Scientists hypothesize that vertebrates, animals with a backbone, evolved from a common fish-like ancestor. Scientists study traits of living and extinct vertebrates to understand how they are related to one another.

The table gives information about six groups of living vertebrates. Based on the information in the table, the diagram shows how new traits gave rise to different groups of vertebrates over time.

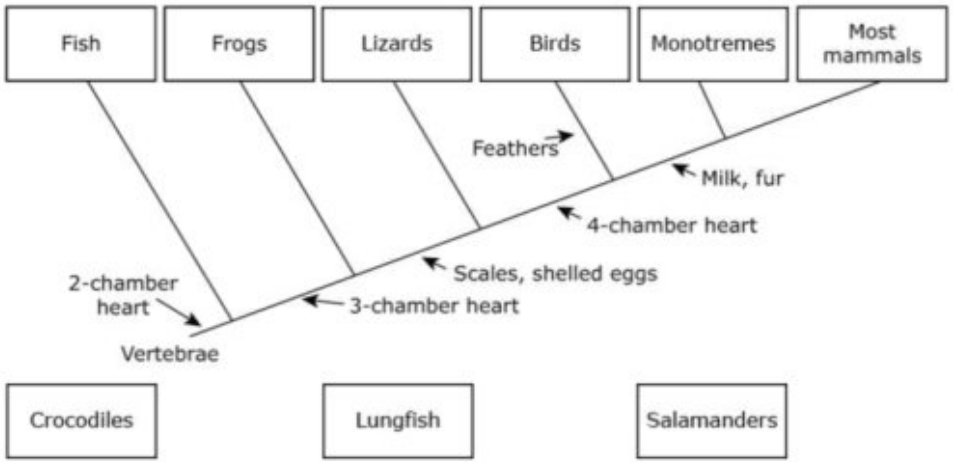
Simplified Characteristics of Groups of Vertebrates

Animal Group	Heart Chambers	Body Covering	Reproduction
crocodiles	4	scales	shelled eggs
birds	4	feathers	shelled eggs
lungfish	2	scales	soft eggs
monotremes	4	fur	produce milk
salamanders	3	skin	soft eggs
lizards	3	scales	shelled eggs

Complete the diagram using the information in the table.

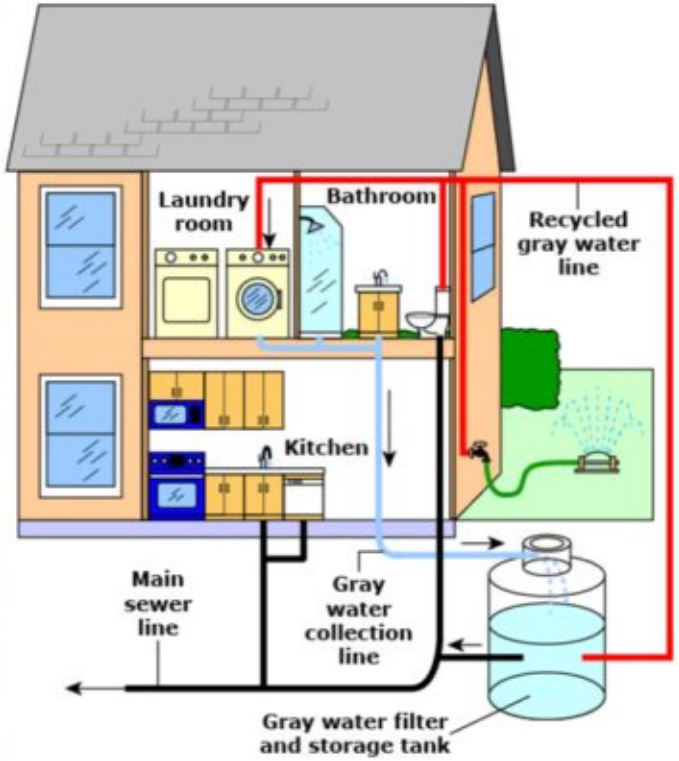
Drag the correct animal groups into the empty boxes in the diagram.

Evolution of Vertebrates



1 It is estimated that 32–38% of the water consumed in the United States is used for irrigation. Severe water shortages in many areas mean that recycling water will be necessary for continued landscape irrigation. One potential source of water is gray water—wastewater recycled from relatively clean sources such as bathtubs and clothes washers.

2 Collecting gray water does not require a specialized system. For example, bathtub water can be saved and poured on grass or hoses can be connected to a clothes washer and run directly outside. However, commercial systems are available that attach directly to a home's existing wastewater line. Sensors are placed throughout the house to ensure that only gray water is collected. The water is then sent through filters and exposed to UV light to eliminate harmful bacteria. The treated gray water is used primarily for landscape irrigation, although some limited human uses exist. The figure shows one way a gray water collection system can function in a home.



3 Because gray water can contain additives such as laundry bleach not found in fresh water, researchers have performed several studies on the watering of grass and other landscape plants with gray water. In most of the studies, gray water allowed plants to survive and grow at nearly normal rates. However, the researchers caution that people should test the effect of gray water on their plants before completely switching over to gray water for landscape uses.

4 The widespread use of gray water for irrigation purposes has the potential to help water conservation efforts. Long-term studies are needed to determine the overall success of using gray water to replace fresh water in landscape irrigation.

Which statement best describes the use of gray water depicted in the diagram?

- ○ Humans may use gray water for all activities as long as it is sent through filters and exposed to ultraviolet light.
- ◉ Humans may use gray water for certain activities as long as humans do not ingest or bathe in it.
- ○ Humans should avoid contact with gray water and use it only for outdoor plants.
- ○ Humans may use gray water in the kitchen while preparing food but should not bathe in gray water.

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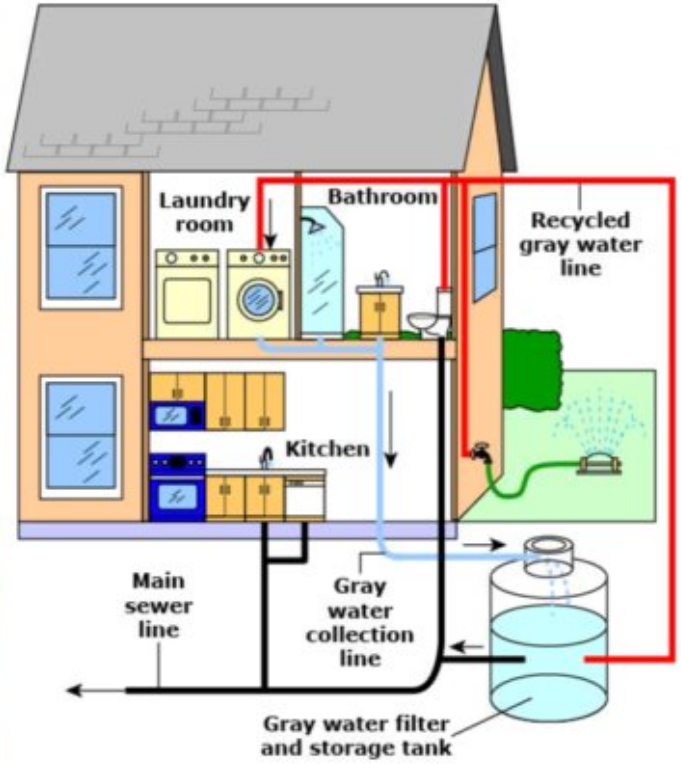

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Which text from the passage best supports the conclusion that gray water should be used primarily for landscape irrigation rather than other purposes?

