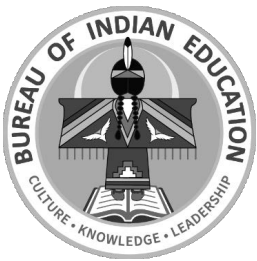




BIE Science
Practice Test
Grade 11



cognia[™]

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Science Session 1

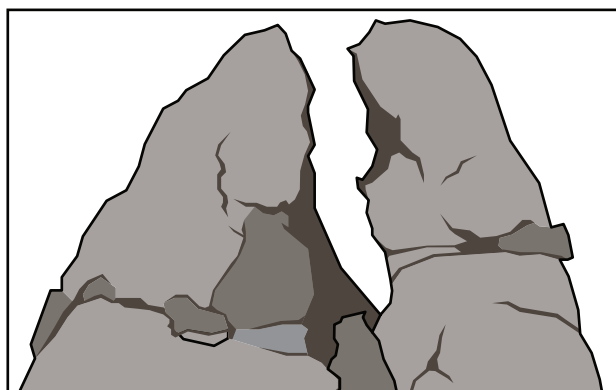
DIRECTIONS

Read each question carefully. For each multiple-choice question, decide which is the best answer and be sure to mark your answer in your answer document. For each open-ended item, be sure to write your answer in the lined box provided in your answer document. Only answers and work written inside the answer boxes will be scored.

This question has two parts. Be sure to answer both parts of the question.

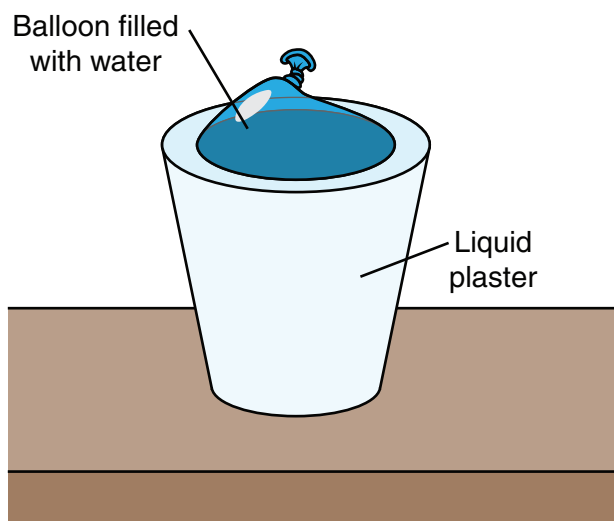
1. A student who is hiking on a high mountain sees the large rock shown in the diagram.

Mountain Rock



She wonders whether water could have caused the rock to break. To investigate, she mixes water with plaster in a paper cup. Then she fills a balloon with water and pushes the balloon into the liquid plaster in the cup. The next morning, the plaster has become solid like a rock and she peels away the paper cup. The balloon is surrounded by plaster as shown in the diagram.

Plaster Rock



SESSION

1



Part a

Based on the diagrams, which action could the student take to collect data about whether water can break the plaster rock like the mountain rock?

- A** Put the plaster rock under running water so that water can erode the rock.
- B** Put the plaster rock in a bucket of water so that water can dissolve the rock.
- C** Put the plaster rock in an oven so that water can evaporate inside the balloon.
- D** Put the plaster rock in the freezer so that water can expand inside the balloon.

Part b

How could the student's investigation provide evidence of the natural process that caused changes in the mountain rock?

- A** When water freezes inside the balloon, the volume of the water increases, which applies pressure that cracks the plaster rock.
- B** When water evaporates inside the balloon, the volume of the water decreases, which applies pressure that cracks the plaster rock.
- C** When water flows over the plaster rock, water flows into cracks in the rock, which applies pressure that erodes small pieces of the rock.
- D** When water surrounds the plaster rock, water flows into the cracks in the rock, which applies pressure that dissolves the rock into small pieces.

This question has two parts. Be sure to answer both parts of the question.



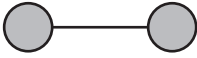
2. A student learns that one goal of space exploration is to launch rockets that can safely return to Earth and be reused. This involves careful calculations of the gravitational force between Earth and the rocket. The student learns that the gravitational force between two objects depends on the relationships and variables shown in the table.

Gravitational Force Equation

$F = G \frac{m_1 m_2}{d^2}$	F = Gravitational force G = Universal gravitational constant m_1 = Mass of object 1 m_2 = Mass of object 2 d = Distance between object 1 and object 2
-----------------------------	---

The student uses three models to show how changes in mass and distance affect the gravitational force between a rocket and Earth. The table shows the masses and distances of objects in the models.

Three Gravitational Force Models

Model	Diagram
1	$d = 10$ meters  $m_1 = 10$ kilograms $m_2 = 10$ kilograms
2	$d = 10$ meters  $m_1 = 5$ kilograms $m_2 = 10$ kilograms
3	$d = 5$ meters  $m_1 = 10$ kilograms $m_2 = 10$ kilograms

Part a

Which description of the gravitational force in the models is supported by the equation?

- A** The gravitational force between the objects in Model 2 is one-fifth the gravitational force between the objects in Model 1.
- B** The gravitational force between the objects in Model 2 is one-half the gravitational force between the objects in Model 1.
- C** The gravitational force between the objects in Model 2 is twice the gravitational force between the objects in Model 1.
- D** The gravitational force between the objects in Model 2 is five times the gravitational force between the objects in Model 1.

Part b

Which statement describes the gravitational force in the models?

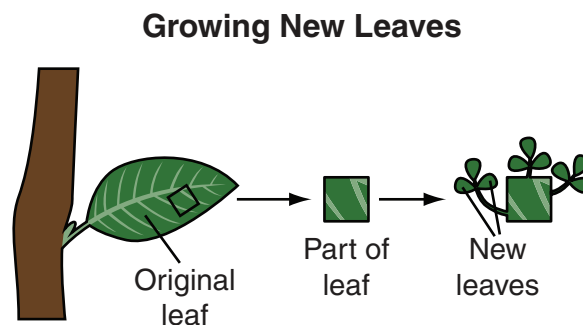
- A** The gravitational force between the objects in Model 3 is one-fourth the gravitational force between the objects in Model 1.
- B** The gravitational force between the objects in Model 3 is one-half the gravitational force between the objects in Model 1.
- C** The gravitational force between the objects in Model 3 is twice the gravitational force between the objects in Model 1.
- D** The gravitational force between the objects in Model 3 is four times the gravitational force between the objects in Model 1.



This question has two parts. Be sure to answer both parts of the question.

3. A student learns that multicellular organisms have different types of specialized cells, but each somatic cell in the organism has the same number of chromosomes. For example, leaves have specialized cells for transporting water and gases through the leaf.

She reads about an investigation that scientists designed in order to study specialized cells in leaves. Scientists put part of a leaf into a solution with hormone and nutrient. In a few days, new leaves were observed growing on the original leaf. The diagram shows the original leaf and the new leaves.



Part a

Which question could be answered by the investigation shown in the diagram?

- A What process causes cells with the same chromosomes to produce specialized cell structures?
- B What process causes some chromosomes to divide and produce new chromosomes and specialized cell structures?
- C What process causes some chromosomes to produce more specialized cells than other chromosomes?
- D What process causes cells with the same chromosomes to mutate and produce specialized cells?

Part b

The scientists compared cells in the original leaf to cells in the new leaves.

Which question could this comparison answer?

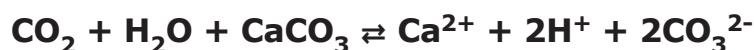
- A** How do the chromosomes in leaves help the plant transport water and gases?
- B** Do chromosomes transport water and gases in the original leaf and the new leaves?
- C** How many chromosomes do the leaves use to build structures that transport water and gases?
- D** Which parts of the chromosomes in leaves contain instructions for cell structures that transport water and gases?

This question has two parts. Be sure to answer both parts of the question.

4. Some students work at a local aquarium. One of their tasks is to care for mollusks and corals in ocean water in a tank at the aquarium. The students need to make sure that the ocean water has the right balance of calcium ions (Ca^{2+}) and carbonate ions (CO_3^{2-}) that the mollusks and corals need to build their shells and skeletons.

To do this, the students need to ensure that calcium and carbonate ions are continuously added to the ocean water in the tank. The students know that ocean water contains calcium carbonate, which naturally breaks down into calcium and carbonate ions. The equilibrium relationship between the components in the water is shown in the equation.

