect evidence. These models predict the sources of heat in Earth's interior. The substances found in the different layers of Earth's interior determine the possible source of heat in each layer. The core contains elements that "like to be with iron," but the mantle and crust contain "rock-loving" elements. These elements are the source of rock-forming minerals of the Earth's crust. Uranium, thorium, and potassium are unstable isotopes that are examples of these "rock-loving" elements.

- 3 Which statement correctly describes a source of heat within Earth's interior?
- (1) Radioactive isotopes in Earth's interior decay in the mantle and crust, further driving convection currents that cycle materials.
 - (2) Radioactive activity in the mantle and crust helps to cycle materials into Earth's inner core and asthenosphere.
 - (3) Radioactive elements in Earth's interior decay, cycling materials in convection currents only within Earth's crust.
 - (4) Radioactive isotopes in Earth's interior decay, cycling materials in convection currents formed in the mantle and asthenosphere.

The model below represents processes involved in rock formation. Tectonic processes labeled *A* and *B* are missing.



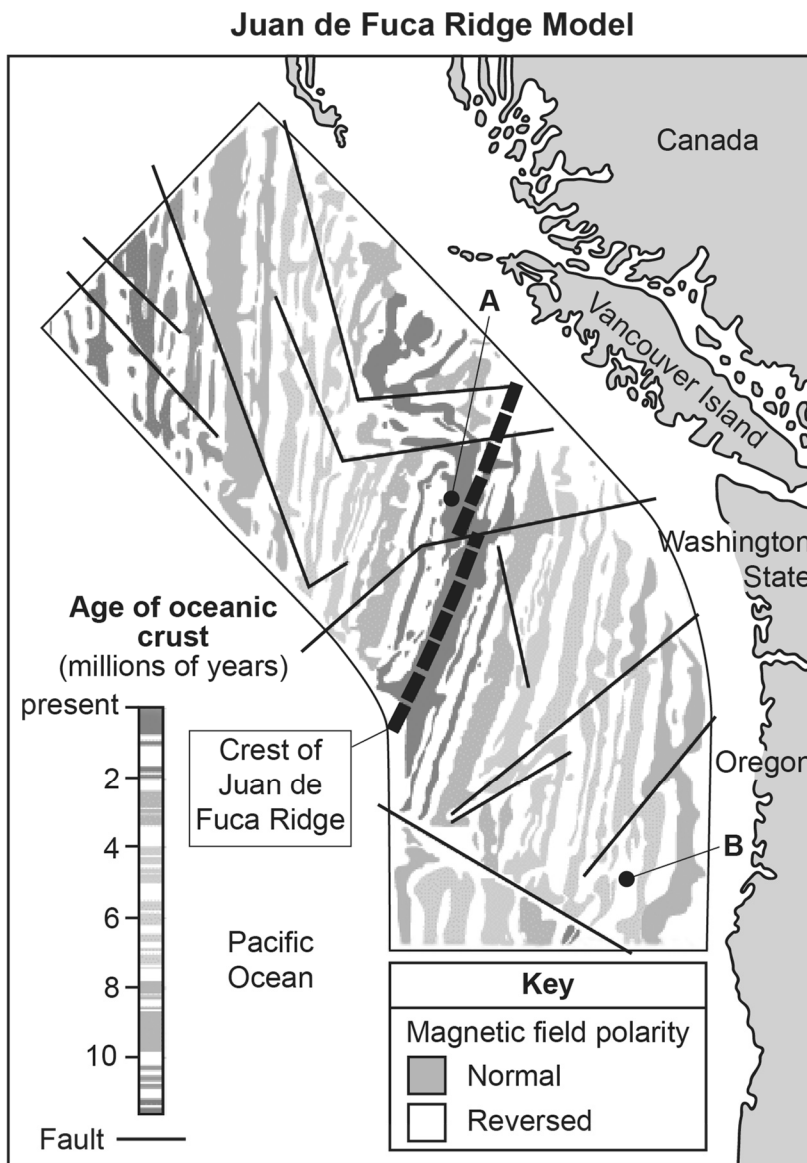
- 4 Using evidence from the *Earth's Surface and Interior Model*, complete the *Rock Cycle Model* by identifying **one** tectonic plate interaction that is responsible for the formation of each rock type indicated. [1]

Tectonic interaction *A*: _____

Tectonic interaction *B*: _____

Certain magnetic minerals in rocks can record the direction and intensity of Earth's magnetic field at the time they are formed. The direction of Earth's magnetic field has reversed several times during Earth's history. These reversals are recorded in the bedrock of the ocean floor.

The model below shows some information about the age and magnetic polarity of ocean floor bedrock along the Juan de Fuca ridge system.