- ○ "In most of the studies, gray water allowed plants to survive and grow at nearly normal rates." (paragraph 3)
- ○ "Severe water shortages in many areas mean that recycling water will be necessary for continued landscape irrigation." (paragraph 1)
- ◉ ". . . gray water can contain additives such as laundry bleach not found in fresh water . . ." (paragraph 3)
- ○ ". . . bathtub water can be saved and poured on grass or hoses can be connected to a clothes washer and run directly outside." (paragraph 2)

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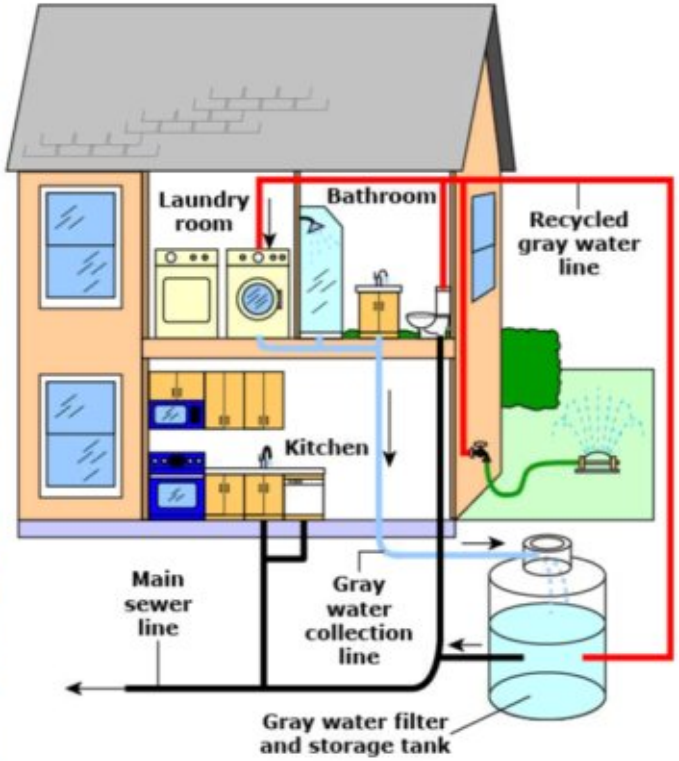

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4 The widespread use of gray water for irrigation purposes has the potential to help water conservation efforts. Long-term studies are needed to determine the overall success of using gray water to replace fresh water in landscape irrigation.

Which statement accurately summarizes the passage?

- ○ Research studies show that gray water does not negatively affect the growth of many plants.
- ◉ Collecting, treating, and recycling gray water may be a viable way to address the shortage of water for landscaping purposes.
- ○ The process of recycling gray water can be easier with the use of commercially available collection and filtering systems.
- ○ Humans should replace fresh water with gray water for landscape irrigation to ensure plants get the minerals needed to grow.

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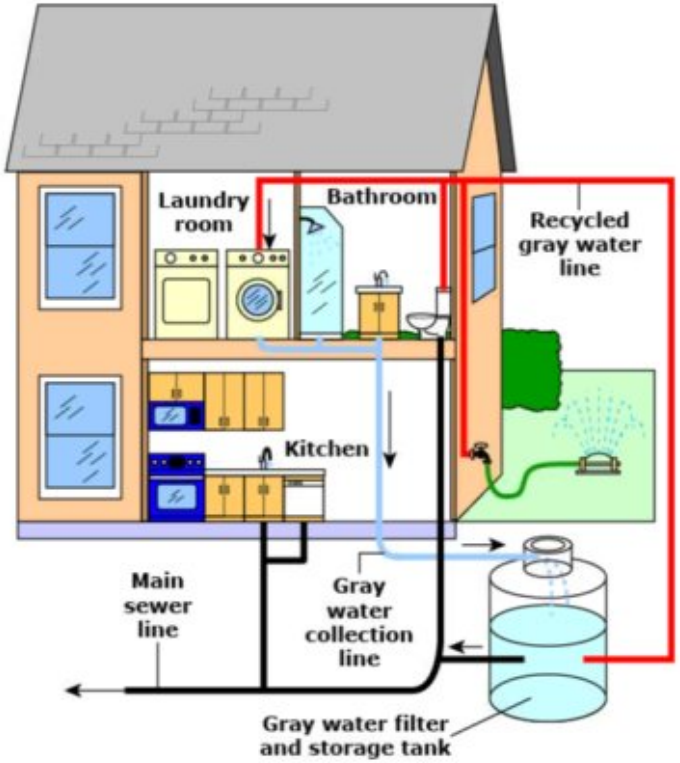

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Which pathway could water follow as it flows through the house shown in the diagram?

- clothes washer → recycled gray water line → gray water filter and storage tank → gray water collection line → shower
- shower → gray water collection line → gray water filter and storage tank → recycled gray water line → clothes washer
- outside faucet → recycled gray water line → toilet → recycled gray water line → clothes washer → main sewer line
- toilet → main sewer line → gray water filter and storage tank → recycled gray water line → clothes washer

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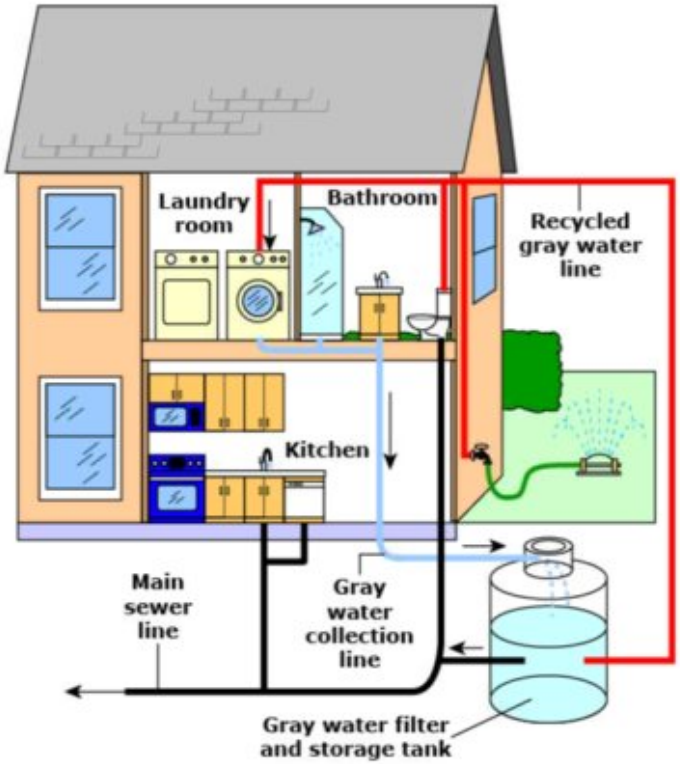

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Read the brief passage about heat.