Equilibrium Equation



The students decide to test the equilibrium relationships in the equation. With ocean water as an input, the students remove calcium ions (Ca^{2+}) as the ions form in the water in the tank. The students observe that as they remove calcium ions, more calcium ions form in the tank. They realize that this is an example of Le Chatelier's principle that describes the equilibrium relationships in the water.

The people who work at the aquarium tell the students that ocean water contains carbon dioxide (CO_2) and that increasing amounts of CO_2 in ocean water can cause some of the calcium carbonate (CaCO_3) in the shells and skeletons of ocean organisms to dissolve.

The students want to solve this problem by decreasing the amount of carbon dioxide in ocean water.

- Describe one way students could decrease the amount of CO_2 in ocean water by applying Le Chatelier's principle.
- Describe one constraint on implementing the change described in Part (a).



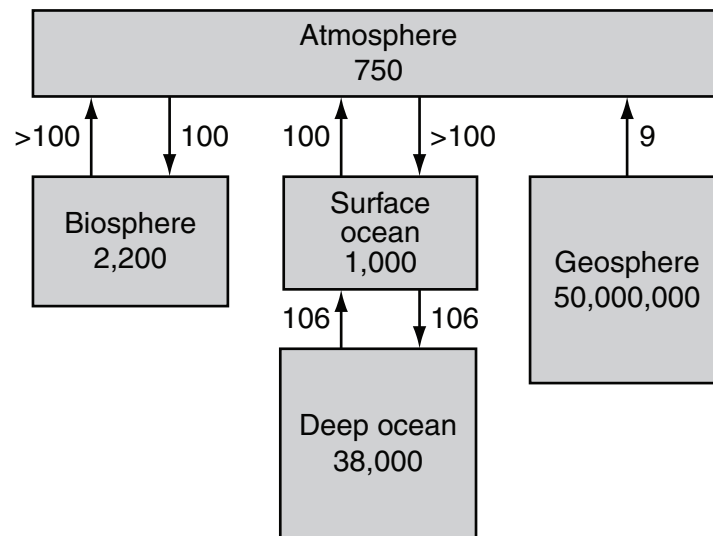
Read the information. Then answer the questions that follow.

Carbon in the Oceans

Students have learned that humans add large amounts of carbon to the atmosphere when carbon dioxide (CO_2) is released from burning fossil fuels. They want to learn more about how human activities affect the movement of carbon among Earth's spheres.

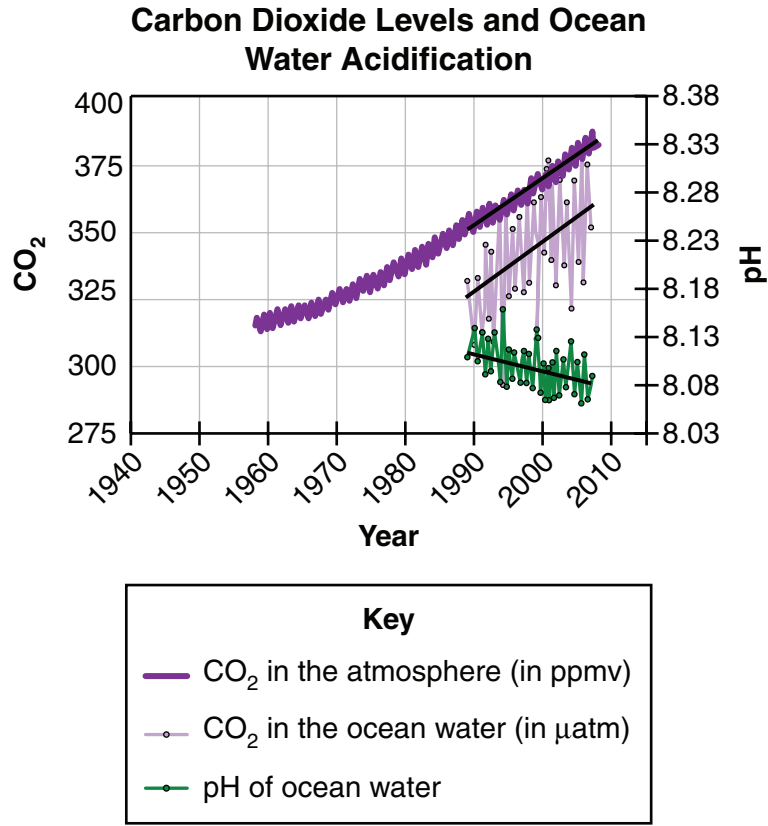
The students find a quantitative model that shows the amount of carbon stored in Earth's spheres and the amount that moves into and out of the atmosphere from the other spheres. The amounts shown are in 10^{12} kilograms per year.

Global Movement of Carbon Model

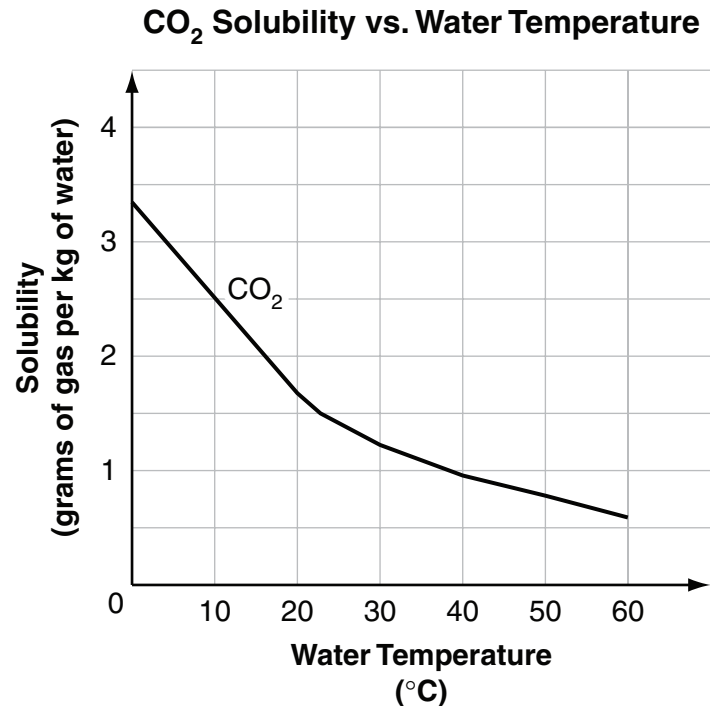


When the students research the effects of increasing carbon levels in the atmosphere, they learn that the carbon dioxide that oceans remove from the atmosphere increases the amount of carbon dioxide dissolved in ocean water and causes the ocean water to become more acidic. The amount of ocean acidification is measured by pH: As ocean water becomes more acidic, pH decreases. Ocean water that is more acidic causes damage to ocean organisms and the ecosystems they live in.

As the students continue to research ocean acidification, they find a graph that shows how carbon dioxide in Earth’s atmosphere and oceans and the pH of ocean water changed between 1960 and 2010.



The students also learn that the amount of carbon dioxide that can dissolve in ocean water depends on the temperature of the ocean water. The graph shows how the solubility of carbon dioxide depends on water temperature.



5. As the students study the model, they realize that the carbon released by burning fossil fuels moves only a small amount of carbon into the atmosphere every year.

Which statement **best** describes how burning fossil fuels is a problem for Earth's spheres and is supported by the model?

- A Burning fossil fuels adds less carbon to the atmosphere than the oceans.
- B Burning fossil fuels moves carbon from the biosphere into the atmosphere.
- C Millions of years ago, the carbon in fossil fuels was part of plants in the biosphere.
- D Carbon released from burning fossil fuels is not quickly recycled back to Earth's other spheres.

6. Which claim is supported by the model and graphs?
- A By 2100, Earth's oceans will be more acidic because of increasing levels of carbon in Earth's atmosphere.
 - B By 2100, Earth's oceans will be more acidic because of decreasing levels of carbon in Earth's atmosphere.
 - C By 2100, Earth's oceans will be less acidic because of increasing levels of carbon in Earth's atmosphere.
 - D By 2100, Earth's oceans will be less acidic because of decreasing levels of carbon in Earth's atmosphere.

This question has two parts. Be sure to answer both parts of the question.

7. As human populations and carbon emissions continue to increase, ocean ecosystems will continue to be damaged.

Part a

Based on the CO₂ Solubility vs. Water Temperature graph, which part of Earth's oceans is **most likely** to contain ecosystems that have been damaged by ocean acidification?