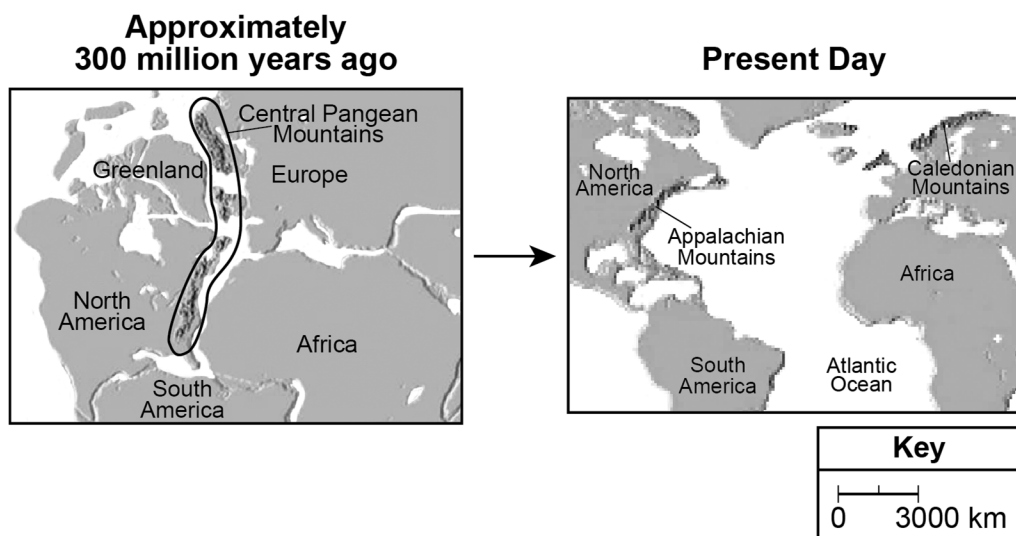
- 5 Which statement correctly compares locations on the *Juan de Fuca Ridge Model*?
- (1) The basalt at location *A* is older than the basalt at location *B*.
 - (2) A greater amount of outward flow of energy from Earth's interior occurs at location *A* than at location *B*.
 - (3) The magnetic polarity of basalt at location *A* is the same as the magnetic polarity of basalt at location *B*.
 - (4) The motion of the tectonic plate is from location *B* to location *A*.
- 6 Describe how the pattern of magnetic field reversal of ocean floor basalt shown in the rocks on either side of the Juan de Fuca Ridge is evidence for convection currents in the mantle. [1]

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Plate Tectonics

Alfred Wegener was a German geophysicist and meteorologist who proposed the theory of continental drift in 1912. This theory attempted to explain how similar rock formations and plant and animal fossils could be found on separate continents. Widely dismissed by other scientists from Wegener's time, continental drift would eventually be accepted and become known as the theory of plate tectonics by the 1960s.

The model below shows some information about the position of the continents.



- 1 Use the model to explain how the Central Pangean Mountains were separated into the Appalachian Mountains and the Caledonian Mountains. In your explanation include a spatial *or* a temporal numerical value in which this process occurred. [1]

One of the methods used to determine the absolute age of a rock is through the collection and analysis of zircon crystals. Zircon crystals have been found in some Appalachian Mountain regions. They grow in magma or semi-molten rock and are made of silicon, oxygen, and zirconium. Zircon crystals are ideal for age dating because they have the following characteristics:

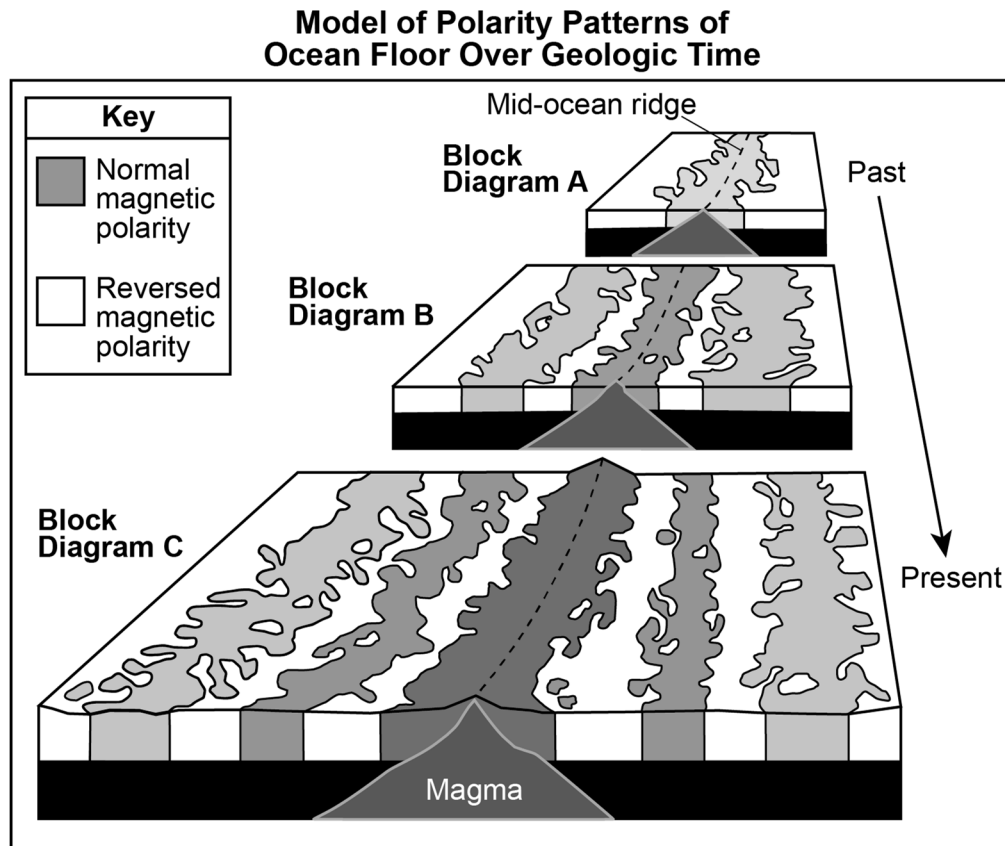
- commonly formed in felsic igneous rocks
- found in numerous sediments, such as beach sand, river sediments, and wind (eolian) deposits
- have a very high melting temperature and hardness
- high density but non-magnetic
- contain small but measurable amounts of uranium (which substitutes for the zirconium in the crystal lattice when the crystal grows)

- 2 Identify one characteristic of zircon crystals that makes them ideal for determining the absolute age of rocks found in the Appalachian Mountains. Explain how this characteristic can be used to determine absolute age. [1]

Characteristic: _____

Explanation: _____

The model below represents the polarity patterns found on the Atlantic Ocean floor over geologic time.