After Benjamin Franklin argued that electricity was a fluid, the scientific community started discussing other phenomena as being related to fluids. In 1787, Lavoisier developed the idea that heat was an invisible fluid called a caloric fluid. This fluid would leave a hot substance and travel to a colder substance.

Later, in 1783, Lavoisier demonstrated that oxygen was required for combustion.

In 1798, Count Rumford observed that the process of boring out cannons from brass cylinders continuously produced heat. He also found the brass filings produced from the drilling process contained enough heat to boil water while retaining their weight.

In the early 1940s, James Joule discovered that heat could be produced by moving a wire through a magnetic field.

Which statement from the passage refutes Lavoisier's idea that heat is a fluid that leaves a hot substance and travels to a colder substance?

- "Count Rumford observed that the process of boring out cannons from brass cylinders continuously produced heat."
- "Lavoisier demonstrated that oxygen was required for combustion."
- "James Joule discovered that heat could be produced by moving a wire through a magnetic field."
- "He also found the brass filings produced from the drilling process contained enough heat to boil water while retaining their weight."

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Calculator Reference

Domestic cats exhibit a great variety of coat characteristics. Two important genes governing cat coat traits are the white masking gene and the gene for fur length. The alleles for these traits are:

W – dominant allele for white masking, produces solid white fur
w – recessive allele, produces colored fur
L – dominant allele for fur length, produces short hair
l – recessive allele, produces long hair

The Punnett square below shows a cross between a male long–haired cat with white fur and a female short–haired cat with colored fur.

		Male long-haired cat with white fur (WwII)			
		Wl	**Wl**	**wl**	**wl**
Female short-haired cat with colored fur (wwLl)	**wL**	WwLl	WwLl	wwLl	wwLl
	wL	WwLl	WwLl	wwLl	wwLl
	wl	Wwll	Wwll	wwll	wwll
	wl	Wwll	Wwll	wwll	wwll

If this cross is repeated several times to produce a total of 20 offspring, what is the *most likely* number of long–haired kittens with colored fur?

You may use the calculator.

- ○ 15
- ○ 20
- ◉ 5
- ○ 10

Gregor Mendel determined that the offspring in crosses between plants with two heterozygous traits resulted in a 9:3:3:1 ratio, as shown in the table. The largest number of offspring expressed both dominant traits, while the fewest number of offspring expressed both recessive traits. Mendel concluded that different traits are inherited independently from each other.

Appearance of Offspring	Number of Offspring
round, yellow seeds	315
round, green seeds	108
wrinkled, yellow seeds	101
wrinkled, green seeds	32

William Bateson and his colleagues designed a similar experiment using heterozygous pea plants. Bateson crossed plants that were heterozygous for flower color and pollen shape. These experiments resulted in numbers of offspring that did not match Mendel's 9:3:3:1 ratio. The number and appearance of the offspring are shown in the table. Bateson concluded that some traits are not inherited independently.

Appearance of Offspring	Number of Offspring
purple flowers with long pollen grains	284
purple flowers with round pollen grains	21
red flowers with long pollen grains	21
red flowers with round pollen grains	55

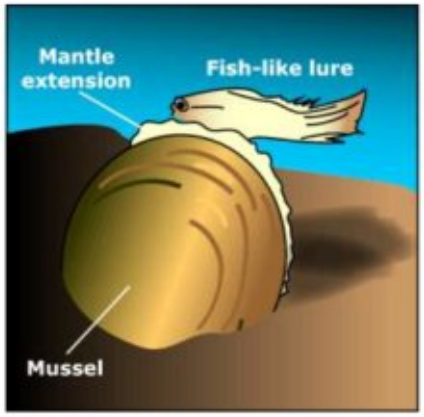
How do the results of Bateson's experiment affect the interpretation of Mendel's experimental results?

- Bateson's experimental results show that Mendel's conclusions were incorrect.
- Bateson's experiments studied different traits than Mendel's so Bateson's results could not challenge or support Mendel's conclusions.
- Bateson's experimental results show that Mendel's conclusions were incomplete.
- Bateson's experiments resulted in different ratios of traits in the offspring, confirming Mendel's conclusion.

1 There are more than 280 species of mussels and clams in North American waterways. Some mussels have parasitic relationships. In this type of nonmutual relationship, one organism benefits at the expense of the other.

2 One family of freshwater mussel, *Unionidae*, has a life cycle that requires a parasitic larval stage. Each tiny mussel larva attaches to the gills of a fish. The fish immune system encapsulates the larva in a cyst, and the larva develops within that cyst until it is ready for an independent life. The fish is harmed by the parasite infesting the tissues of the gills. When the larva hatches from the gill cyst, it settles into the riverbed to develop into an adult mussel.

3 How do mussel larvae get to the gill of a fish? In most cases, mussels and fish do not interact. However, in *Lampsilis*, one genus of *Unionidae*, there must have been ancestor mussels that, because of random mutation, developed so that part of their extended surface slightly resembled a small fish—the favorite food of big fish. One of the signature elements that fish recognize in their prey is the eyes. Gradually, over generations, these mussels developed a fish-like lure with an eyespot, which is a dark dot that mimics the appearance of a fish eye. When a big fish approaches to eat the lure, the female clam releases her eggs into the big fish's mouth.