- A cold water ecosystems near the poles
- B warm water ecosystems near the poles
- C cold water ecosystems near the equator
- D warm water ecosystems near the equator

Part b

Which statement describes how evidence from the graph supports the claim in Part (a)?

- A Half as much carbon dioxide dissolves in water at 50°C as dissolves in water at 30°C.
- B Half as much carbon dioxide dissolves in water at 40°C as dissolves in water at 60°C.
- C Twice as much carbon dioxide dissolves in water at 0°C as dissolves in water at 20°C.
- D Twice as much carbon dioxide dissolves in water at 40°C as dissolves in water at 10°C.

This question has two parts. Be sure to answer both parts of the question.

- 8.** The students learn that underwater forests made of plants like kelp store carbon in the same way that trees in forests on land store carbon. They are surprised to learn that organisms that live in kelp forests can increase the amount of carbon stored by the kelp. For example, scientists have determined that when sea otters live in kelp forests, the forests store up to 12 times more carbon than kelp forests without sea otters.

Part a

Which statement describes how sea otters can increase the amount of carbon stored by the biosphere?

- A** Sea otters eat organisms that eat kelp, which allows the kelp forest to grow larger.
- B** Sea otters only live in kelp forests that are small enough to have low levels of carbon.
- C** Sea otters only live in kelp forests that release large amounts of carbon into the water.
- D** Sea otters are less likely to eat organisms that live in kelp forests with large amounts of dissolved carbon.

Part b

Which statement describes the effect of sea otters on carbon in the hydrosphere?

- A** The sea otter population directly causes the amount of carbon in ocean water to increase.
- B** The sea otter population directly causes the amount of carbon in ocean water to decrease.
- C** The sea otter population indirectly causes the amount of carbon in ocean water to increase.
- D** The sea otter population indirectly causes the amount of carbon in ocean water to decrease.

Read the information. Then answer the questions that follow.

Land Use and Erosion

A student lives in a forested area. A logging company wants to harvest trees from land near her home by clearcutting the area. When a forested area is clearcut, all the trees in the area are cut down. The clearcut area is often replanted with one of the following:

- tree plantations to harvest wood
- tree crops like nuts and fruits
- rotating food crops like grains and vegetables

The land that is being considered for clearcutting and replanting has steep hills and is very close to a stream. The student wonders how this change in land use could affect the environment.

She finds a study that assesses how much soil disturbance is caused by five different logging methods. Each logging method uses one of two cut patterns: harvesting trees selectively by cutting down only the large trees in an area, or clearcutting. The logging methods studied vary in the amount of trees and ground cover removed, the number of roads built, and the way logs are stored. These differences result in different amounts of bare soil after the logging.

The table shows the percentage of bare soil that results from each logging method.

SESSION
1

Soil Disturbance from Logging

Logging Method	Cut Pattern	From Tree Removal	From Road Building	From Log Storage
1	Selective cut	15.0	25–30	none
2	Clearcut	14.1	6.2	3.6
3	Selective cut	15.5	2.7	5.7
4	Clearcut	12.1	2.0	none
5	Clearcut	6.0	1.2	none

Next, the student finds a study that investigates the amount of soil erosion that results from different types of land use. The table shows the amount of erosion in tons per hectare per year.

Soil Erosion and Land Use

Type of Land Use	Erosion (tons/ha/yr)
Natural forest, undisturbed soil	6.16
Tree plantation, undisturbed soil	6.20
Tree plantation, bare soil	104.80
Tree crops, ground cover	5.60
Tree crops, bare soil	182.90
Rotating food crops, ground cover	7.40
Rotating food crops, bare soil	70.05

SESSION

1

9. Which description of the effect of land use on erosion is supported by the Soil Erosion and Land Use table?
- A Planting tree crops with ground cover after logging a natural forest could decrease the amount of erosion.
 - B Planting rotating food crops with ground cover after logging a natural forest could decrease the amount of erosion.
 - C Planting tree plantations without ground cover after logging a natural forest could decrease the amount of erosion.
 - D Planting rotating food crops without ground cover after logging a natural forest could decrease the amount of erosion.

This question has two parts. Be sure to answer both parts of the question.

10. Part a

Which claim is supported by the Soil Disturbance from Logging table?

- A** Road building during clearcutting results in less soil disturbance than during selective cutting.
- B** Tree removal during selective cutting results in more soil disturbance than during clearcutting.
- C** Clearcutting results in more soil disturbance than selective cutting because more logs are stored.
- D** Selective cutting results in less soil disturbance than clearcutting because fewer trees are cut down.

Part b

Which set of statements describes a feedback loop between the biosphere and the geosphere caused by logging?

- A**
 - When trees are planted on bare soil, a positive feedback loop occurs.
 - Planting the trees increases the amount of ground cover.
 - This causes the amount of erosion to decrease.
 - This change causes increased ground cover.
- B**
 - When trees are planted on bare soil, a positive feedback loop occurs.
 - Planting the trees decreases the amount of ground cover.
 - This causes the amount of erosion to increase.
 - This change causes decreased ground cover.
- C**
 - When trees are planted on bare soil, a negative feedback loop occurs.
 - Planting the trees increases the amount of ground cover.
 - This causes the amount of erosion to decrease.
 - This change causes increased ground cover.
- D**
 - When trees are planted on bare soil, a negative feedback loop occurs.
 - Planting the trees decreases the amount of ground cover.
 - This causes the amount of erosion to increase.
 - This change causes decreased ground cover.

- 11.** A logging company is choosing a logging method to selectively cut an area of forest. The company wants to use a method that will reduce human impact and stabilize the amount of erosion in the area. Based on the Soil Disturbance from Logging table, which method should the logging company use?
- A** Method 3, because removing fewer trees will result in a smaller increase in erosion than method 1.
 - B** Method 3, because clearing less land for roads will result in a smaller increase in erosion than method 1.
 - C** Method 1, because not using land to store logs will result in a smaller increase in erosion than method 3.
 - D** Method 1, because leaving less soil bare after logging will result in a smaller increase in erosion than method 3.



This question has two parts. Be sure to answer both parts of the question.

- 12.** The logging company decides to clearcut the forest near the student's home.

Part a

Based on information in the tables, which logging method and land use is **most likely** to reduce the human impact on the ecosystem near the student's home?

- A** Clearcut with Method 2 and then plant tree crops with ground cover.
- B** Clearcut with Method 4 and then plant tree crops with ground cover.
- C** Clearcut with Method 2 and then plant rotating food crops with ground cover.
- D** Clearcut with Method 4 and then plant rotating food crops with ground cover.

Part b

Which statement describes a reason for the answer to Part (a)?

- A** This logging method and land use will result in less bare soil and less erosion.
- B** This logging method and land use will result in more bare soil but less erosion.
- C** This logging method and land use will result in the smallest increase in bare soil and erosion.
- D** This logging method and land use will result in the largest decrease in bare soil and erosion.



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Science Session 2

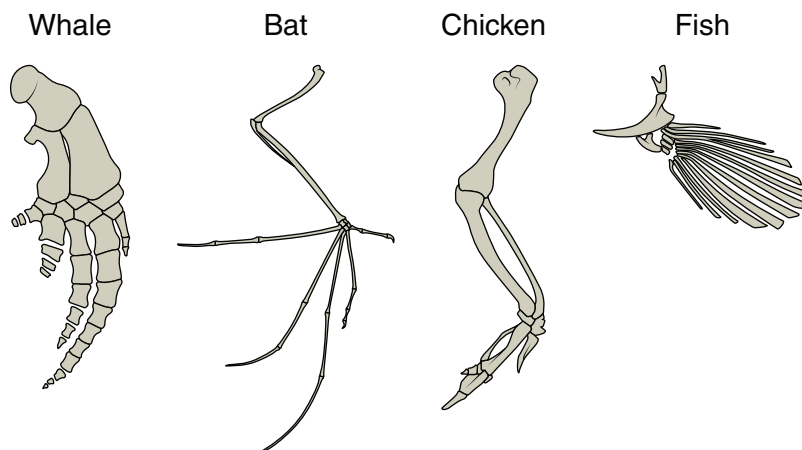
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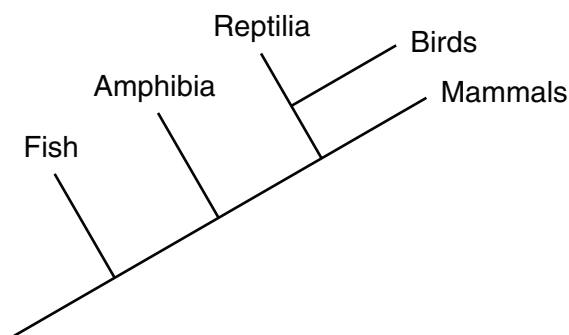
- 13.** A student is studying how the bone structure of animals has changed over time. The student finds a diagram that shows bones in the forelimbs of four vertebrates. Whales and bats are mammals. Chickens are birds.

