

# PRACTICE EXAM 25: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

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**Instructions:** This simulation exam mirrors the format of the New York State Regents Examination in Life Science: Biology. Questions are organized into stimulus-based clusters. Read each cluster's stimulus completely before answering any questions in that set. Select the one best answer for each question.

*Base your answers to questions 1 through 5 on the information below and on your knowledge of biology.*

A student investigated osmosis using potato cubes. The student cut six identical cubes of potato (each 2 cm × 2 cm × 2 cm) and recorded the initial mass of each cube. The student then placed each cube into a different concentration of sucrose (sugar) solution and left them for 1 hour. After 1 hour, the student removed each cube, blotted it dry, and measured its final mass. The change in mass was then calculated as a percentage of each cube's initial mass.

Sucrose Concentration (M)	Average Mass Change (%)
0.0 (pure water)	+12
0.2	+6
0.4	0
0.6	-5
0.8	-11
1.0	-16

1. What is the main scientific question this experiment is designed to investigate?

A. How varying sucrose concentrations affect the movement of water into or out of potato cells  
B. Whether potato cubes float or sink when placed into sucrose solutions of different strengths  
C. Whether sucrose can be broken down into glucose and fructose inside the potato cells  
D. How temperature changes affect the rate of cellular respiration in potato cells over time

2. In the 0.0 M sucrose solution (pure water), the potato cubes gained mass. This is because:

A. The cubes absorbed sucrose molecules from the surrounding water by diffusion across the membrane  
B. Water moved into the cubes by osmosis from a region of higher water concentration  
C. The cubes produced new cells through mitosis when exposed to pure water for an hour  
D. The cubes lost dissolved minerals from their cytoplasm into the surrounding water

3. In the 1.0 M sucrose solution, the potato cubes lost 16% of their mass. The best explanation is that:

A. Water moved out of the cubes by osmosis into the more concentrated sucrose solution  
B. Sucrose molecules entered the cubes by active transport, displacing the water inside  
C. The potato cells died and dissolved into the surrounding sucrose solution over time  
D. The sucrose solution chemically reacted with the starch inside the potato cubes

4. At the 0.4 M sucrose concentration, the potato cubes showed no change in mass. The best explanation is that:

A. The potato cell membranes were not permeable to either water or sucrose at this concentration  
B. All osmosis stopped because the temperature dropped below the freezing point of water  
C. The sucrose concentration outside matched the solute concentration inside the cubes  
D. The cubes had reached a permanent steady state and could no longer change in mass at all

5. The movement of water across the cell membrane in this experiment is best described as:

A. Active transport, which requires ATP energy to move water against a concentration gradient  
B. Endocytosis, in which the cell membrane folds inward to engulf water molecules from outside  
C. Diffusion of sucrose, in which sucrose molecules move down their concentration gradient  
D. Osmosis, the diffusion of water across a selectively permeable membrane

*Base your answers to questions 6 through 10 on the information below and on your knowledge of biology.*

Researchers compared the activity of an enzyme isolated from three different organisms at various temperatures: a bacterium living in an arctic glacier, a typical mammalian cell, and a bacterium living in a hot spring. The optimal temperature for each enzyme was determined by measuring the reaction rate over a range of temperatures and finding the peak activity. The results are shown below.

Source Organism	Optimal Temperature (°C)
Arctic glacier bacterium	5
Mammalian enzyme	37
Hot spring bacterium	75

6. The wide variation in optimal temperatures among these enzymes is best explained by:

A. Each enzyme evolved to function best at the temperatures of its organism's environment B. The temperature of the laboratory was different for each enzyme during the test itself C. The enzymes are all made of different non-protein molecules with varied properties D. All enzymes work equally well at any temperature for any organism that produces them

**7.** The mammalian enzyme has an optimal temperature of 37°C. This temperature corresponds to:

A. The normal core body temperature of a typical mammal B. The freezing point of pure water under standard atmospheric conditions C. The boiling point of water at sea level under standard atmospheric conditions D. The temperature at which all enzymes universally function the most efficiently

**8.** The arctic glacier bacterium's enzyme would most likely lose function if:

A. It was placed back into the cold conditions of the arctic glacier from which it came B. It was tested in solutions of varied pH but kept near its optimal temperature setting C. It was exposed to temperatures of 75°C similar to those found in a hot spring D. It was used to catalyze reactions involving its natural substrate molecules