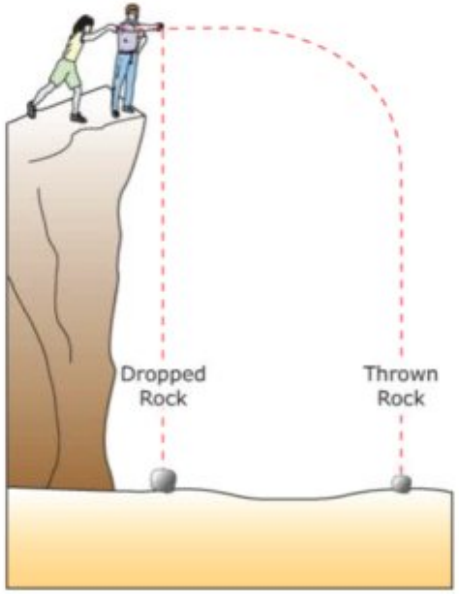


4 Even with this modification, researchers estimate the mortality rate for *Lampsilis* eggs to be 99.99%.

Which sentence from the passage demonstrates natural selection in *Lampsilis* mussels?

- ○ "The fish immune system encapsulates the larva in a cyst, and the larva develops within that cyst until it is ready for an independent life." (paragraph 2)
- ○ "In most cases, mussels and fish do not interact." (paragraph 3)
- ◉ "Gradually, over generations, these mussels developed a fish-like lure with an eyespot, which is a dark dot that mimics the appearance of a fish eye." (paragraph 3)
- ○ "There are more than 280 species of mussels and clams in North American waterways." (paragraph 1)

Two people are standing at the edge of a high cliff. One person throws a rock horizontally off the cliff. At the exact same time, the other person drops a rock vertically off the cliff from the same height.



According to Galileo, the two rocks should hit the ground at the same time.

Which uncontrolled part of this investigation can prevent the rocks from hitting the ground at the same time?

- air resistance
- gravity
- strength of the person
- mass of the rocks

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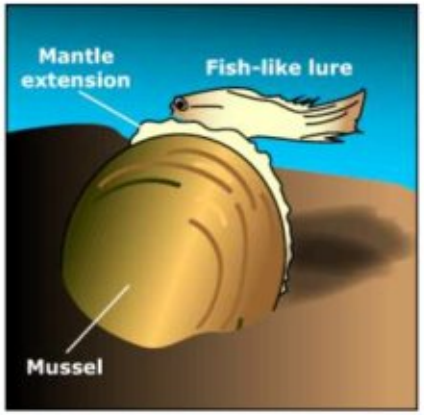

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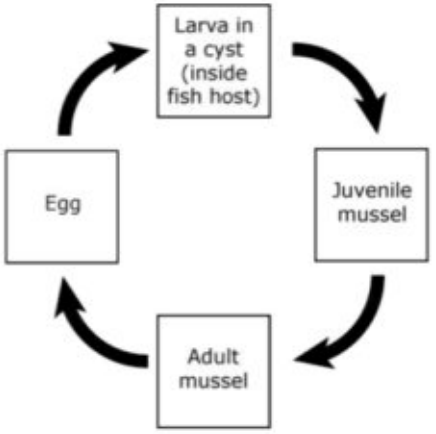
An incomplete life cycle of a freshwater mussel is shown below.

Based on the passage, complete the life cycle of the freshwater mussel.

Click on the stage of development you want to select and drag it into the correct box.

Mussel Life Cycle



1 In June 2012, an experimental airplane completed the first solar-powered intercontinental flight. The milestone voyage, from Madrid to Morocco, took 19 hours. The experimental airplane's cruising speed was just 71 kilometers per hour (kph), below the minimum speed on many American highways and far lower than the cruising speed of a large commercial jet airplane—which is nearly 917 kph, or 255 meters per second.

Characteristic	Jet Airplane	Experimental Airplane
Mass	396,890 kg	1,600 kg
Cruising speed	917 kph	71 kph
Fuel used	11 liters per km	0
Flight range	12,800 km	2,500 km
Maximum altitude	10,600 m	8,500 m

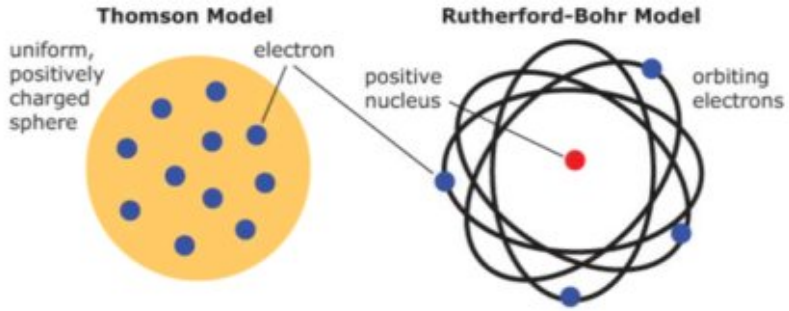
2 The experimental airplane carries nearly 12,000 solar cells, which power the plane's four electric motors. The solar cells, mounted on the wings, use sunlight to generate electricity. Photons from the Sun hit the solar cells and are absorbed by semiconductors. Electrons from atoms in the semiconductor are energized by the photons and break free from the atoms. This change causes an electric potential difference, and electric current flows to cancel that difference. The result is electricity that can be stored or used by the aircraft's electric motors.

3 During the day, the solar-powered plane uses its motors to climb through the atmosphere, reaching altitudes of up to 8,500 meters. At night, the plane glides down toward land, converting the potential energy gained during its ascent into kinetic energy. When the plane is less than 1,600 meters above ground, battery power turns the motors back on and keeps the plane at a safe and level altitude until sunrise.

Which of the following is the primary energy source for the experimental airplane?

- (●) sunlight
- ( ) batteries
- ( ) electrons
- ( ) gasoline

In the nineteenth century, scientists determined that atoms consist of electrons and protons. J. J. Thomson modeled the atom as a uniform arrangement of electrons inside a positive sphere of charge. In the early twentieth century, Earnest Rutherford concluded from experiments that most of the mass and all of the positive charge of atoms were concentrated in the center of the atom, with the negatively charged electrons orbiting the center.



Which statement describes one feature of the Rutherford-Bohr atom model that the Thomson model does not share?

- The Rutherford-Bohr model restricts the positive charge of the atom to the nucleus.
- The Rutherford-Bohr model maintains the observed neutral charge of atoms.
- The Rutherford-Bohr model identifies different elements by the numbers of particles present.
- The Rutherford-Bohr model correctly describes the types of particles in the atom.

Recording

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Calculator Reference

The relationship between velocity (v), distance (d), and time (t) is given in the equation.

$$v = \frac{d}{t}$$

The distance from Paris to Berlin is 877 kilometers. Which statement correctly describes the flight times of the jet airplane and the experimental airplane from Paris to Berlin?

You may use the calculator.

- The jet airplane takes about 0.95 hours, but the experimental airplane takes about 12.4 hours.
- The jet airplane takes about 1.04 hours, but the experimental airplane takes about 8.09 hours.
- The jet airplane takes about 0.95 hours, but the experimental airplane takes about 8.09 hours.
- The jet airplane takes about 1.04 hours, but the experimental airplane takes about 12.4 hours.