Forelimbs of Four Vertebrates



The student also finds a cladogram showing the evolutionary relationships among vertebrates.

Vertebrates Cladogram



Part a

Based on evidence in the diagram and the cladogram, which two animals have the **most** similar DNA sequences?

- A** whale and bat
- B** fish and whale
- C** bat and chicken
- D** chicken and fish

Part b

Which statement explains why the animals have the most similar DNA sequences?

- A** The two animals have similar bone structures.
- B** The two animals adapted to the same environment.
- C** The two animals have the most recent common ancestor.
- D** The two animals have forelimbs adapted for the same function.

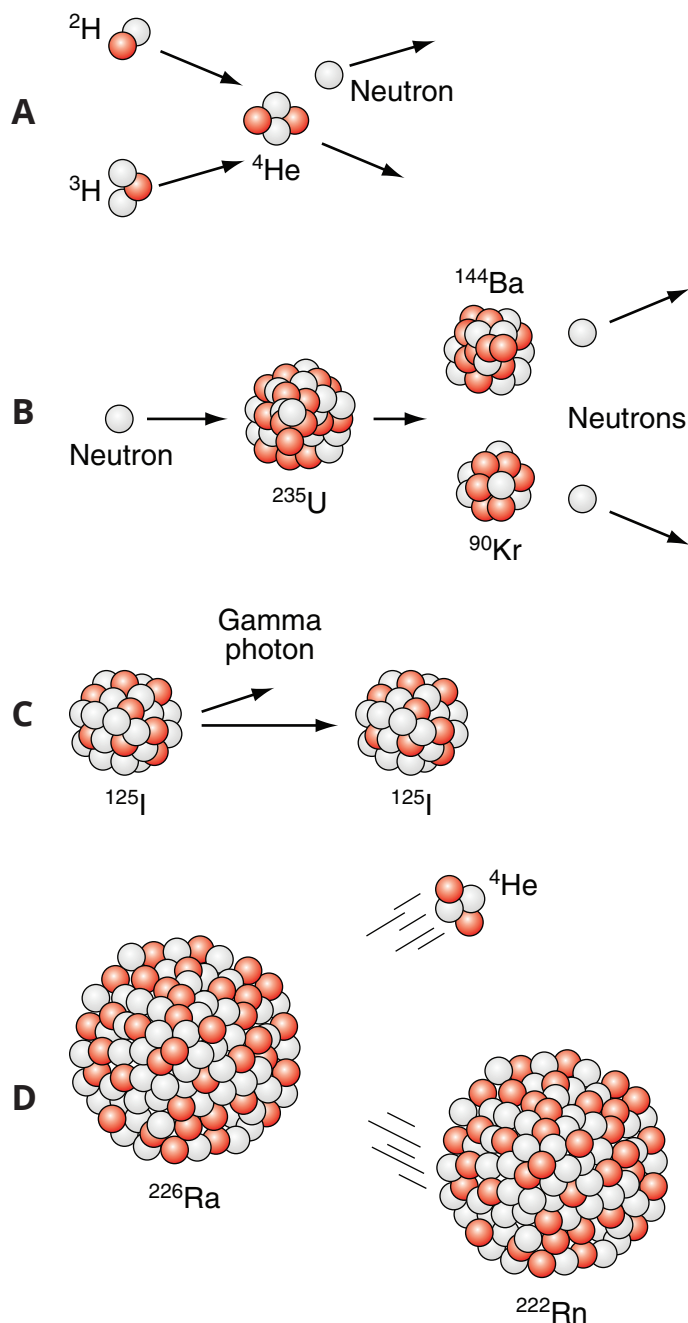
This question has two parts. Be sure to answer both parts of the question.

14. A student who is interested in nuclear fusion finds an article on the first successful detonation of a nuclear fusion bomb.

Part a

The student wants to use a model of nuclear fusion to show the process that occurs inside bombs.

Which model could the student use?



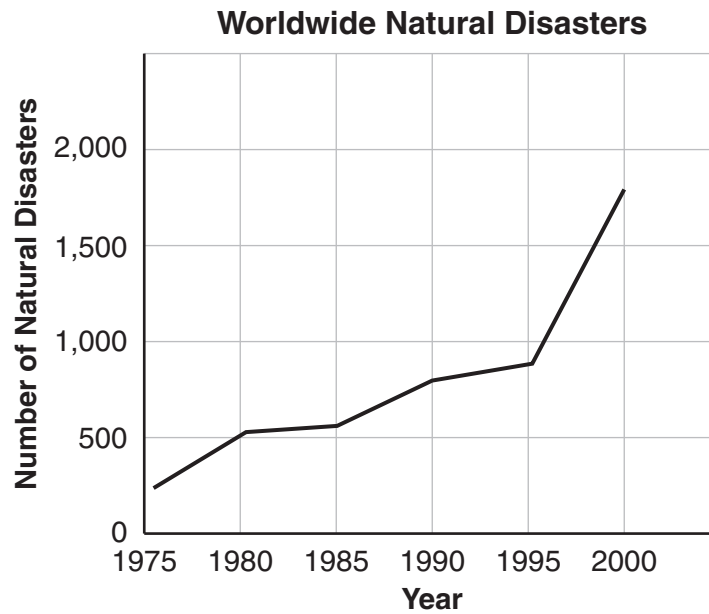
Part b

Which statement about nuclear processes is supported by the models in Part (a)?

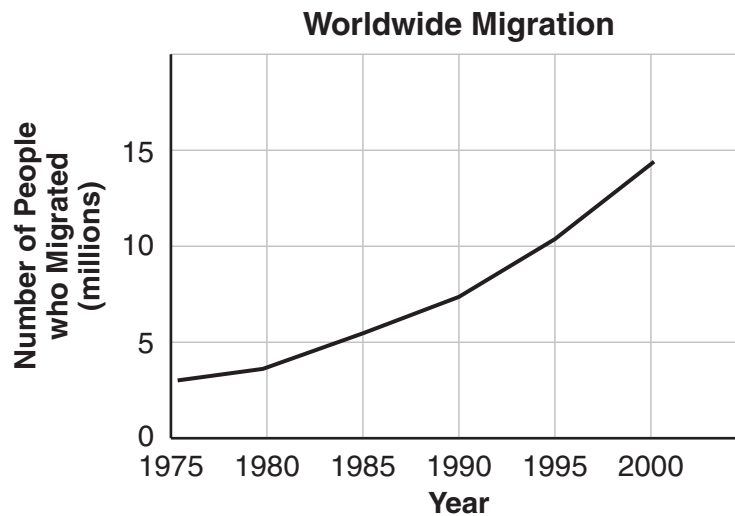
- A** During nuclear processes, the total number of atoms is conserved.
- B** During nuclear processes, the total number of protons is conserved.
- C** During nuclear processes, the total number of neutrons is conserved.
- D** During nuclear processes, the total number of neutrons and protons is conserved.

This question has two parts. Be sure to answer both parts of the question.

15. A student is studying the effects of climate change and natural disasters on human populations. The student finds a graph that shows the number of natural disasters between 1975 and 2000.



The student finds another graph that shows the number of people who migrated from low-income countries during the same time period.



Part a

Which statement explains the trends shown in the graphs?

- A** The largest number of natural disasters occurred between 1980–1985, which corresponded to a slight decrease in the rate of migration.
- B** The largest number of natural disasters occurred between 1985–1990, which corresponded to a slight increase in the rate of migration.
- C** The largest number of natural disasters occurred between 1990–1995, which corresponded to a sharp decrease in the rate of migration.
- D** The largest number of natural disasters occurred between 1995–2000, which corresponded to a sharp increase in the rate of migration.