**9.** If the hot spring bacterium's enzyme were placed in a typical mammalian body at 37°C, the most likely result would be:

A. The enzyme would function more efficiently than the natural mammalian enzyme B. The enzyme would function very slowly because the temperature is well below its optimum C. The enzyme would denature instantly upon contact with mammalian body fluids D. The enzyme would produce different products than it normally would at its optimum

**10.** Enzymes from extremophiles like the hot spring bacterium are particularly useful in biotechnology because they:

A. Are easier to extract from the bacteria than enzymes from other types of organisms B. Cannot denature under any conditions and are immortal in their chemical activity C. Produce more energy per reaction than enzymes from any other type of organism D. Can function at high temperatures used in industrial processes and DNA amplification

*Base your answers to questions 11 through 15 on the information below and on your knowledge of biology.*

Students investigated how young plant seedlings respond to light. The students placed identical bean seedlings in three identical light-tight boxes, with each box having a single small opening. In Box A, the opening was on the top, so light came directly from above. In Box B, the opening was on the side, so light entered only from one side. In Box C (the control), the opening was sealed shut so no light entered the box. After one week, the students opened the boxes and observed the seedlings.

Box	Light Source	Observation After One Week
A	From directly above	Stem grew straight up toward the light
B	From one side only	Stem bent toward the light source on the side
C	None (sealed)	Stem grew tall but became pale and weak

**11.** The bending of the stem toward the light source in Box B is called:

A. Geotropism, the response of a plant to the force of gravity from Earth  
 B. Phototropism, the response of a plant to the direction of a light source  
 C. Thigmotropism, the response of a plant to touching another solid object  
 D. Hydrotropism, the response of a plant to the presence of nearby water sources

**12.** The pale and weak appearance of the seedlings in Box C (no light) is most likely because:

A. The seedlings lacked carbon dioxide for photosynthesis inside the sealed box  
 B. The seedlings respired more rapidly than usual in the sealed dark environment  
 C. Without light, the seedlings could not produce chlorophyll or perform photosynthesis  
 D. The temperature inside the sealed box was much higher than in the other two boxes

**13.** The plant hormone primarily responsible for phototropism is:

A. Insulin, which regulates the concentration of sugars in the plant phloem tissue  
 B. Adrenaline, which causes the plant to grow rapidly in response to threats  
 C. Estrogen, which controls the timing of flower production in the plant  
 D. Auxin, which causes cell elongation on the shaded side of the stem

**14.** The mechanism by which auxin causes a stem to bend toward the light involves:

A. Higher auxin concentration on the shaded side, causing those cells to elongate more  
 B. Equal distribution of auxin across the stem, causing the entire stem to bend toward light  
 C. Higher auxin concentration on the lighted side, causing those cells to elongate more  
 D. Complete destruction of auxin on the lighted side, stopping all growth in that area

**15.** Phototropism is adaptive for plants because it:

A. Ensures that all plants of the same species grow in exactly the same direction  
 B. Maximizes the amount of sunlight the plant captures for photosynthesis  
 C. Provides the plant with protection against being eaten by herbivorous animals  
 D. Prevents the plant from growing taller than other plants in the surrounding area

*Base your answers to questions 16 through 19 on the information below and on your knowledge of biology.*

Students measured the rate of cellular respiration in yeast by adding equal amounts of yeast to flasks containing different amounts of glucose. Each flask was sealed with a stopper containing a gas

collection tube. As the yeast respired, the CO<sub>2</sub> produced was collected, and the total volume was measured after 30 minutes. The data are shown below.

Glucose Added (g)	Total CO <sub>2</sub> Produced After 30 Minutes (mL)
0	1
1	12
3	32
5	48
10	50
20	51

16. As glucose increased from 0 to 5 grams, the rate of CO<sub>2</sub> production:

A. Decreased steadily because high glucose levels inhibit yeast activity in all conditions  
B. Remained constant because glucose is not necessary for cellular respiration to occur  
C. Increased because more glucose provided more substrate for cellular respiration  
D. Fluctuated unpredictably with no clear relationship to the amount of glucose added

17. Between 10 and 20 grams of glucose, the CO<sub>2</sub> production leveled off at about 50 mL. The best explanation is that:

A. The yeast cells became the limiting factor — they could not process glucose any faster  
B. The yeast began to die at glucose concentrations above 10 grams in the flask  
C. The CO<sub>2</sub> began to be reabsorbed by the yeast after reaching 50 mL of gas in the tube  
D. The glucose at high concentrations chemically converted CO<sub>2</sub> back into glucose molecules

18. The 1 mL of CO<sub>2</sub> in the flask with 0 grams of added glucose was most likely due to:

A. Air leaking into the flask from outside through the seal of the gas collection tube  
B. CO<sub>2</sub> produced by the chemical reaction of water with the glass of the flask  
C. The collection tube itself producing CO<sub>2</sub> from the materials it is made of  
D. Yeast respiring small amounts of nutrients already present in the yeast cells themselves

19. If the experiment were repeated with a much larger amount of yeast and 20 grams of glucose, the most likely result would be:

A. CO<sub>2</sub> production would remain at 51 mL because glucose is the only limit on yeast activity  
B. CO<sub>2</sub> production would decrease because too much yeast would crowd each other out  
C. CO<sub>2</sub> production would increase because more yeast can process the glucose faster  
D. CO<sub>2</sub> production would stop entirely because the glucose would be exhausted too quickly

*Base your answers to questions 20 through 24 on the information below and on your knowledge of biology.*

Sickle cell anemia is a genetic disorder caused by a mutation in the gene that codes for the beta chain of hemoglobin. A person who inherits two copies of the mutant allele (SS) has sickle cell anemia, in which red blood cells become misshapen and cause serious health problems. A person with two normal alleles (NN) does not have the disease. A heterozygote (NS) has sickle cell trait, with only mild symptoms under most conditions. In regions of Africa where malaria is common, the heterozygous NS genotype is much more frequent than would be expected, because heterozygotes are more resistant to malaria than NN homozygotes while still avoiding the most severe consequences of sickle cell anemia.

**20.** A person with sickle cell anemia has the genotype:

A. NN, which contains two copies of the normal hemoglobin allele  
B. NS, which contains one normal allele and one sickle cell allele  
C. SS, which contains two copies of the sickle cell allele on the chromosomes  
D. Nn, which contains only one normal hemoglobin allele on the chromosome

**21.** The higher frequency of the sickle cell allele in malaria regions is an example of:

A. Genetic engineering by humans to fight the spread of malarial infection in those regions  
B. Acquired immunity that individuals develop during their lifetimes after malaria exposure  
C. Random genetic drift in small populations that strongly affects allele frequencies  
D. Natural selection favoring a trait that provides survival benefit in a specific environment

**22.** The heterozygote (NS) is favored in malaria regions because:

A. The heterozygote has resistance to malaria while avoiding the worst effects of sickle cell anemia  
B. The heterozygote is completely free of both sickle cell anemia and any malarial infection  
C. The heterozygote is unable to reproduce, leaving more resources for normal individuals  
D. The heterozygote produces more children per generation than either homozygote genotype

**23.** The persistence of the sickle cell allele despite causing disease demonstrates that:

A. Genetic diseases always disappear from populations within just a few generations  
B. Mutations always increase in frequency over time regardless of natural selection  
C. A harmful allele can be maintained in a population if it also provides some advantage  
D. The sickle cell allele is not actually harmful in any environmental context

**24.** If two parents who are both heterozygous (NS) have a child, the probability that the child will have sickle cell anemia (SS) is:

A. 0%, because at least one parent must be SS for the child to inherit the disease  
B. 25%, because one of every four offspring combinations is homozygous recessive (SS)  
C. 50%, because half of all children of two heterozygotes are affected by sickle cell anemia  
D. 75%, because three of every four offspring will inherit at least one sickle cell allele

Base your answers to questions 25 through 29 on the information below and on your knowledge of biology.

Hemophilia is a genetic disorder in which blood does not clot properly. The gene for blood clotting is located on the X chromosome, and hemophilia is inherited as an X-linked recessive trait. The allele for normal clotting ( $X^H$ ) is dominant over the allele for hemophilia ( $X^h$ ). The Y chromosome does not carry this gene. A famous historical case involves Queen Victoria of England, who was a carrier of the hemophilia allele and passed it to several of her children, spreading the disorder through European royal families.