Limestone and marble are often used in buildings. Both types of rock contain calcium carbonate, which is sensitive to chemical weathering by acids. A scientist conducted an experiment to test the effect of acid strength on calcium carbonate, using the following procedure.

- Collect four samples of marble and four samples of limestone, all with equal masses.
- Mix four solutions with differing pH levels.
- Measure the pH of each solution, using the pH scale (in which 0 is the most acidic and 14 the most basic).
- For each solution, spray one sample of marble and one sample of limestone with an equal volume of solution.
- Measure the calcium ions in the runoff from each sample.

The scientist hypothesized that the amount of calcium ions in the runoff would increase as the acidity of the solution sprayed on the samples increased. The data tables show the experimental results.

Marble

Initial pH of Acid	Calcium Ions Collected in Runoff (mg/L)
5.60	9.17
4.79	6.37
3.59	11.08
3.00	26.05

Limestone

Initial pH of Acid	Calcium Ions Collected in Runoff (mg/L)
5.60	14.61
4.79	12.55
3.59	16.96
3.00	32.35

Except for one pH value, the data appear to support the hypothesis.

Which change would reduce the possibility of error in the experiment?

- ○ using more of the acidic solution
- ◉ performing multiple trials for each solution pH
- ○ performing the experiment with a different acid in the solution
- ○ using a solution with a pH below 3.00

Recording

A researcher conducted an investigation about how the human body changes during exercise. The researcher's procedure is outlined below.

Experimental Procedure:

1. Observe and record the body temperature, breathing rate, and heart rate of a test subject at rest.
2. The subject jumps rope for 10 minutes.
3. Every two minutes, the researcher records the body temperature, breathing rate, and heart rate of the test subject.
4. Repeat procedure with additional subjects.

Which hypothesis is suitable for this investigation?

- ○ Body temperature, breathing rate, and heart rate increase with exercise.
- ◉ Body temperature, breathing rate, and heart rate depend on the health of the subject.
- ○ Many of the body's systems respond to exercise.
- ○ Subjects at rest have better health than subjects that exercise.

Calculator Reference

Ten cars raced on an oval track. At one moment in the race, the speed of each car in kilometers per hour (kph) was recorded in the table and listed by speed.

Car Number	Speed (kph)
65	156
77	169
88	171
0	174
73	177
40	179
23	180
8	180
17	181
42	183

What is the median speed of the cars?

You may use the calculator.

- 178 kph
- 183 kph
- 175 kph
- 180 kph

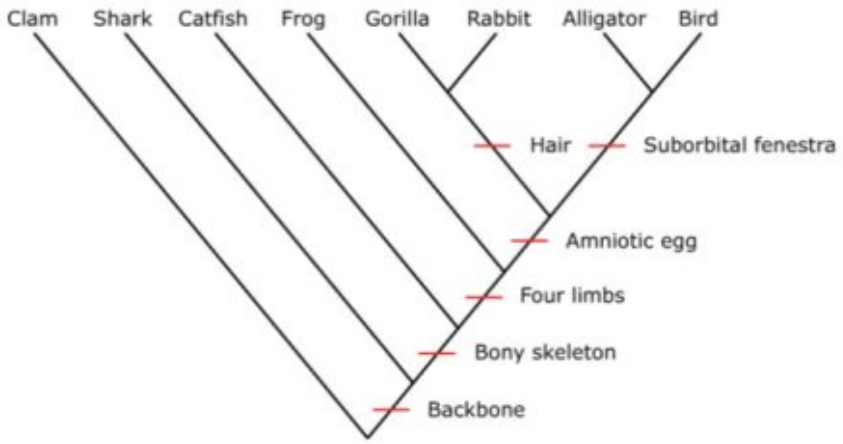
Recording

Which sentence describes a difference between artificial selection and natural selection?

- In natural selection, variation is heritable; in artificial selection, variation is not heritable.
- In natural selection, there is differential reproduction; in artificial selection, there is not differential reproduction.
- In natural selection, reproductive success is driven by naturally occurring processes; in artificial selection, reproductive success is driven by human-imposed processes.
- In natural selection, there is variation within the population of organisms; in artificial selection, there is no variation within the population or organisms.

Recording

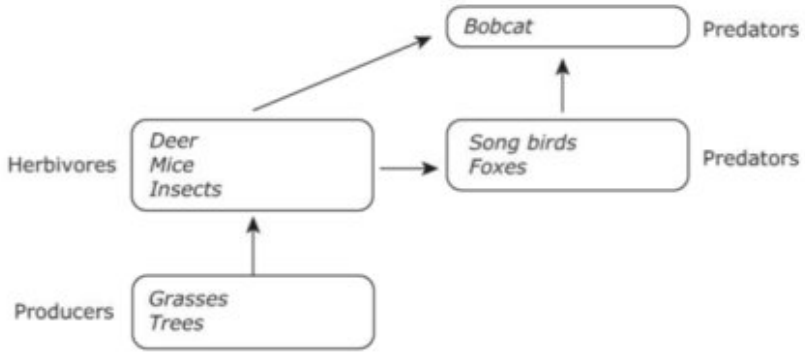
The cladogram shows the relatedness of several organisms based on shared characteristics.



Which characteristic separates catfish from frogs?

- ○ Suborbital fenestra
- ○ Bony skeleton
- ○ Amniotic egg
- ◉ Four limbs

A diagram produced for biological research is shown below.



What do the lines connecting the boxes represent?

- to show the positions and movements of the organisms over time
- to show the genetic relationships of organisms
- to show the direction of the flow of energy and nutrients between organisms
- to show how organisms evolve over time

Calculator Reference

Sound waves are amplified when they travel through a metal tube, called a resonating column. Resonating columns can be open on both ends or closed on one end. The amplification of the sound waves is partially based on the type of tube used. The table shows the initial wavelengths of some sounds and the sounds' wavelengths as they travel through open resonating columns.

Wavelengths in Resonating Columns

Initial Wavelength (m)	Wavelength in Open Tube (m)
1.72	0.86
1.36	0.68
1.20	0.60
0.88	

What is the missing number in the table?

You may use the calculator.

- ○ 0.52 m
- ● 0.44 m
- ○ 1.20 m
- ○ 3.52 m

506830284

Calculator Reference

Saturn's rings contain enormous numbers of particles. These particles sometimes experience collisions with each other. Scientists need to know how those collisions transfer energy in order to model the overall structure and composition of the rings. Images of particles in Saturn's rings reveal that only 50–60% of the particles' energy remains after a collision. To identify which types of particles could explain the observations, a scientist tests substances in a laboratory and measures the energy remaining after collisions between particles of those substances. The table shows the scientist's results.