- 3 Which statement identifies the evidence for how the past and current movements of oceanic crust explain the ages of this ocean floor rock?
- (1) Oceanic crust at the mid-ocean ridge in block diagram *A* is now the youngest normal magnetic polarity rock found in block diagram *C*.
 - (2) Ocean crust at the mid-ocean ridge in block diagram *A* is now the oldest normal magnetic polarity rock found in block diagram *C*.
 - (3) The reverse magnetic polarity rock closest to the mid-ocean ridge in block diagram *A* is younger than the reverse magnetic polarity rock closest to the mid-ocean ridge in block diagram *B*.
 - (4) The reverse magnetic polarity rock in block diagram *B* is the same age as the normal magnetic polarity rock in block diagram *B*.

One of the pieces of evidence that Wegener was missing to explain his theory was the driving force for moving tectonic plates across Earth. The diagram below represents the structure of Earth and the geothermal gradient (the rate of change in temperature with respect to increasing depth in Earth's interior). The model is a block diagram of a portion of Earth. Arrows represent motion of tectonic plates.

Structure of Earth and the Geothermal Gradient

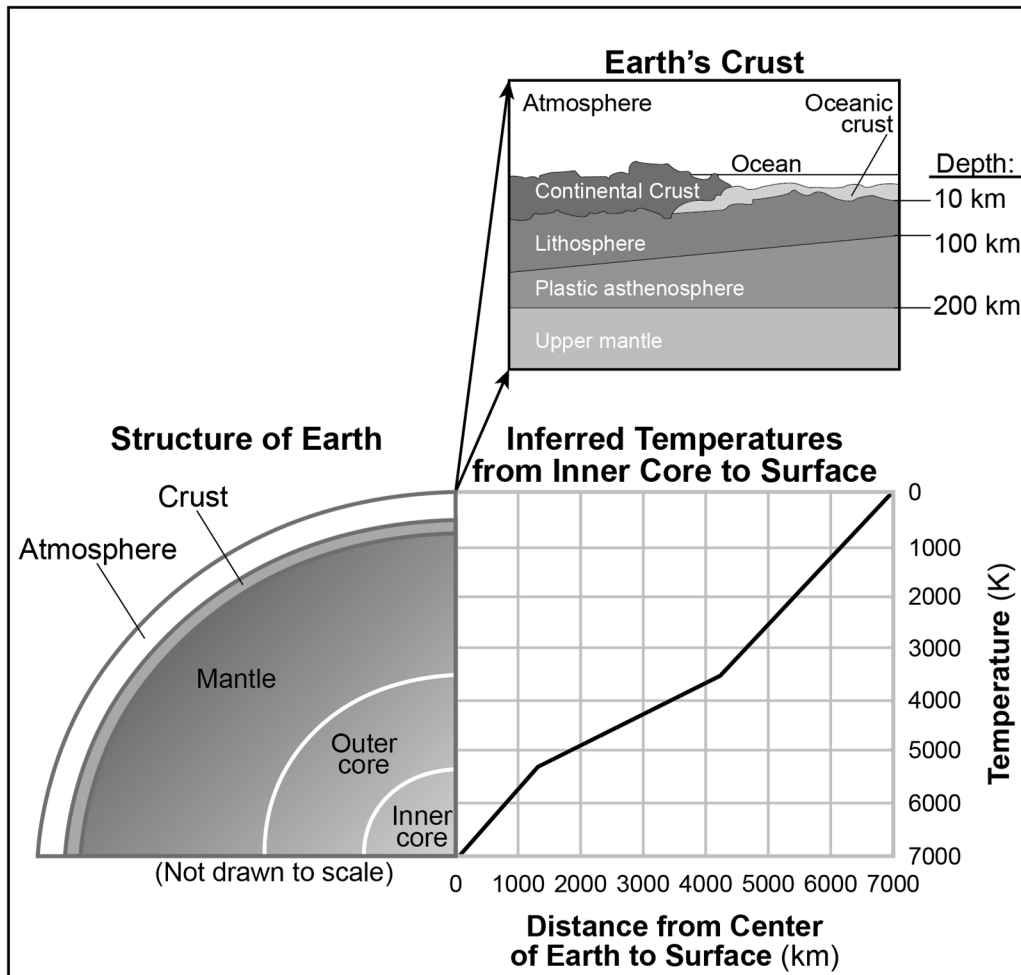
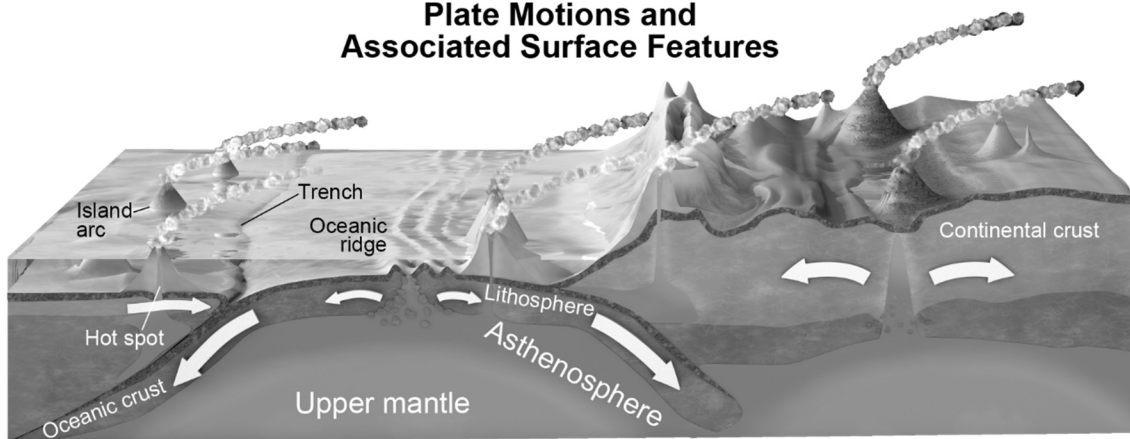
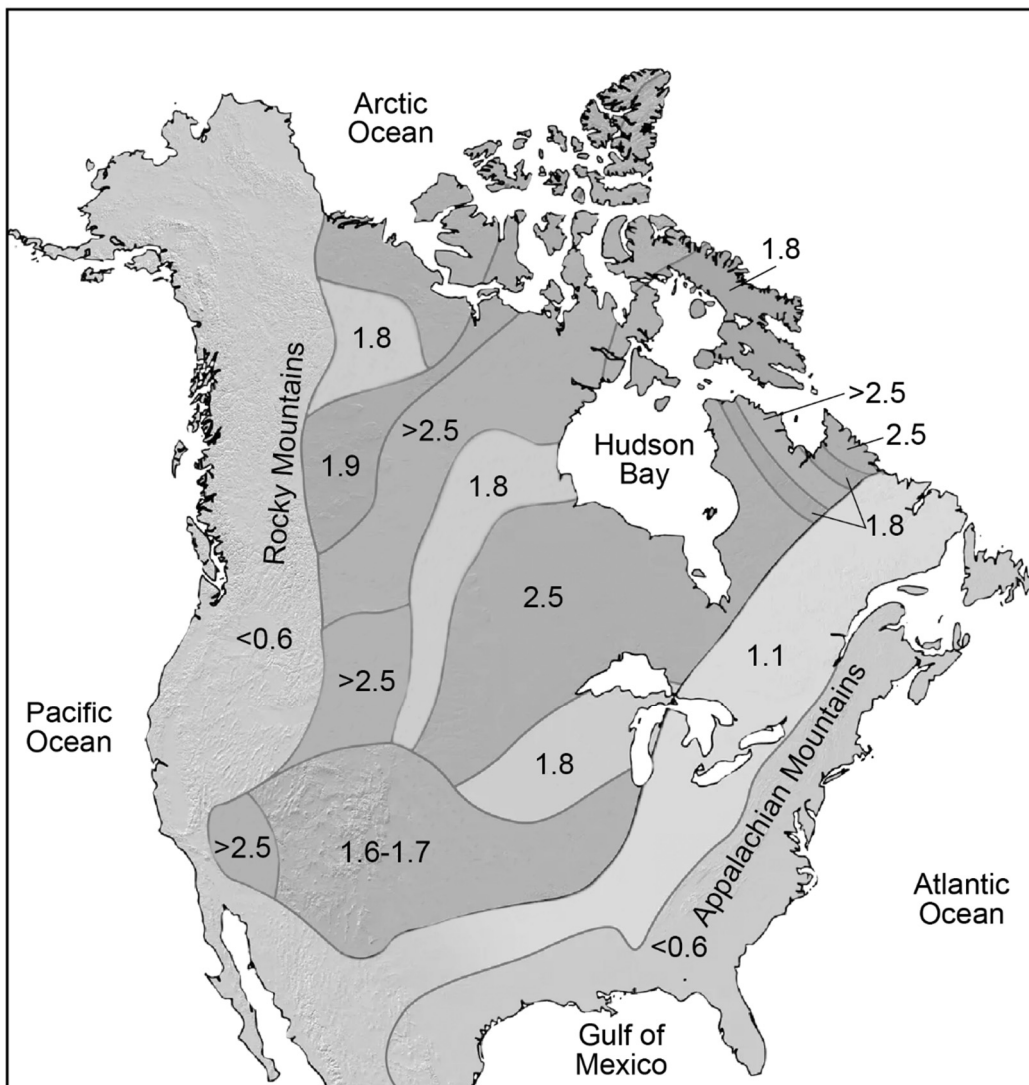