**25.** A male has the genotype  $X^h Y$ . This means he:

A. Is a carrier of hemophilia without showing any symptoms of the disease in his lifetime  
B. Is unaffected because the Y chromosome carries a normal version of the clotting gene  
C. Has a 50% chance of developing hemophilia later in his lifetime as he ages  
D. Has hemophilia, because his single X chromosome carries the recessive allele

**26.** A woman with the genotype  $X^H X^h$  is best described as:

A. Affected by hemophilia, with severe symptoms throughout her entire lifetime  
B. Completely homozygous normal, with no possibility of having children with hemophilia  
C. A carrier of hemophilia who does not show symptoms but can pass the allele on  
D. Unable to produce X chromosomes that carry the hemophilia allele in her gametes

**27.** A carrier mother ( $X^H X^h$ ) has children with a normal father ( $X^H Y$ ). What is the probability that any single son will have hemophilia?

A. 50%, because half of all sons will inherit the  $X^h$  chromosome from their mother  
B. 25%, because one of four offspring combinations produces an affected son  
C. 0%, because the father has normal clotting and contributes only normal alleles  
D. 100%, because all sons will inherit the affected X chromosome from their mother

**28.** Hemophilia occurs much more often in males than in females because:

A. The gene for blood clotting is located on the Y chromosome, which only males carry  
B. Males need only one copy of the recessive allele to be affected, while females need two  
C. Females are biologically protected from the effects of any X-linked recessive trait  
D. The mutation that causes hemophilia occurs more often in males than in females

**29.** For a daughter to be born with hemophilia, she must:

A. Inherit two  $X^h$  alleles from her mother, since the father cannot contribute the trait  
B. Have parents who are both carriers of the hemophilia allele on their X chromosomes  
C. Receive both X chromosomes

from her father, who passes them on to all daughters D. Inherit one X<sup>h</sup> allele from each parent, requiring her father to also have hemophilia

*Base your answers to questions 30 through 36 on the information below and on your knowledge of biology.*

In streams of Trinidad, guppies (small freshwater fish) show variation in male coloration. In streams where predatory fish are common, male guppies tend to be drab and gray. In streams with few predators, male guppies tend to be brightly colored with vivid spots. Bright coloration attracts females (and increases mating success) but also attracts predators. Researchers transplanted brightly colored male guppies from a low-predator stream into a high-predator stream and tracked the population over many generations. Over time, the transplanted population gradually became less colorful.

**30.** In streams with many predators, drab gray male guppies survive better because:

A. Drab guppies can swim faster than colorful guppies to escape from predators B. Drab guppies produce a chemical that poisons their predators upon contact C. Drab guppies are harder for predators to see in the stream environment D. Drab guppies have larger teeth that can be used to defend themselves from predators

**31.** In streams with few predators, brightly colored males are more common because:

A. Bright colors attract females, increasing the colorful males' mating success B. Bright colors poison the few predators that exist in those streams effectively C. Bright colors help guppies see each other to coordinate group movements D. Bright colors prevent guppies from being affected by changes in water temperature

**32.** The change in male coloration over generations in the transplanted population demonstrates:

A. Acquired traits passed from individual guppies to their offspring during one lifetime B. The disappearance of all natural variation in guppy coloration within a population C. A genetic mutation that occurred in every guppy simultaneously after the transplant D. Natural selection, in which existing color variation was shaped by predation pressure

**33.** For male coloration to evolve over generations in response to predation, the trait must be:

A. Acquired by individual guppies after they observe predator attacks in the stream B. Heritable, encoded in DNA and passed from parent guppies to their offspring C. Identical in every male guppy at the start of the experiment for all to evolve D. Reversible within a single generation when guppies are placed in a new environment

**34.** The pattern observed in the transplanted population shows that natural selection:

A. Always produces traits that are entirely beneficial in every environment encountered B. Only operates on populations after thousands of years have passed in the wild C. Can produce measurable evolutionary change within several generations under strong pressure D. Requires a researcher to actively guide which traits survive in each new generation

**35.** The colorful males in low-predator streams illustrate a trade-off in evolution: the same trait can be:

A. Beneficial in one environmental context and harmful in another environmental context B. Identical in every population regardless of the environmental pressures encountered C. Completely neutral, having no effect on survival or reproductive success at all D. Caused entirely by random genetic drift rather than by any selective pressure