Energy in Particles After a Collision

Material	Energy Remaining
bedrock	95%
carbon rock	83%
ice	50%
loose rocks	24%
loose snow	20%

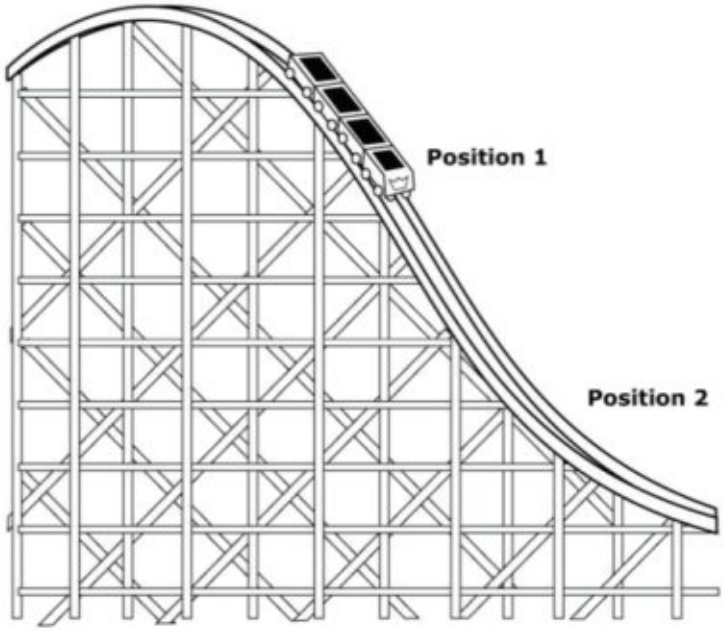
Based on these results and assuming that whenever two materials are present their remaining energy is averaged, what would the scientist best conclude to be the composition of Saturn's rings?

You may use the calculator.

- ○ equal amounts of loose rocks and loose snow
- ○ equal amounts of ice and bedrock
- ◉ large amounts of ice and smaller amounts of carbon rock
- ○ a small amount of bedrock and a large amount of carbon rock

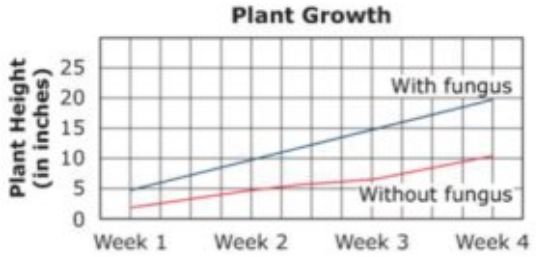
Recording

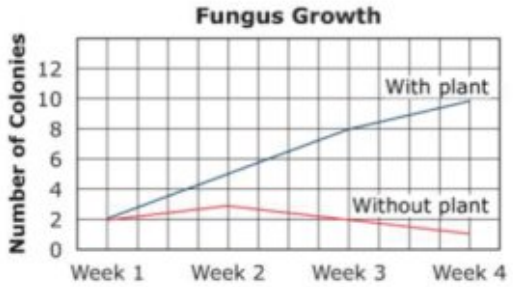
The roller coaster diagram shows a set of cars moving downward from position 1 to position 2.



As the cars travel from position 1 toward position 2, their [gravitational potential energy ▾] decreases, yet their [total energy ▾] remains unchanged.

A botanist discovered fungus growing in the soil near a certain plant species and hypothesized that the plant and fungus have a mutualistic relationship. The botanist performed an investigation to test this hypothesis. The graphs below show the results.





Based on the information in the graphs, which conclusion should the botanist reach?

- Since both the plant and the fungus grow better together, the hypothesis is supported.
- Since neither the plant nor the fungus grows better when grown together, the hypothesis is rejected.
- Since neither the plant nor the fungus grows better when grown together, the hypothesis is supported.
- Since both the plant and the fungus grow better together, the hypothesis is rejected.

1 Scientists agree that our planet is getting warmer. But is there a human cause for global warming, or is it a natural fluctuation in a long-term cycle?

2 Warming cycles throughout Earth's history have caused glacial melting, animal and plant habitat shifts, and earlier flowering seasons for trees. These climate changes often correlate with changes in Earth's orbit known as Milankovitch cycles. For example, Earth's angle of axial tilt varies over the course of 41,000 years from 22.1° to 24.5°. At greater angles, Earth's poles receive more direct solar radiation, or insolation. Increased insolation results in higher mean temperatures. The Milankovitch theory proposes that cycles in climate arise from these cyclical changes in Earth's orbit. According to one viewpoint, the current warming of our planet is just evidence of a Milankovitch cycle. However, current climate changes are occurring at a faster rate than those in the past.

3 To explain the different rates, many scientists point to human use of fossil fuels. Fossil fuels release carbon dioxide (CO_2) when burned. CO_2 traps thermal radiation in Earth's atmosphere, a phenomenon known as the greenhouse effect. Recent increased levels of CO_2 correlate very strongly with increased mean temperatures. Furthermore, the rate of increase in CO_2 levels is also rising.

4 For this reason, many scientists conclude that climate change is anthropogenic (caused by humans). Data that support Milankovitch cycles do not necessarily contradict this conclusion. Supporters of the anthropogenic climate change model only need to demonstrate that the current warming deviates from Milankovitch cycles and that human activities provide a better explanation.

5 Both the anthropogenic climate change model and the Milankovitch theory are consistent with some of the observed climate changes. However, only one offers the best explanation for the current warming of Earth.

Current Warming Cycle

Variable	Compared to Previous Warming Cycles		
	Higher	Lower	Same
rate of glacial melt	X		
insolation		X	
rate of mean temperature increase	X		
rate of CO_2 increase	X		
volume of glacial melt			X
shifts in animal and plant habitats			X
earlier flowering of trees			X

The table contains variables that can be used to compare current warming cycles to previous warming cycles. Click on the variables for which the data support the theory or model that best describes the currently observed increase in global temperature.

Current Warming Cycle

Variable	Compared to Previous Warming Cycles		
	Higher	Lower	Same
rate of glacial melt	X		
insolation		X	
rate of mean temperature increase	X		
rate of CO_2 increase	X		
volume of glacial melt			X
shifts in animal and plant habitats			X
earlier flowering of trees			X

506830284

Calculator Reference

A kneepad manufacturer tested a new kneepad design for use in industrial settings. In order to be rated for the intended use, the kneepads each needed to withstand a force of 100 newtons (N) on the outside of the kneepad without distorting the inside by more than 5 millimeters. During testing, the force on each kneepad was steadily increased until the kneepad failed. The table shows the manufacturer's results from testing 100 of the kneepads.