Plate Motions and Associated Surface Features



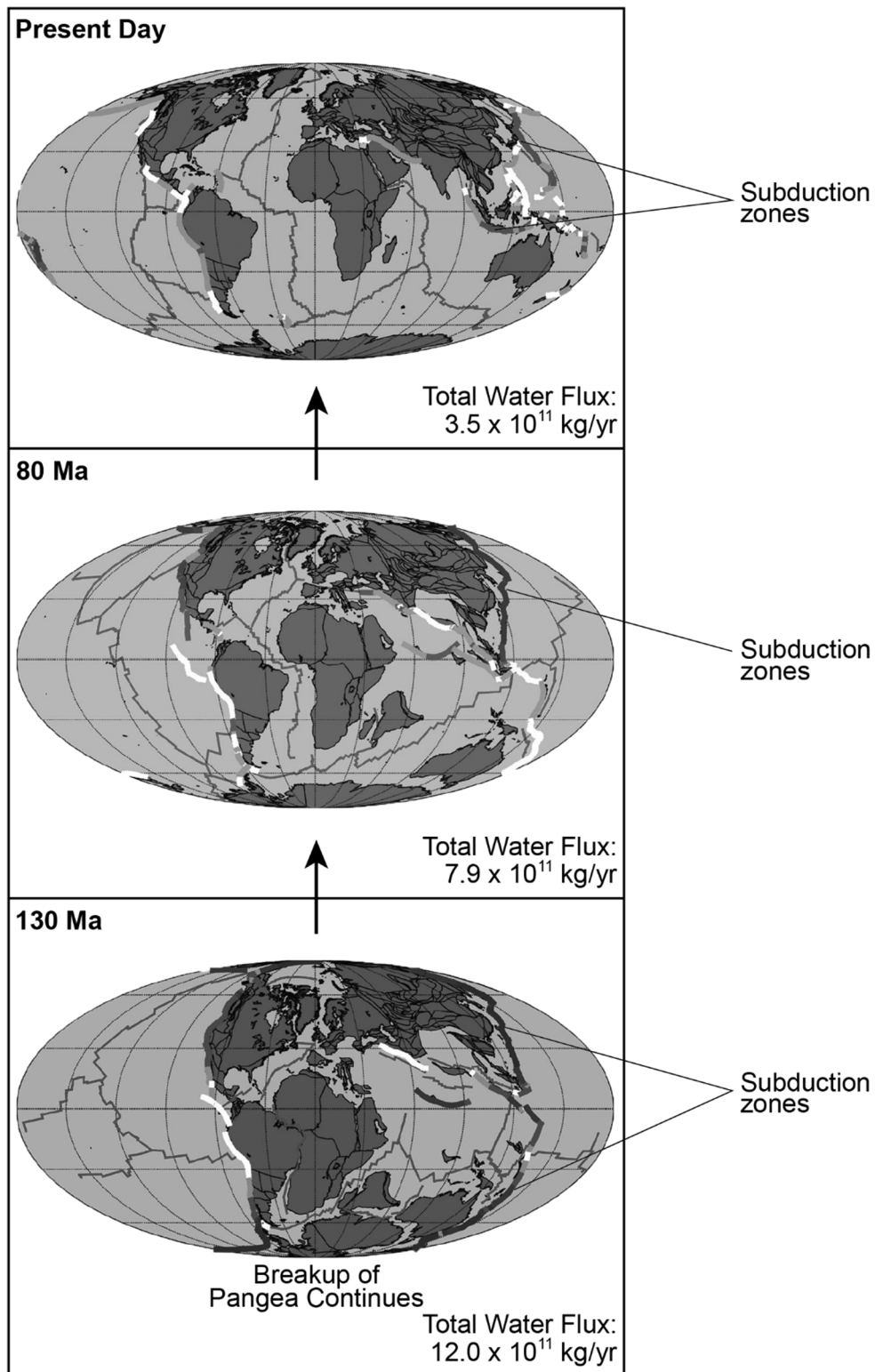
- 4 Which statement, based on evidence presented in the diagram, model, and graph, most accurately identifies our current understanding of the driving force for the theory of plate tectonics?
- (1) The highest amounts of heat from Earth's core is cycled by thermal convection in the mantle, causing lithospheric plates to diverge at mid-ocean ridges.
 - (2) The highest amounts of heat at Earth's surface is cycled by thermal convection in the lithosphere, causing plates to diverge at hot spots.
 - (3) Higher amounts of heat in the inner core than in the outer core transfer heat to the mantle, causing plates to diverge at ocean trenches.
 - (4) Higher amounts of heat in the mantle than in the outer core transfer heat absorbed by the crust, causing plates to converge and form volcanic mountain chains on continents.

Average Age of North American Continental Crust in Billions of Years



- 5 Based on evidence from the map, which statement identifies the pattern of the ages of crustal rocks in North America?
- (1) The oldest rocks in North American are found along the Gulf of Mexico, and the youngest rocks are found along the Hudson Bay.
 - (2) The central region of the continent contains the oldest rocks, while the youngest rocks are found along the Atlantic and Pacific Coasts.
 - (3) The oldest rocks are found in the Appalachian and Rocky Mountains.
 - (4) Rocks of the same age are found along the entire coastline of North America.

The maps below show the distribution of continents 130 Ma (million years ago) to the present day. Water flux is the amount of water flowing into Earth's mantle. The graph shows some information about sea level change.



- 6 After Pangea broke up 130 Ma, over time the number of subduction zones on Earth changed. This change to the geosphere created a feedback that caused changes to Earth's hydrosphere. Use the geoscience information provided on the maps to make a prediction about how the hydrosphere most likely changed and how this change most likely affected the global sea level. [1]