**36.** Sexual selection, in which females choose colorful males, is a special case of natural selection because:

A. Sexual selection always counteracts the effects of predation-based natural selection B. Sexual selection can only occur in species where the females are larger than the males C. Sexual selection produces only traits that have no effect on the survival of the organism D. Sexual selection affects which individuals reproduce, like other forms of natural selection

*Base your answers to questions 37 through 41 on the information below and on your knowledge of biology.*

Ecologists have studied the populations of snowshoe hares and Canada lynx (a predator that primarily eats hares) in the boreal forests of North America for many decades. Both populations cycle up and down over time with a period of about 10 years, with hare populations rising first, followed by lynx populations rising, then hare populations falling, then lynx populations falling. This classic predator-prey cycle has been documented through trapping records dating back to the 1800s.

**37.** The increase in lynx population that follows an increase in hare population is best explained by:

A. The lynx and hare are unrelated populations whose increases happen to coincide B. The hares deliberately produce extra offspring to feed the lynx population in cold years C. Abundant hares provide more food for lynx, allowing more lynx to survive and reproduce D. The lynx develop new hunting strategies whenever hare populations begin to increase

**38.** After lynx populations increase, hare populations begin to decline because:

A. The hares migrate to new areas to escape the growing lynx population in the boreal forest B. Predation by the abundant lynx reduces hare numbers faster than hares can reproduce C. The hares lose interest in reproduction once they sense that lynx are nearby in the forest D. The hares are infected by a disease that the lynx carry to them during predation events

**39.** After hare populations decline, lynx populations also decline because:

A. With fewer hares available as food, fewer lynx can survive and reproduce successfully B. The lynx are deliberately hunted by humans when there are too few hares in the forest C. The lynx leave the area in search of completely new prey species in different forests D. The lynx develop a new disease that becomes common when hare populations are low

**40.** The recovery of the hare population after lynx populations decline occurs because:

A. The lynx that remain produce more cubs in order to maintain their food supply B. The hares develop new defenses against lynx that they did not have before the decline C. With fewer predators, more hares survive to reproduce and the population rebounds D. The hares migrate from other regions to rebuild the population in the boreal forest

**41.** The cyclic relationship between snowshoe hares and Canada lynx best illustrates:

A. The fact that predators and prey have no significant effect on each other's populations B. That predator populations are independent of any factor in the surrounding environment C. That prey species can never recover once a predator population begins to grow again D. How predator and prey populations regulate each other through their interactions

*Base your answers to questions 42 through 45 on the information below and on your knowledge of biology.*

Earth's atmosphere contains gases that allow visible sunlight to pass through and reach the surface, but trap some of the heat (infrared radiation) that the warmed surface emits back outward. These gases are called greenhouse gases because they act somewhat like the glass of a greenhouse. Major greenhouse gases include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and water vapor (H<sub>2</sub>O). This natural greenhouse effect keeps Earth's average surface temperature warm enough for life. However, human activities — particularly the burning of fossil fuels — have increased atmospheric CO<sub>2</sub> levels significantly since the Industrial Revolution, intensifying the greenhouse effect and contributing to global warming and climate change.

**42.** The natural greenhouse effect is essential for life on Earth because it:

A. Provides additional sunlight that increases the rate of photosynthesis in plants B. Keeps Earth's average surface temperature warm enough to support liquid water C. Removes harmful chemicals from the atmosphere through chemical reactions in the air D. Generates the oxygen that all aerobic organisms need to survive on land and in the ocean

**43.** Which of the following is the primary human activity that increases atmospheric CO<sub>2</sub> levels?

A. Burning fossil fuels such as coal, oil, and natural gas in vehicles and power plants B. Drinking carbonated beverages that release CO<sub>2</sub> during digestion in the stomach C. Walking or running, which

causes humans to exhale CO<sub>2</sub> produced by respiration D. Painting buildings, which produces small quantities of CO<sub>2</sub> from the paint pigments

**44.** The intensified greenhouse effect from increased CO<sub>2</sub> is contributing to:

A. A worldwide decrease in average global temperatures across all of Earth's regions B. The complete loss of all sunlight reaching Earth's surface from outer space C. Global warming, rising sea levels, and significant changes in regional climates D. The immediate destruction of all atmospheric gases in the lower troposphere