Part b

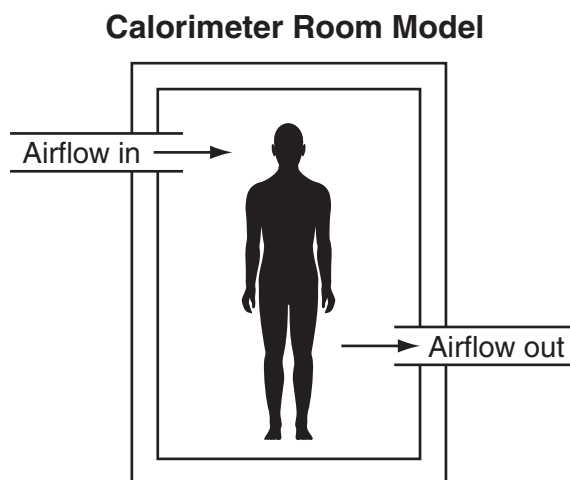
Which claim about natural disasters is supported by the graphs?

- A** The number of natural disasters will decrease in the future.
- B** Natural disasters are the most important cause of migration.
- C** Natural disasters increase the difficulty of finding the resources needed to survive.
- D** The number of people who migrate will stop increasing as people become settled in their new country.

This question has three parts. Be sure to answer all three parts of the question.

- 16.** Students learn that scientists have been investigating the source of energy that powers the human body for many years. They learn that scientists use special rooms called “calorimeter rooms” to measure the inputs and outputs of the human body in order to understand how cellular respiration produces energy used by the body.

Air is a mixture of gases. The model shows how air flows into and out of a calorimeter room.



- a. Use the model to describe two differences between the air flowing into the room and the air flowing out of the room. Explain the reason for both differences.
- b. Identify one input and one output of cellular respiration that are not described in part (a) and describe how to add both to the model.
- c. Explain how cellular respiration releases stored energy that powers the human body.

Read the information. Then answer the questions that follow.

Mixing Liquids

On a hot summer day, a student makes lemonade by mixing lemon juice, sugar, and water. The student has no ice to chill his lemonade, so he mixes in cold lemon juice from the refrigerator with room temperature water and sugar. When he finishes mixing, the lemonade mixture is warmer than he expects. He adds even more cold lemon juice to make the mixture cooler, but this makes the lemonade much too sour to drink. The student decides to investigate how mixing different amounts of warm and cold liquids affects the final temperature of the mixture.

He learns that the amount of thermal energy transferred to or from a substance depends on the variables and relationships shown in the table.

Energy Transfer Equation

$Q = mc\Delta T$	Q = thermal energy transferred (in Joules)
	m = mass of substance (in grams)
	c = specific heat of substance (in $J/g^{\circ}C$)
	ΔT = change in temperature of substance (in $^{\circ}C$)

The student also learns that the specific heat of a substance is the amount of energy required to change the temperature of 1 gram (g) of the substance by $1^{\circ}C$. For example, water has a specific heat of $4.184 J/g^{\circ}C$, which means that the temperature of 1 g of water will change $1^{\circ}C$ when 4.184 Joules (J) of energy are added to or removed from the water.

During his investigation, the student mixes several different masses and temperatures of water inside a closed system. His data are shown in the table.

Investigation Data

Mixture	Mass of Cold Water (g)	Temperature of Cold Water ($^{\circ}C$)	Mass of Hot Water (g)	Temperature of Hot Water ($^{\circ}C$)	Final Temperature of Mixture ($^{\circ}C$)
1	20.0	20.0	80.0	50.0	43.0
2	40.0	18.0	60.0	52.0	37.0
3	75.0	22.0	25.0	60.0	31.0

- 17.** Which statement explains why the student's investigation produced low-quality data?
- A** The student used only three mixtures.
 - B** The student used only water in the mixtures.
 - C** The student changed many variables at the same time.
 - D** The student did not use mixtures with a wide range of water temperatures.

- 18.** People who are outside on a hot day often cool off by going for a swim in a pool that is outside.

Which statement explains why a person could cool off in the pool?

- A** The water temperature is cooler than the air temperature because water has a lower specific heat than air. This means that when a person goes into the water, thermal energy flows into the person's body.
- B** The water temperature is cooler than the air temperature because water has a lower specific heat than air. This means that when a person goes into the water, thermal energy flows out of the person's body.
- C** The water temperature is cooler than the air temperature because water has a higher specific heat than air. This means that when a person goes into the water, thermal energy flows into the person's body.
- D** The water temperature is cooler than the air temperature because water has a higher specific heat than air. This means that when a person goes into the water, thermal energy flows out of the person's body.

This question has two parts. Be sure to answer both parts of the question.

19. The student decides to repeat the investigation and collect new data.

Part a

Which change to the procedure will improve the quality of the data the student collects?

- A** Change only the mass of cold water in all the mixtures.
- B** Change both liquids to have the same mass and temperature in all the mixtures.
- C** Change the mass of cold water to be larger than the mass of hot water in all the mixtures.
- D** Change the temperature of cold water to be lower than the temperature of hot water in all the mixtures.

Part b

In addition to the change in Part (a), which variable should the student control during the investigation?

- A** the size of the container
- B** the final temperature of the mixture
- C** the mass of water in the final mixture
- D** the time to reach the final temperature

This question has two parts. Be sure to answer both parts of the question.

- 20.** The student uses the equation and his data to calculate the amount of thermal energy transferred during his investigation.

Part a

How much thermal energy is transferred into the cold water in mixture 1?

- A** 860 J
- B** 1,674 J
- C** 1,925 J
- D** 3,598 J

Part b

Which statement describes how the student could calculate how much thermal energy is transferred away from the liquids during his investigation?

- A** (thermal energy from cold liquid – thermal energy into hot liquid)
- B** (thermal energy from hot liquid – thermal energy into cold liquid)
- C** (thermal energy into cold liquid – thermal energy from hot liquid)
- D** (thermal energy into hot liquid – thermal energy from cold liquid)

Read the information. Then answer the questions that follow.

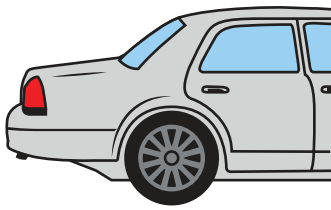
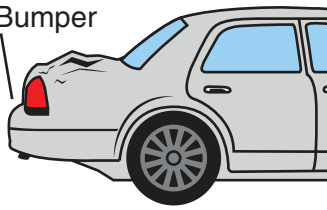
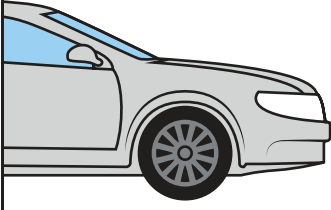
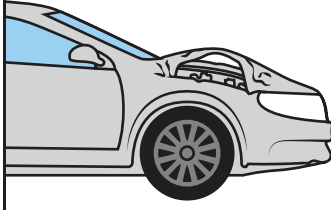
Crumple Zones

While driving to school, a student passes a car that backed out of a parking space and into a wall. The student observes that even though the car was moving slowly, the rear bumper of the car was damaged. She wonders why the bumper was damaged by a low-speed collision. She decides to investigate.

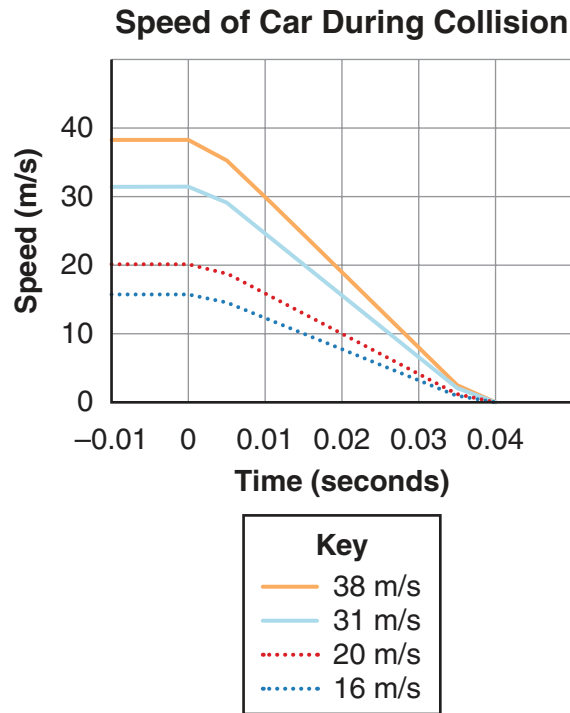
The student is surprised to learn that cars are designed to be damaged during collisions. When cars were first built, they were designed to be undamaged by collisions. However, people soon realized that when cars were not damaged during collisions, the people inside them were. So cars were redesigned to increase damage to the car in order to decrease damage to the people inside the car.