Predicted hydrosphere change: _____

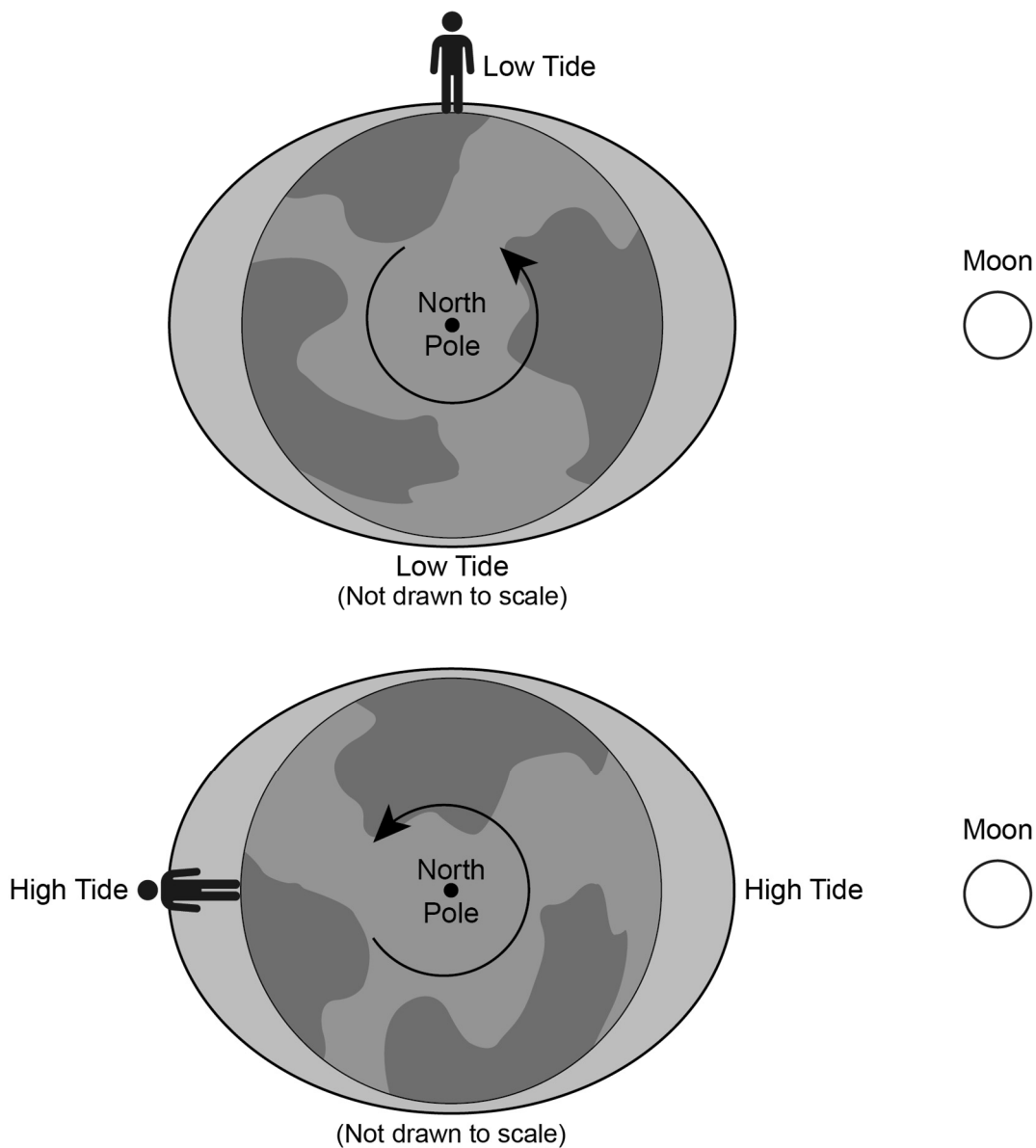
Predicted sea level change: _____

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The Effect of the Moon on Earth

Earth's Moon is the only celestial object beyond Earth where humans have set foot. It is the brightest and largest object in the night sky. The Moon makes Earth a more livable planet by moderating the wobble of Earth on its axis, leading to a relatively stable climate.

The models below represent two different positions of a person on Earth's surface six hours apart. The relative height of the ocean tides at these positions are indicated. The arrow represents the direction of Earth's rotation.



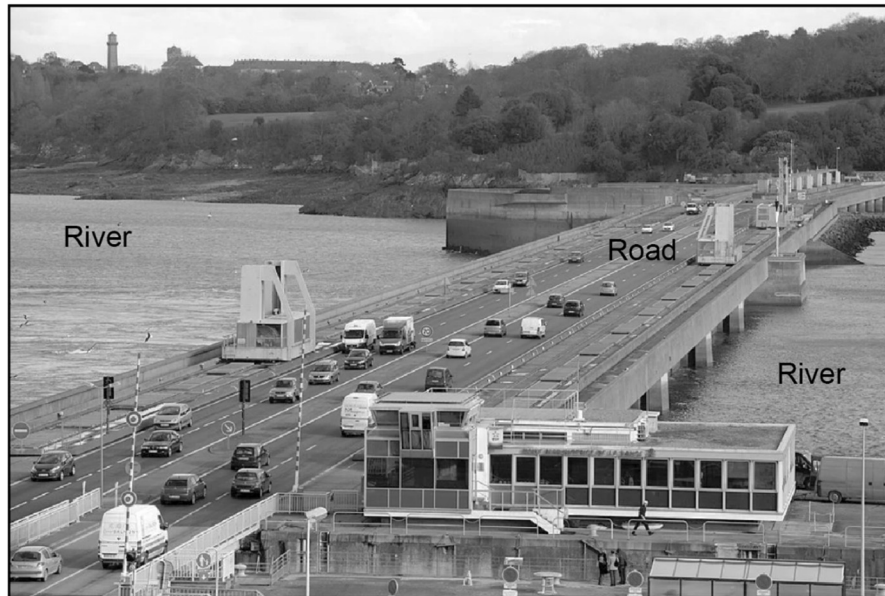
- 1 Construct an explanation using evidence from the models to support the claim that tides on Earth change cyclically. [1]

- 2 The Moon is moving away from Earth at approximately 2.5 cm per year. Which explanation correctly describes how this increased distance from Earth would affect Earth's tides after 1,000,000 years?