**45.** Strategies to reduce the human contribution to climate change include all of the following EXCEPT:

A. Switching from fossil fuels to renewable energy sources such as solar and wind power B. Protecting and restoring forests, which absorb CO<sub>2</sub> through photosynthesis in their tissues C. Improving energy efficiency in buildings, vehicles, and industrial manufacturing processes D. Increasing the burning of coal in power plants for both home and industrial use

*Base your answers to questions 46 through 50 on the information below and on your knowledge of biology.*

The nervous system controls all of the body's responses to stimuli. The basic functional unit of the nervous system is the neuron (nerve cell). A neuron has dendrites that receive signals from other neurons or from sensory receptors, a cell body that contains the nucleus, and an axon that transmits signals to other neurons or to muscle cells. A reflex arc is a simple neural pathway that produces an automatic, rapid response to a stimulus without requiring conscious thought from the brain. A typical reflex arc involves a sensory neuron, an interneuron in the spinal cord, and a motor neuron that triggers a muscle response.

**46.** When you touch a hot stove and quickly pull your hand away, this rapid response is best classified as a:

A. Voluntary movement, requiring deliberate planning by the higher brain regions B. Reflex, an automatic response that does not require conscious thought from the brain C. Hormonal response, mediated by chemicals traveling through the bloodstream of the body D. Tropism, a slow growth response of the body toward or away from a stimulus

**47.** The basic functional unit of the nervous system is the:

A. Neuron, a specialized cell that transmits electrical and chemical signals B. Mitochondrion, which produces the ATP that all body cells need for their function C. Ribosome, which assembles the proteins that make up the body's nerve tissues D. Hormone, a chemical messenger carried through the bloodstream by the heart

**48.** The part of a neuron that receives signals from other neurons or sensory receptors is the:

A. Cell body, which contains the nucleus and most of the cell's organelles B. Axon, which transmits signals away from the cell body and to other neurons C. Synapse, which is the small gap between two adjacent neurons in the nervous system D. Dendrite, which is a branching extension that receives incoming signals

**49.** During the touch-the-hot-stove reflex, the signal travels along the following pathway:

A. Brain → motor neuron → spinal cord → sensory receptor → muscle of the hand B. Sensory receptor → brain → motor neuron → spinal cord → muscle of the hand C. Sensory receptor → sensory neuron → spinal cord → motor neuron → muscle of the hand D. Muscle of the hand → motor neuron → spinal cord → sensory neuron → brain region

**50.** The advantage of a reflex arc compared to a voluntary response is that:

A. Reflex arcs are slower, giving the body time to evaluate the situation thoroughly B. Reflex arcs are much faster because they do not require processing by the brain C. Reflex arcs work without using any energy from the body's normal metabolism D. Reflex arcs can be controlled at will by the conscious decisions of the person

## **PRACTICE EXAM 25 – EXPLAINED ANSWER KEY (Q1-Q50)**

**1. A** — The experiment varies sucrose concentration and measures the resulting mass change in potato cubes, which directly reflects water movement. The setup tests the relationship between solute concentration and water movement across cell membranes. Understanding this relationship is the central goal of the investigation.

**2. B** — In pure water, the inside of the potato cell has a higher solute concentration (and therefore lower water concentration) than the surrounding solution. Water moves down its concentration gradient by osmosis into the cubes, increasing their mass. This is the same process that keeps non-woody plant tissues firm and turgid.

**3. A** — In a 1.0 M sucrose solution, the surrounding fluid has a higher solute concentration (and lower water concentration) than the potato cells. Water therefore diffuses outward through the membrane to balance the gradient, and the cells lose mass. This is why salted vegetables and meats shrivel.

**4. C** — When the solute concentrations inside and outside the cell are equal, the solution is isotonic. Water still crosses the membrane, but the rates in and out are equal, so there is no net change in mass. This balance occurred between the 0.4 M sucrose solution and the interior of the potato cells.

**5. D** — Osmosis is the specific term for the diffusion of water across a selectively permeable membrane down its concentration gradient. No ATP is required, and no membrane folding or solute transport is involved. Osmosis is one of the most important means by which water enters and leaves all living cells.