To understand this, the student learns that cars are designed with crumple zones at the front and rear ends of the car that reduce the force on a car during a collision. The diagram shows how a collision can affect the crumple zones at the ends of a car.

Crumple Zones

Part of Car	Before Collision	After Collision
Rear		
Front		

The student starts to think about how Newton's laws of motion affect the forces on a car during a collision. She finds data from a scientific study in which researchers measured the speed of a car during a collision that stopped the car. The researchers used cars with four different initial speeds in their study. The graph shows the initial speed of each car and how the speed of the car changed during the collision with the wall.



This question has two parts. Be sure to answer both parts of the question.

21. Part a

What caused the damage that the student observed on the rear bumper of the car that backed into the wall?

- A** The bumper had momentum before the collision but not after the collision.
- B** The wall changed the momentum of the car by exerting a force on the car.
- C** The bumper exerted a force on the wall before the rest of the car hit the wall.
- D** The wall exerted more force on the bumper than the bumper exerted on the wall.

Part b

How did the crumple zone on the rear bumper decrease the force on the car during the collision with the wall?

- A** The crumple zone increased the speed of the car.
- B** The crumple zone increased the car's acceleration.
- C** The crumple zone increased the momentum of the car.
- D** The crumple zone increased the time for the car to stop.

- 22.** The student wonders how the data in the graph would be different if the car had taken twice as much time to stop during the collision.

Which claim is supported by the graph?

- A** Increasing the time for the car to stop would have decreased the acceleration of the car and decreased the force on the car.
- B** Increasing the time for the car to stop would have decreased the acceleration of the car and increased the force on the car.
- C** Increasing the time for the car to stop would have increased the acceleration of the car and increased the force on the car.
- D** Increasing the time for the car to stop would have increased the acceleration of the car and decreased the force on the car.

This question has two parts. Be sure to answer both parts of the question.

- 23.** The student studies the graph that shows how the speed of a car changes during a collision.

Part a

Which claim is supported by the data in the graph?

- A** More force is needed to stop a car that has less mass.
- B** More force is needed to stop a car that has more mass.
- C** More force is needed to stop a car that has less speed.
- D** More force is needed to stop a car that has more speed.

Part b

Which evidence in the graph supports the claim in Part (a)?

- A** Cars that were moving faster before the collision accelerated more during the collision.
- B** Cars that were moving slower before the collision stopped more quickly during the collision.
- C** Cars that changed speed less during the collision had more acceleration during the collision.
- D** Cars that changed speed more during the collision took more time to stop during the collision.

- 24.** Engineers design cars with crumple zones to protect people inside cars. They have also added seat belts and air bags to protect people.

Which statement describes how seat belts and air bags protect people during collisions?

- A** Seat belts and air bags decrease the force on people during a collision by increasing the time for the people to stop.
- B** Seat belts and air bags decrease the force on people during a collision by decreasing the time for the people to stop.
- C** Seat belts and air bags increase the force on people during a collision by decreasing the time for the people to stop.
- D** Seat belts and air bags increase the force on people during a collision by increasing the time for the people to stop.

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Science Session 3

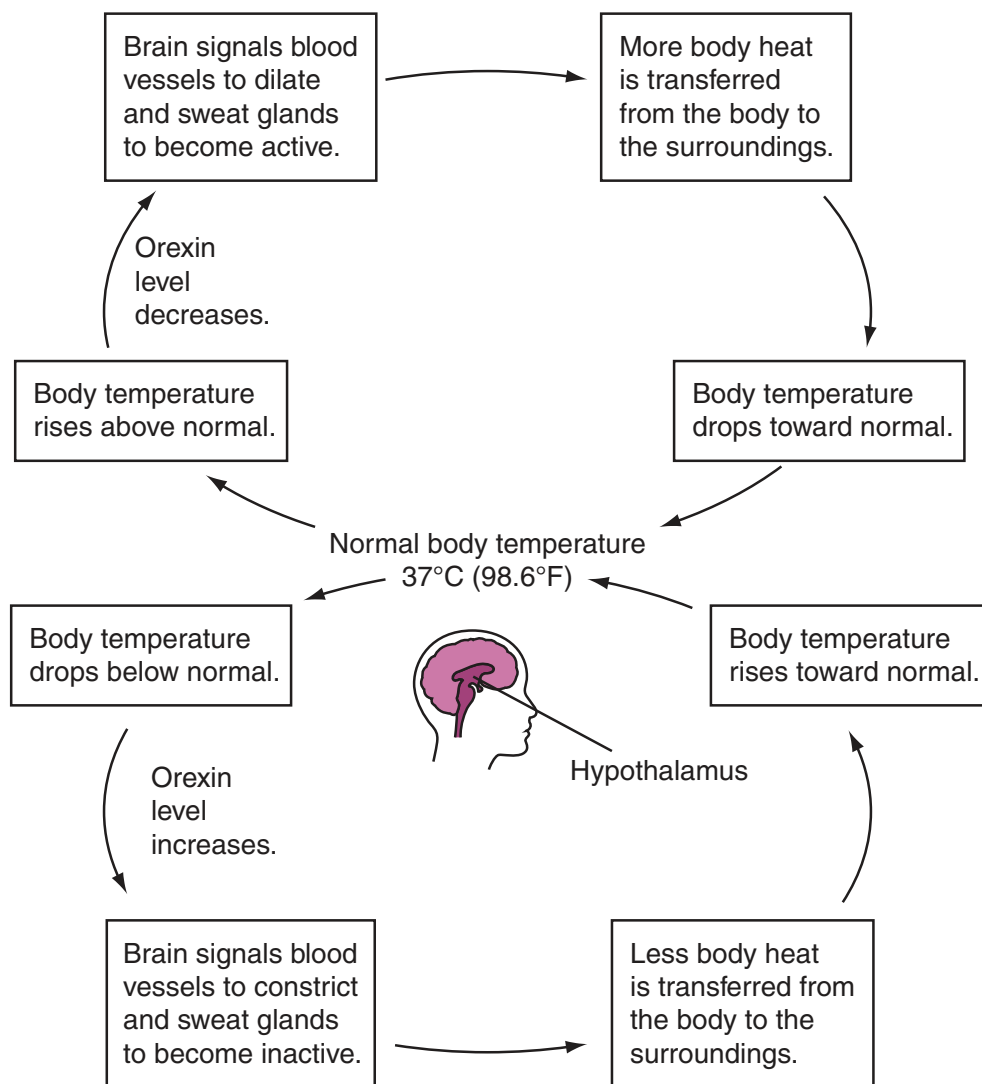
DIRECTIONS

Read each question carefully. For each multiple-choice question, decide which is the best answer and be sure to mark your answer in your answer document. For each open-ended item, be sure to write your answer in the lined box provided in your answer document. Only answers and work written inside the answer boxes will be scored.

This question has two parts. Be sure to answer both parts of the question.

25. A research group is studying the effects of orexin, a neurotransmitter that is produced in the hypothalamus. Because orexin is known to regulate many processes, the group wants to investigate whether orexin helps maintain body temperature in the way shown in the diagram.

Maintaining Body Temperature



SESSION
3

Part a

Which procedure could provide evidence that orexin has the effects shown in the diagram?

- A** comparing body temperatures of active individuals who produce normal and low levels of orexin
- B** comparing body temperatures of resting individuals who produce normal and low levels of orexin
- C** comparing body temperatures of active individuals and resting individuals who produce low levels of orexin
- D** comparing body temperatures of active individuals and resting individuals who produce normal levels of orexin

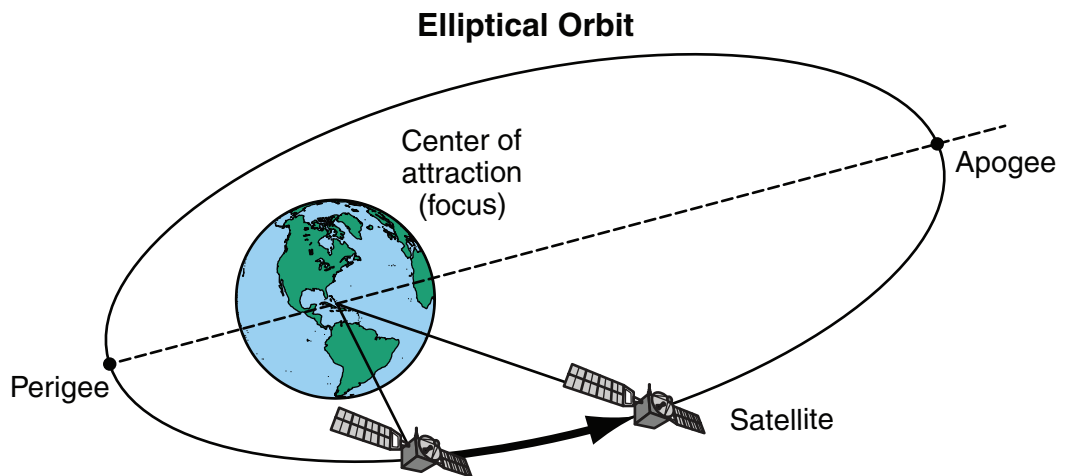
Part b

Which type of feedback is shown in both loops in the diagram?