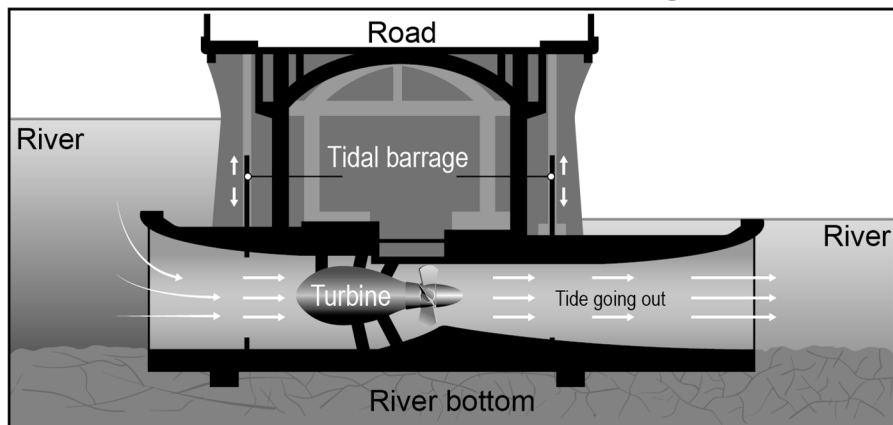
- (1) The difference between low tide and high tide will be smaller.
- (2) The difference between low tide and high tide will be greater.
- (3) The gravitational force exerted on Earth by the Moon would be greater, causing high tides to be higher.
- (4) The gravitational force exerted on Earth by the Moon would be less, causing low tides to be lower.

The La Rance Tidal Barrage in western France is a dam-like structure built to take advantage of the periodic cycling of tidal waters. The model below shows the position of a turbine and the movement of tidal water.

La Rance Tidal Barrage



Model of La Rance Tidal Barrage


































The La Rance Tidal Barrage was built in northwest France because of the availability of access to _____ (A) _____. This structure creates _____ (B) _____ energy that decreases emissions of _____ (C) _____ that would otherwise be generated from _____ (D) _____ resources.

- 3 Which set of terms constructs a correct explanation that describes why humans have built the La Rance Tidal Barrage across the La Rance River?

| | A | B | C | D |
|-----|--------------|---------------|------------------|---------------|
| (1) | fresh water | hydroelectric | auto exhaust | renewable |
| (2) | fresh water | hydroelectric | greenhouse gases | non-renewable |
| (3) | fossil fuels | nuclear | auto exhaust | renewable |
| (4) | fossil fuels | nuclear | greenhouse gases | non-renewable |

The Moon influences tides and is visible from Earth in different phases.

The calendar below shows the Moon phases seen by an observer in New York State for the month of September 2025. The name of the phase and the amount of the lighted portion visible from Earth is indicated.

| September 2025 | | | | | | |
|--|--|--|--|--|---|---|
| Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
| August 31  First Quarter Visible: 50% ↑ | 1  Waxing Gibbous Visible: 66.6% ↑ | 2  Waxing Gibbous Visible: 75.6% ↑ | 3  Waxing Gibbous Visible: 83.8% ↑ | 4  Waxing Gibbous Visible: 90.8% ↑ | 5  Waxing Gibbous Visible: 96.1% ↑ | 6  Waxing Gibbous Visible: 99.2% ↑ |
| 7  Full Moon Visible: 100% | 8  Waning Gibbous Visible: 97.9% ↓ | 9  Waning Gibbous Visible: 93.2% ↓ | 10  Waning Gibbous Visible: 86% ↓ | 11  Waning Gibbous Visible: 76.9% ↓ | 12  Waning Gibbous Visible: 66.4% ↓ | 13  Waning Gibbous Visible: 55.1% ↓ |
| 14  Last Quarter Visible: 50% ↓ | 15  Waning Crescent Visible: 33% ↓ | 16  Waning Crescent Visible: 23.2% ↓ | 17  Waning Crescent Visible: 14.8% ↓ | 18  Waning Crescent Visible: 8.1% ↓ | 19  Waning Crescent Visible: 3.4% ↓ | 20  Waning Crescent Visible: 0.7% ↓ |
| 21  New Visible: 0% | 22  Waxing Crescent Visible: 1.4% ↑ | 23  Waxing Crescent Visible: 4.5% ↑ | 24  Waxing Crescent Visible: 9.3% ↑ | 25  Waxing Crescent Visible: 15.6% ↑ | 26  Waxing Crescent Visible: 23% ↑ | 27  Waxing Crescent Visible: 31.4% ↑ |
| 28  Waxing Crescent Visible: 40.5% ↑ | 29  First Quarter Visible: 50% ↑ | 30  Waxing Gibbous Visible: 60% ↑ | | | | |

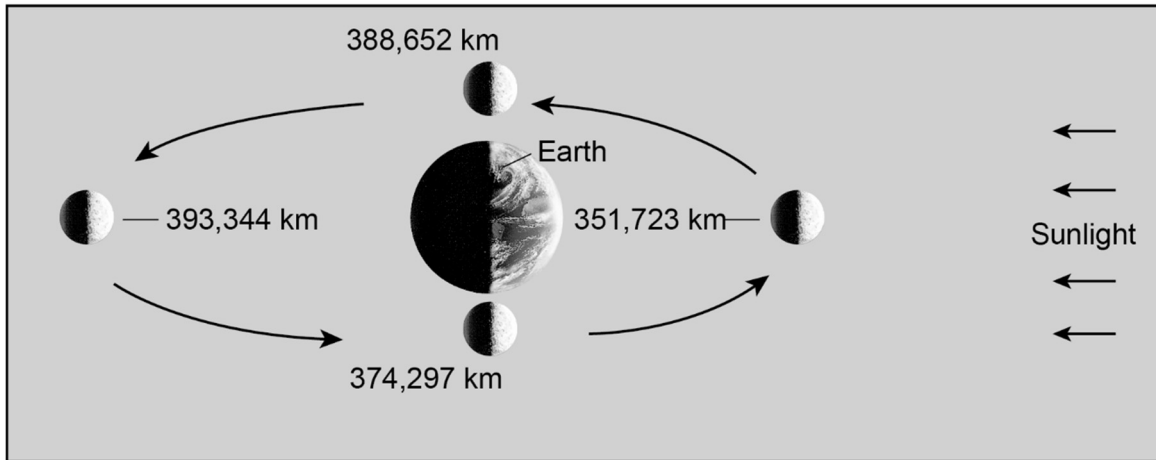
- 4 Identify the date in October 2025 when a full Moon will be observed. Use evidence from the calendar to support your choice. [1]

Date: _____

Evidence: _____

The model below shows the Moon in four positions in its orbit around Earth and the distances between Earth and the Moon at these four positions. Below the model, claims about the Moon's visibility, distance from Earth, and orbital velocity are listed.