- 6. A** — Enzymes are proteins whose three-dimensional shapes have been shaped by natural selection to be most stable and active at the temperatures their host organism experiences. An arctic enzyme keeps the right flexibility at 5°C, while a thermophile's enzyme stays folded at 75°C. Each is optimized for its own environment, not for some universal temperature.
- 7. B** — Mammalian body temperature is held near 37°C by homeostatic mechanisms, and mammalian enzymes have evolved to function best at this temperature. This is why fever (significantly above 37°C) can impair normal enzyme activity. The match between body temperature and enzyme optimum is no coincidence.
- 8. C** — At 75°C, an enzyme adapted to 5°C would have far too much thermal energy disrupting its weak bonds, causing it to denature. The active site would distort and the enzyme would no longer function. Cold-adapted enzymes are notably unstable when exposed to high temperatures.
- 9. B** — At 37°C, the hot spring bacterium's enzyme is well below its optimal temperature of 75°C, so molecules within it move sluggishly and the enzyme works very slowly. The enzyme is not denatured — it is simply too cold to operate at normal speed. Activity would rise sharply if the temperature were raised toward its optimum.
- 10. D** — Heat-stable (thermophilic) enzymes can withstand the high temperatures used in many industrial reactions and in polymerase chain reaction (PCR), where DNA is repeatedly heated to near boiling. Taq polymerase from a hot spring bacterium is the classic example. These enzymes have transformed modern molecular biology and biotechnology.
- 11. B** — Phototropism is the directional growth of a plant in response to light. The bending of the Box B seedling toward the side opening is the textbook example. The other tropisms listed respond to gravity, water, or touch — not to light direction.
- 12. C** — Chlorophyll production requires light, so seedlings grown in total darkness fail to produce the green pigment and remain pale. Without chlorophyll, they cannot photosynthesize and survive only on stored seed energy. This is why such etiolated seedlings grow long but become weak and eventually die.
- 13. D** — Auxin is the major plant hormone responsible for phototropism. It is redistributed across the stem in response to directional light and causes cells on the shaded side to elongate more than those on the lit side. This differential growth bends the stem toward the light.
- 14. A** — When light hits a stem from one side, auxin accumulates on the shaded side. Cells on the shaded side elongate more than cells on the lit side, causing the stem to curve toward the light. This unequal growth is the cellular mechanism behind phototropism.
- 15. B** — By orienting growth toward the brightest available light, phototropism maximizes the light energy a plant can capture for photosynthesis. More light energy means more sugar produced and more energy for growth and reproduction. This adaptation is critical in dense vegetation where light is the most contested resource.

**16. C** — As more glucose was added, more substrate was available for the yeast to break down through cellular respiration, so the rate of CO<sub>2</sub> production rose. This pattern is typical of substrate-dependent reactions when substrate is the limiting factor. The relationship continues until another factor takes over.

**17. A** — Beyond about 10 g of glucose, the rate plateaus because the yeast itself becomes the bottleneck: the cells already metabolize glucose as fast as their enzymes allow. Adding more substrate cannot speed a reaction whose enzymes are saturated. To raise the maximum rate, one would need more yeast, not more glucose.

**18. D** — Yeast cells contain small amounts of stored nutrients (glycogen and other reserves) that they can metabolize even without added glucose. This baseline respiration produces a small amount of CO<sub>2</sub>. The 1 mL background is consistent with this normal cellular maintenance activity.

**19. B** — With more yeast cells available, more cellular machinery can process the available glucose simultaneously, raising the rate of respiration and CO<sub>2</sub> production. This confirms that yeast — not glucose — was the limiting factor at the highest glucose levels. Increasing the limiting factor is the way to raise reaction output.

**20. C** — The genotype SS contains two sickle cell alleles, producing only abnormal hemoglobin. With no normal hemoglobin made, red blood cells take on the characteristic sickled shape, especially under low oxygen. This homozygous recessive condition produces the full disease.

**21. D** — Where malaria is common, NS heterozygotes are partially protected from severe malaria, so they survive and reproduce more than NN homozygotes. Over generations, this selective advantage raises the frequency of the S allele above what would be expected if it only caused harm. This is a textbook example of how a specific environment can favor a normally harmful allele.

**22. A** — In malaria regions, NS individuals get the survival benefit of malaria resistance without the severe symptoms of full sickle cell disease (which affects SS individuals). They therefore survive and reproduce better than either homozygote. This pattern is known as heterozygote advantage, or balanced polymorphism.

**23. C** — Sickle cell anemia is clearly harmful, yet the S allele persists because heterozygotes have a survival benefit in malaria regions. This shows that selection can maintain harmful alleles in a population when they also confer some advantage. Many other "disease" alleles in human populations show similar balancing-selection patterns.