- A** The loops show positive feedback because changes in orexin levels are beneficial to body temperature.
- B** The loops show positive feedback because orexin level increases when body temperature increases.
- C** The loops show negative feedback because changes in orexin levels result in normal body temperature.
- D** The loops show negative feedback because orexin level decreases when body temperature decreases.

This question has two parts. Be sure to answer both parts of the question.

26. Astronomers want to send a satellite into the elliptical orbit around Earth that is shown in the diagram.



Part a

Which statement describes the speed of the satellite in the orbit shown in the diagram?

- A** The speed of the satellite is smallest at perigee and largest at apogee.
- B** The speed of the satellite is smallest between perigee and apogee.
- C** The speed of the satellite is largest at perigee and smallest at apogee.
- D** The speed of the satellite is largest directly before perigee and apogee.

Part b

Which statement explains why the satellite's speed changes during the orbit?

- A** The satellite moves fastest where the force of Earth's gravity is largest, and the satellite has the largest acceleration when the satellite is at perigee.
- B** The satellite moves fastest where the force of Earth's gravity is largest, and the satellite has the largest acceleration when the satellite is at apogee.
- C** The satellite moves fastest where the force of Earth's gravity is smallest, and the satellite has the largest acceleration when the satellite is at perigee.
- D** The satellite moves fastest where the force of Earth's gravity is smallest, and the satellite has the largest acceleration when the satellite is at apogee.

This question has two parts. Be sure to answer both parts of the question.

- 27.** While watching an old movie, a student sees an actor putting his ear on the steel rail of a railroad track to listen for the train coming down the tracks. She is surprised that the actor with his ear to the rail hears the sound of the wheels before the other actors standing next to him hear the sound of the wheels.

The student investigates and finds that the speed of sound waves in a medium depends on the arrangement of particles in the medium. She finds that the speed of sound waves in steel is almost 17 times the speed of sound waves in air.

Part a

Which statement describes the sound waves made by the train wheels?

- A** The wavelength of sound waves in steel is the same as the wavelength of sound waves in air, and the frequency of sound waves in steel is 17 times longer than the frequency of sound waves in air.
- B** The wavelength of sound waves in steel is the same as the wavelength of sound waves in air, and the frequency of sound waves in steel is 17 times shorter than the frequency of sound waves in air.
- C** The wavelength of sound waves in steel is 17 times shorter than the wavelength of sound waves in air, and the frequency of sound waves in steel is the same as the frequency of sound waves in air.
- D** The wavelength of sound waves in steel is 17 times longer than the wavelength of sound waves in air, and the frequency of sound waves in steel is the same as the frequency of sound waves in air.

Part b

Which relationship explains the answer to Part (a)?

- A** The speed of a wave is wavelength divided by frequency.
- B** The speed of a wave is the sum of wavelength plus frequency.
- C** The speed of a wave is the product of wavelength times frequency.
- D** The speed of a wave is the difference of frequency minus wavelength.

This question has two parts. Be sure to answer both parts of the question.

- 28.** A student reads about a scientist who is investigating how an environmental change affects a population of guppies, a species of small fish. In the investigation, the scientist moves guppies from a stream ecosystem that includes predators to a stream ecosystem without predators.

After a year, the scientist collects guppies from both streams and compares their DNA. She finds differences in 135 genes related to metabolism, immune function, and development.

Part a

The student claims that guppies were chosen for the investigation because they reproduce rapidly.

Which statement describes the student's claim?

- A** The claim is valid because genetic changes occur more quickly in individuals than in populations.
- B** The claim is valid because genetic changes in a population can appear after several generations.
- C** The claim is not valid because genetic changes require millions of years to spread throughout a population.
- D** The claim is not valid because genetic changes in a population are caused by environmental changes, not by reproduction.

Part b

A student claims that the guppies living in the stream without predators have become a new species.

Which piece of evidence would support the student's claim?

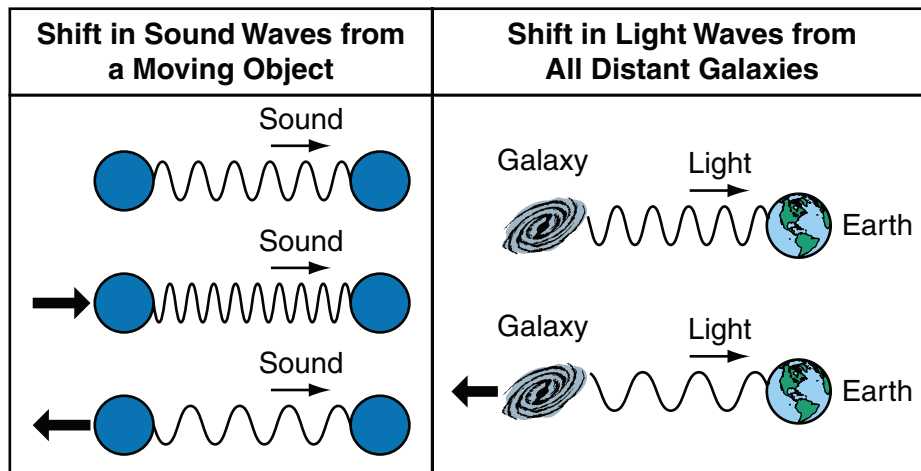
- A** Guppies in the two streams are genetically different from each other.
- B** Guppies in the two streams cannot produce offspring with each other.
- C** Guppies in one stream have reproduced more rapidly than guppies in the other stream.
- D** Guppies in one stream are eaten by predators more often than guppies in the other stream.

This question has two parts. Be sure to answer both parts of the question.

- 29.** A student learns about the big bang theory, which describes the early universe as very hot and very small. He also learns that scientists who study light coming to Earth from distant galaxies observe that the wavelengths of light are shifted because of the movement of the galaxies.

The diagram shows observed shifts in the wavelengths of sound waves and light waves. The arrows in the diagram show the direction of motion.

Shift in Waves



- a. Use evidence from the diagram to describe one way the universe is changing. Be sure to explain how the evidence supports the change.

Scientists also observe cosmic microwave background radiation. This radiation shows that the average temperature of the universe today is very cold.

- b. Describe how this radiation is another piece of evidence that supports the change in the universe described in part (a).

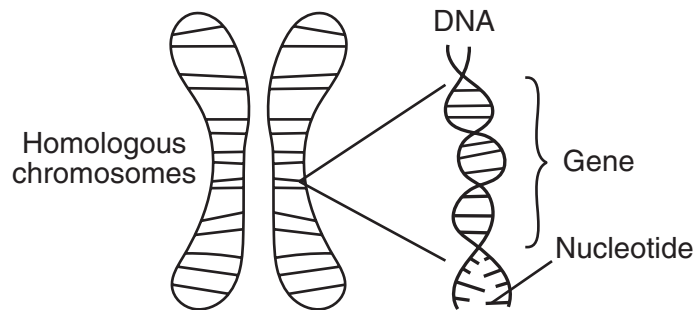
Read the information. Then answer the questions that follow.

Cytochrome C

For millions of years, many living organisms have used oxygen during cellular respiration. Some students learn that all these organisms produce a protein called cytochrome c that is used during aerobic cellular respiration. The students wonder how much the cytochrome c protein has changed during those millions of years.

To understand how generations of organisms can produce the same protein, one student draws a model that shows relationships among chromosomes, DNA, and genes.

Chromosomes, DNA, and Genes Model



As a result of research, the students learn that the cytochrome c protein in all organisms contains 104 amino acids. They also learn that scientists have compared the sequence of the 104 amino acids in the cytochrome c protein of different species. The number of differences between organisms in five species is shown in the table.