Kneepad Testing Results

Tested Force (N)	Number of Failures
0–129.99	0
130–134.99	5
135–139.99	17
140–144.99	53
145–149.99	22
150–154.99	3

If these results correctly predict the performance of this kneepad design, what is the probability that one of the kneepads will require a force of 145 N or greater to cause failure?

You may use the calculator.

- ● 25%
- ○ 75%
- ○ 22%
- ○ 53%

1 Scientists agree that our planet is getting warmer. But is there a human cause for global warming, or is it a natural fluctuation in a long-term cycle?

2 Warming cycles throughout Earth's history have caused glacial melting, animal and plant habitat shifts, and earlier flowering seasons for trees. These climate changes often correlate with changes in Earth's orbit known as Milankovitch cycles. For example, Earth's angle of axial tilt varies over the course of 41,000 years from 22.1° to 24.5°. At greater angles, Earth's poles receive more direct solar radiation, or insolation. Increased insolation results in higher mean temperatures. The Milankovitch theory proposes that cycles in climate arise from these cyclical changes in Earth's orbit. According to one viewpoint, the current warming of our planet is just evidence of a Milankovitch cycle. However, current climate changes are occurring at a faster rate than those in the past.

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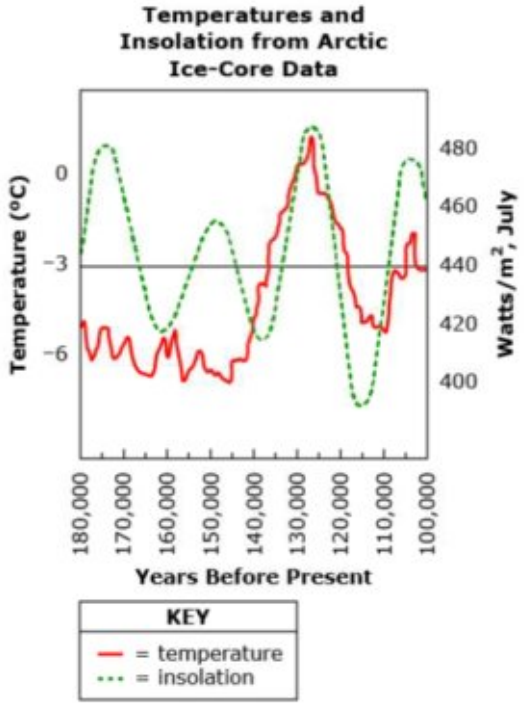
Current Warming Cycle

Variable	Compared to Previous Warming Cycles		
	Higher	Lower	Same
rate of glacial melt	X		
insolation		X	
rate of mean temperature increase	X		
rate of CO_2 increase	X		
volume of glacial melt			X
shifts in animal and plant habitats			X
earlier flowering of trees			X

Scientists can indirectly observe temperatures and insolation (the intensity of direct solar radiation) in the distant past by measuring oxygen isotope ratios in ice cores collected from polar ice. The graph presents data for the period from 100,000 to 200,000 years ago.



What time period in the graph shows the greatest correlation between Milankovitch cycles and climate?

- ○ 120,000–140,000 years ago
- ◉ 160,000–180,000 years ago
- ○ 140,000–160,000 years ago
- ○ 100,000–120,000 years ago

Recording

Doctors and scientists have noted that the average shoe size of women in the United States has rapidly increased since 1890, as shown in the graph. This rapid increase is thought to be the result of changing diet and increasing rates of obesity.

If this trend continues, which shoe size would be a reasonable average size for women in the year 2040?

- 9.0
- 10.5
- 13.0
- 8.5

1 Water that has large amounts of dissolved calcium and magnesium is referred to as hard water. Calcium and magnesium naturally occur in Earth materials such as limestone, magnesite, gypsum, and other minerals groundwater comes into contact with.

2 Calcium is a vital component of bones and teeth. Calcium is also necessary for proper muscle action, blood clotting, and regulating the heartbeat. Magnesium is necessary for more than 300 biochemical processes in the body, such as regulating heartbeat and blood sugar levels, helping maintain normal blood pressure, and facilitating protein synthesis.

3 The health benefits of drinking hard water have been well documented since the 1920s. One study investigated the effects of different amounts of dietary magnesium on rat survival rates. The first table shows the summary data from this study.

Effect of Dietary Magnesium (Mg) on Rat Survival Rate

Group	Mg Intake per Day (milligrams of Mg/ mass of rat in kilograms)	Survival Rate (live rats at end of study/ live rats at beginning of study)
control group	775 mg/kg	30/40
magnesium-deficient diet	200 mg/kg	24/40
magnesium-supplemented diet	3,000 mg/kg	35/40

4 Softening water has become a common practice in many homes. Soft water is water that has had the calcium and magnesium ions and other minerals removed to prevent the buildup of a residue called scale in pipes and appliances. Soft water also increases the effectiveness of soaps and detergents.

5 Research around the health benefits of drinking hard water suggests that people may be at higher risk for certain diseases when their water lacks dissolved calcium and magnesium. The second table summarizes data from two human population studies that examined the role of dietary magnesium and cardiovascular health.

Summary of Human Dietary Magnesium Population Studies

Study	Description	Mg Intake (mg/day)	Results
1	randomized study • Group A was given a magnesium-rich diet. • Group B followed their normal diet.	group A: 1,050 group B: 425	cardiovascular complications twice as likely in group B
2	monitored dietary	urban: 400	heart disease

Scientists claim that levels of dietary calcium and magnesium intake can affect the health of an organism.

Which two pieces of evidence from the passage support this claim?

Click on the pieces of evidence you want to select.

the natural occurrence of calcium and magnesium in many water sources
the control group results in the rat study
the difference in heart disease incidence between urban and rural populations in human study 2
the 425 mg/day of magnesium in a normal diet in human study 1
the magnesium-rich diet condition for group A in human study 1
the survival rates of rats on a low-magnesium diet

1 Water that has large amounts of dissolved calcium and magnesium is referred to as hard water. Calcium and magnesium naturally occur in Earth materials such as limestone, magnesite, gypsum, and other minerals groundwater comes into contact with.

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Human study 1 ▾ provides the strongest evidence that a high level of dietary magnesium ▾ improves cardiovascular health.

Recording

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The following steps describe the procedure used by the researchers who conducted human study 1.

1. Randomly assign equal numbers of participants to group A and group B.
2. ?
3. Monitor magnesium levels in each participant at regular intervals for 10 years.
4. Track all cardiovascular complications in all participants for the duration of the study.
5. Compare the rates of cardiovascular complications in group A to those in group B.

Which instruction would be most appropriate for step 2 of the procedure?