Model of Moon's Orbit Around Earth



(Not drawn to scale)

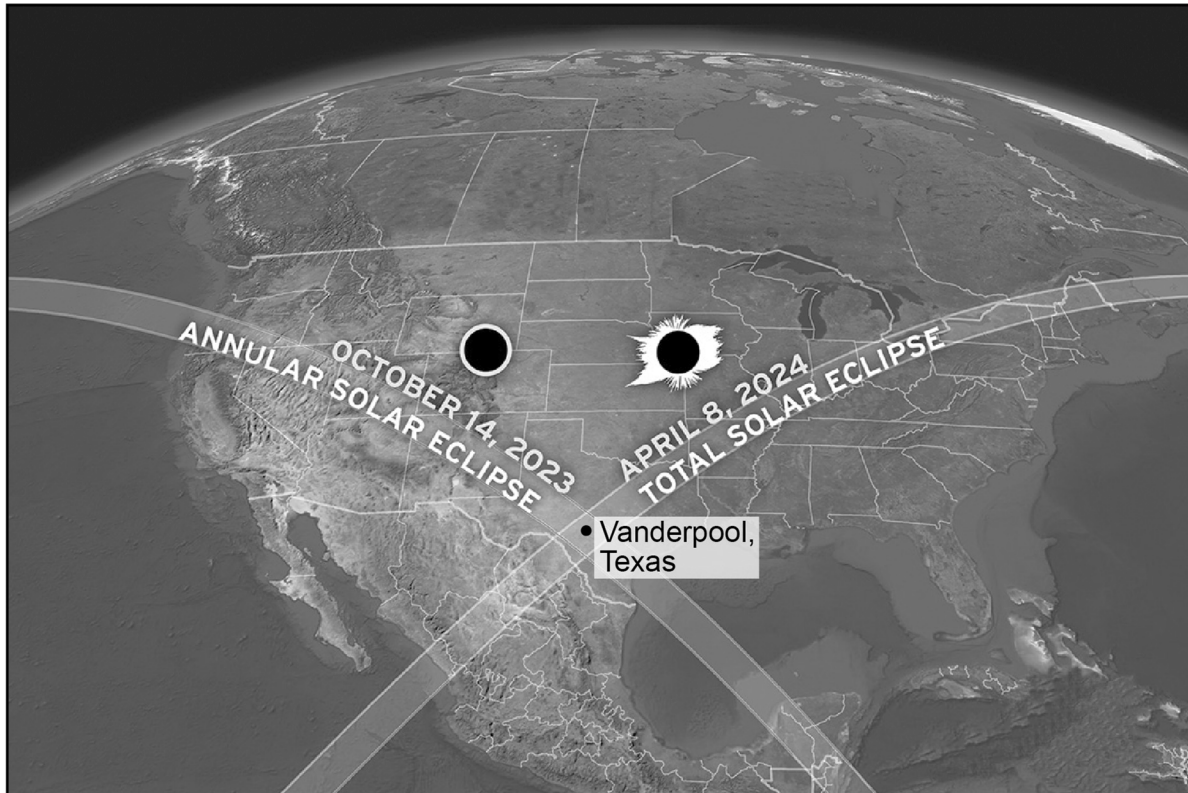
- Claim 1: The illumination of the Moon is increasing from one day to the next.
- Claim 2: The illumination of the Moon is decreasing from one day to the next.
- Claim 3: The distance between Earth and the Moon is increasing from one day to the next.
- Claim 4: The distance between Earth and the Moon is decreasing from one day to the next.
- Claim 5: The orbital velocity of the Moon is increasing from one day to the next.
- Claim 6: The orbital velocity of the Moon is decreasing from one day to the next.

5 Which set of claims correctly predicts the amount of illumination, the distance from Earth, and the orbital velocity for the Moon during the waning gibbous phase?

- (1) claims 1, 4, and 5
- (2) claims 2, 4, and 5
- (3) claims 1, 3, and 6
- (4) claims 2, 3, and 6

The data table below shows some information about celestial objects viewed from Vanderpool, Texas. Vanderpool, Texas is a location where two types of solar eclipses were visible.

Eclipses Visible from Vanderpool, Texas



Solar Eclipses at Vanderpool, Texas

| Solar Eclipse Date | Type of Solar Eclipse | Earth-Sun Distance (km) | Percent of Sun Blocked |
|--------------------|-----------------------|-------------------------|------------------------|
| October 14, 2023 | Annular | 149,224,442 | 90% |
| April 8, 2024 | Total | 149,823,117 | 100% |

- 6 Which statement summarizes evidence in the *Model of Moon's Orbit Around Earth* and the table *Solar Eclipses at Vanderpool, Texas* that describes three conditions that occur during the April 8, 2024 total solar eclipse for an observer in Vanderpool, Texas?
- (1) The Moon is in the new phase, closer to Earth, and appears smaller than during an annular solar eclipse.
 - (2) The Moon is in the full phase, farther from Earth, and appears smaller than during an annular solar eclipse.
 - (3) The Moon is in the new phase, closer to Earth, and appears larger than during an annular solar eclipse.
 - (4) The Moon is in the full phase, farther from Earth, and appears larger than during an annular solar eclipse.