Number of Amino Acid Differences

	Horse	Donkey	Moth	Yeast	Wheat
Horse	—	1	29	45	46
Donkey		—	28	46	45
Moth			—	48	45
Yeast				—	47
Wheat					—

- 30.** One of the students claims that the amino acid differences in the table are evidence that differences in inherited traits are the result of differences in inherited DNA.

Which evidence would support the student's claim?

- A** Species with more amino acid differences have more genes on each DNA molecule.
 - B** Species with more amino acid differences have different numbers of DNA molecules.
 - C** Species with fewer amino acid differences have DNA molecules with fewer differences.
 - D** Species with fewer amino acid differences have DNA molecules that are almost the same length.
- 31.** Yeast is the only species in the table that can reproduce asexually. One student claims that there is no genetic variation when yeast reproduces asexually. Another student claims that asexual reproduction can result in genetic variation.

Which statement describes how genetic variation can occur during asexual reproduction?

- A** One daughter cell can receive a mutation.
- B** Chromosomes can cross over during meiosis.
- C** Only some of the genes can be passed to the offspring.
- D** An error can be made when a DNA molecule is replicated.

This question has two parts. Be sure to answer both parts of the question.

32. Part a

Which claim is supported by information in the table?

- A** Over time, different mutations occurred in different species.
- B** Over time, different species developed genes with different functions.
- C** Over time, different species evolved different numbers of amino acids.
- D** Over time, different amino acids caused species to produce different proteins.

Part b

How does information in the table support the claim in Part (a)?

- A** None of the species have the same amino acid sequences.
- B** All of the species produce the amino acids in cytochrome c.
- C** Horses and donkeys have the fewest number of amino acid differences.
- D** Donkeys and moths have the same number of amino acid differences with wheat.

This question has two parts. Be sure to answer both parts of the question.

- 33.** The students want to use the diagram to understand how organisms produce cytochrome c.

Part a

Which question should the students ask?

- A** Are organisms always producing proteins?
- B** Do different organisms produce different proteins?
- C** How do organisms use energy to produce proteins?
- D** What information do organisms use to produce proteins?

Part b

Which statement describes the relationship between DNA and cytochrome c?

- A** The order of genes in a DNA molecule determines the structure of the protein.
- B** The order of nucleotides in a DNA molecule determines the structure of the protein.
- C** The number of genes in a DNA molecule determines which proteins will be produced.
- D** The number of nucleotides in a DNA molecule determines which proteins will be produced.

Read the information. Then answer the questions that follow.

Trouble in the Water

Students in a small city observe that many fish in the city's river are dying. The students do some research and learn that groundwater can become contaminated when human activities release chemicals and waste products into the environment. Contaminated groundwater can flow into rivers and harm living organisms that use the contaminated water.

Concerned about losing biodiversity in their river, the students alert state wildlife biologists. The wildlife biologists do a survey to determine the river's current biodiversity in order to compare that to historical biodiversity. The table shows nine species that had historically been found at six locations along the river. An "X" indicates that the biologists found the species at that location during their survey.

Aquatic Species Present along the River

Species	Location					
	1	2	3	4	5	6
Bluegill	X	X	X			
Common Carp	X	X	X	X	X	X
Flathead Catfish	X	X	X		X	X
Freshwater Drum	X		X			X
Golden Orb Mussel	X					
Longnose Gar	X	X	X		X	X
Pugnaw Minnow	X	X	X		X	
Rainbow Trout	X	X	X		X	
Smallmouth Bass	X					

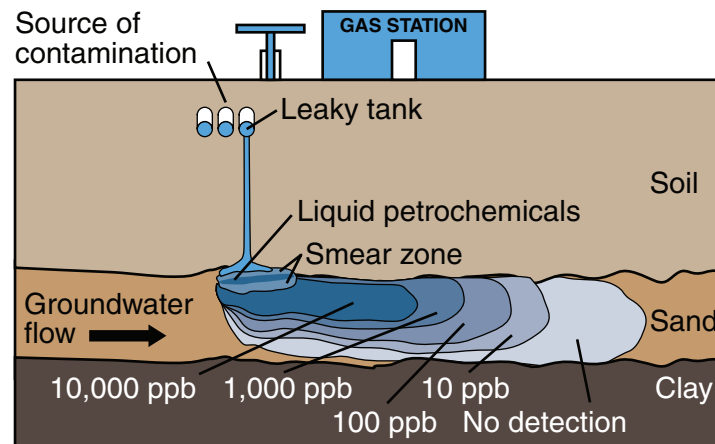
Officials in the students' city hire environmental engineers who find an underground gasoline tank at an abandoned gas station near the river. The engineers know that gasoline contains petrochemicals that can harm living organisms. The table shows the health effects of different levels of petrochemicals. The levels are given in parts per billion (ppb).

Contamination Guide

Level (ppb)	Health Impact of Petrochemicals
0–99	No known effects on health
100–2,000	Small effects on health
2,000–4,000	If short term, effects on health are negligible; If long term, can cause death
4,000 or greater	Deadly to living organisms

The engineers determine that the gas tank is leaking and liquid from the tank has reached the shores of the river. They estimate that 3,000 cubic meters of soil is contaminated. The diagram shows the estimated amount of petrochemical contamination in parts per billion (ppb) near the leaky tank.

Contamination Plume



City officials want a solution that will:

- clean the soil around the gas tank as quickly as possible
- not harm organisms that live in and around the river
- cost less than \$200,000

The officials research possible solutions. Information about three possible solutions is shown in the table.

Contamination Solutions

Information	Electrocoagulation (EC)	Bioremediation	Emulsified Zero Valent Iron (EZVI)
What is done	Apply electrical charge into soil	Inject mixture of nutrients, enzymes, and microbes into soil	Inject iron particles into soil directly above groundwater
What happens	Contaminants settle out of groundwater	Contaminants broken down by microbes into non-toxic compounds	Contaminants react with iron to form non-toxic compounds
Which contaminants are treated	Heavy metal ions in groundwater	Petrochemicals in soil	Chlorinated solvents in groundwater
Effect on organisms	Can electrocute microbes in soil	Adds microbes that can spread to other locations	None
Cost per application	\$9,000	\$120,000	\$150,000
Time to remove contaminants	Hours or days	Months	Days or months

34. The city officials need to evaluate the solutions in order to choose one solution. How can city officials choose the **best** solution for their city?
- A Choose the solution that meets most of the city's criteria.
 - B Choose the solution that permanently solves the problem.
 - C Choose the solution that uses the most up-to-date technology.
 - D Choose the solution that has the largest impact on the environment.
35. A city official reviews the data about aquatic species along the river and the contamination plume. She suggests that the solution be used at the location where most of the fish are dying.
- Which statement describes a **disadvantage** of her suggestion?
- A The leaking gas tank is near the river.
 - B The number of aquatic species varies along the river.
 - C Using the solution here will increase biodiversity along the river.
 - D Most of the contamination plume is likely to be far from this location.

This question has two parts. Be sure to answer both parts of the question.

- 36.** The wildlife biologists' survey showed changes in biodiversity along the river near the leaking underground gasoline tank.

Part a

Based on the data from the survey, which sequence represents the locations in order from highest biodiversity to lowest biodiversity?

- A** 1 → 2 → 3 → 4 → 5 → 6
- B** 1 → 3 → 2 → 5 → 6 → 4
- C** 4 → 6 → 5 → 2 → 3 → 1
- D** 6 → 5 → 4 → 3 → 2 → 1

Part b

Based on the data from the survey, which location is farthest from the leaking tank?

- A** Location 1
- B** Location 2
- C** Location 3
- D** Location 4
- E** Location 5
- F** Location 6

This question has two parts. Be sure to answer both parts of the question.

- 37.** Some city officials recommended using EZVI because the process treats contaminated water.

Part a

Which **two** ways could EZVI meet the needs of the city?

- A** costs less than \$200,000
- B** removes the gasoline tank
- C** can treat soil contamination
- D** cleans up gasoline contamination
- E** can be completed in six months or less

Part b

There are disadvantages to using EZVI to clean up the water.

Which **two** statements best describe reasons to use a different solution?

- A** EC applies electrical charge to soil.
- B** Bioremediation treats petrochemicals in soil.
- C** EC uses microbes to remove petrochemicals.
- D** Bioremediation does not add chemicals to soil.
- E** EC causes contaminants to form non-toxic compounds.





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