- ○ Provide both group A and group B participants with guidelines about which foods they should consume.
- ○ Provide group A participants with a high-magnesium supplement and group B participants with a low-magnesium supplement and then instruct all participants to avoid foods that contain magnesium.
- ○ Provide both group A and group B participants with a daily magnesium supplement.
- ● Provide group A participants with a daily magnesium supplement and provide group B participants with a daily supplement that contains only inactive ingredients.

Recording

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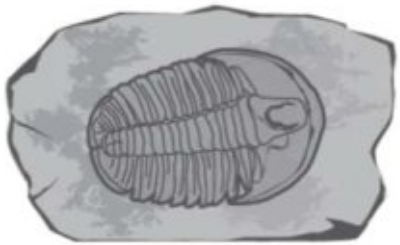
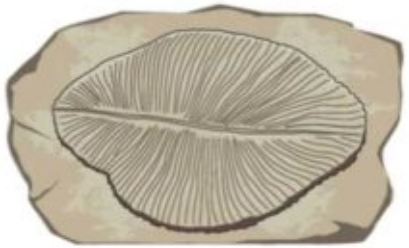
Which statement explains the central idea of the passage?

- (●) People may experience health benefits from drinking hard water because it contains magnesium.
- ( ) People who live in rural environments are healthier than people who live in urban environments.
- ( ) People should stop the practice of softening water because it removes minerals that are necessary for good health.
- ( ) People should consume as much magnesium as possible to ensure good cardiovascular health.

Each exoskeleton was divided into three distinct parts: the head, the body, and the t[redacted]ch swept back along the sides of the body. The body had three sections, or lobes, that were oriented parallel to the length of the body and divided by many perpendicular segments. The end-most segments were fused to form the tail.

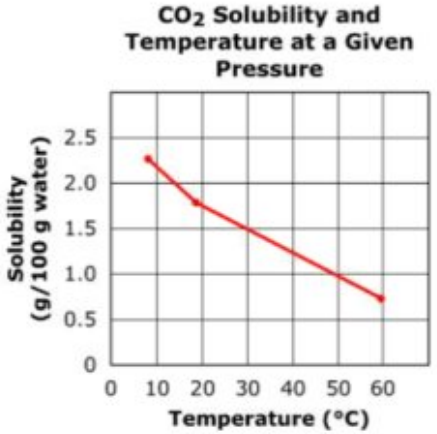
Which fossil formed from one of these animals?





Soft drinks are carbonated by dissolving carbon dioxide in water and bottling the carbonated water under high pressure. High pressure increases the amount of carbon dioxide gas in the solution. When a bottle cap is removed, the pressure suddenly decreases and the gas comes out of the solution and rises to the top in bubbles.

Temperature also affects the amount of gas that can be in the solution.



Four bottles of a soft drink sit on a shelf:

Bottle 1: A bottle that was sealed at 5 °C
Bottle 2: A bottle that was sealed at 20 °C
Bottle 3: A bottle that was just-opened at 5 °C
Bottle 4: A bottle that was just-opened at 20 °C

Which inference about the bottles is best supported by the data?

- ○ Bottles 1 and 2 will have the same amount of carbonation in the soft drink because the bottles were sealed, trapping the carbon dioxide within.
- ○ Bottles 3 and 4 will have the same amount of carbonation in the soft drink because they are both at atmospheric pressure.
- ◉ Bottle 1 will have the highest amount of carbonation in the soft drink because it is under higher pressure and at a lower temperature.
- ○ Bottle 2 will have the least amount of carbonation in the soft drink because higher temperatures mean less solubility for carbon dioxide.

Calculator Reference

The energy density of a fuel is the amount of useful energy stored in a specific amount of that fuel. The energy density, measured in megajoules per kilogram (MJ/kg), is related to the chemical composition of the fuel. The chemical composition and energy density of four fuels are shown in the table.

Fuel	Chemical Composition	Energy Density (MJ/kg)
methane	CH_4	50
propane	C_3H_8	47
butane	C_4H_{10}	46
octane	C_8H_{18}	44

Ethane, which has a chemical composition of C_2H_6, is also a fuel.

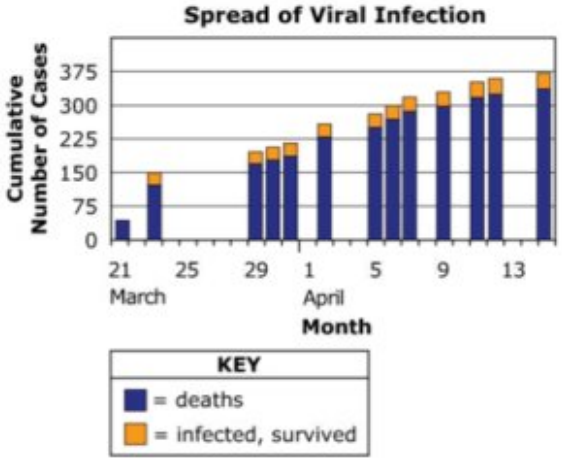
What is the predicted energy density of ethane?

You may use the calculator.

- 48 MJ/kg
- 42 MJ/kg
- 52 MJ/kg
- 45 MJ/kg

Recording

The graph below shows the spread of a viral infection in one nation over a 2-month period.



Based on the graph, which conclusion can be made about the effect of the viral infection in that nation over the 2-month period?

- The numbers of deaths increased, but the numbers of survivors remained relatively constant.
- The numbers of deaths and the numbers of survivors increased at similar rates.
- The numbers of deaths and the numbers of survivors decreased at similar rates.
- The numbers of deaths increased, but the numbers of survivors decreased.

Calculator Reference

A horizontal force (F) of 150 Newtons is applied to a box, causing it to slide 10 meters (d) across a floor.

What amount of work (W) was applied to the box?

You may use the calculator.

$W = F \times d$

1500 Joules

Treating water in a swimming pool with a sanitizer such as chlorine keeps pool water safe for swimming. Chlorine is available for purchase in many different forms. The effectiveness of a chlorine product depends on how the product dissolves to provide the right concentration of chlorine. The following procedure outlines an experiment designed to test the effectiveness of two forms of chlorine, granular chlorine and liquid chlorine.

1. Collect three samples of water from one pool.
2. Treat one sample with granular chlorine and one with liquid chlorine. Leave one sample untreated.
3. Conduct all treatments as indicated by the manufacturer of the chlorine product, treating each sample for the same amount of time.
4. Screen each sample for contaminants and compare the two chlorinated sample results with the control and with each other.

Which statement is an appropriate hypothesis for the experiment?

- When used in any form to treat pool water, chlorine removes a majority of contaminants.
- Granular chlorine is ineffective at removing contaminants from pool water.
- Chlorine in liquid form reduces contaminants in pool water more than chlorine in granular form does.
- Liquid chlorine effectively reduces contaminants in pool water.