**24. B** — A Punnett square of NS × NS gives 1 NN : 2 NS : 1 SS, so 1 of every 4 offspring (25%) will be homozygous SS and develop sickle cell anemia. This 25% recurrence risk applies to each pregnancy independently. It is the standard prediction for any autosomal recessive disorder with two carrier parents.

**25. D** — Males have only one X chromosome, so a single recessive X<sup>h</sup> allele is fully expressed because there is no second X to mask it. A male with X<sup>h</sup> Y therefore has hemophilia. This pattern of hemizygous expression is the hallmark of X-linked recessive disorders in males.

- 26. C** — A heterozygous female ( $X^H X^h$ ) has one normal allele and one hemophilia allele. The normal allele is dominant, so she does not show symptoms, but she can pass the recessive allele to her children. Carrier status is the basis for the family tree pattern seen in Queen Victoria's descendants.
- 27. A** — Each son inherits the Y from his father and one X from his mother. The carrier mother passes  $X^H$  or  $X^h$  with equal probability, so 50% of her sons inherit  $X^h$  and have hemophilia. This is the typical mother-to-son transmission pattern of X-linked recessive disorders.
- 28. B** — Males have only one X chromosome, so a single recessive allele on it is automatically expressed (they are hemizygous). Females need two copies of the recessive allele — one on each X — to show the trait, which is far less likely. This is why most X-linked recessive disorders are dramatically more common in males.
- 29. D** — To be  $X^h X^h$ , a daughter must inherit  $X^h$  from both parents. Her mother can be a carrier or affected, but her father must contribute  $X^h$  to her — which is only possible if he himself is  $X^h Y$ , that is, has hemophilia. This is why affected females are extremely rare.
- 30. C** — In streams full of predators, drab gray males blend into the background and are harder for visual predators to spot. Survival depends heavily on remaining unseen. Bright males in such streams are quickly picked off, leaving drab males to reproduce.
- 31. A** — With fewer predators, the cost of being conspicuous drops, while bright colors still attract more female attention. Brightly colored males therefore enjoy a mating advantage and leave more offspring. The result is a population shift toward more colorful males.
- 32. D** — A heritable trait (color) was subjected to a new selective pressure (high predation), and the trait shifted across generations in a direction that improved survival. This is the textbook definition of natural selection. The change is not learned, not directed, and not the result of a one-time mutation.
- 33. B** — Natural selection can change a trait across generations only if the trait is encoded in DNA and inherited from parents. Acquired changes are not passed on through the gametes. Heritability is therefore the essential prerequisite for any evolutionary change.
- 34. C** — The guppy study (and many like it) show that natural selection can produce visible shifts in populations within just a few generations when selection pressure is strong. Evolution does not always require thousands or millions of years. Real-time evolution is now well documented in many species.
- 35. A** — Bright coloration helps a male guppy attract mates (advantageous when predators are rare) but also attracts predators (disadvantageous when predators are common). The same trait carries opposite fitness consequences depending on the environment. Such trade-offs are common throughout evolutionary biology.
- 36. D** — Sexual selection works by influencing who reproduces, and reproductive success is exactly what natural selection acts on. Any trait that affects how many offspring an individual leaves — including traits driven by mate choice — can therefore drive evolutionary change. This is why elaborate displays, ornaments, and colors are so common in many species.

**37. C** — More hares means more food for lynx; well-fed lynx survive longer and produce more kits that themselves survive. The lynx population therefore grows after a hare boom. Predator increase following prey increase is the first leg of the classic predator–prey cycle.

**38. B** — Once lynx are abundant, they kill so many hares that the hare death rate exceeds the hare birth rate, and the hare population shrinks. This is the second leg of the cycle. The strong top-down pressure overrides the hares' reproductive output.

**39. A** — Lynx depend on hares for food, so when hares become scarce, many lynx starve or fail to reproduce successfully. The lynx population then shrinks. This decline of predators following prey decline is the third leg of the cycle.

**40. C** — With fewer lynx hunting them, more hares survive long enough to reproduce, and the hare population grows again. This recovery is the fourth leg of the cycle, setting up the next round. Predator–prey systems can oscillate in this way indefinitely.

**41. D** — Hare numbers rise → lynx numbers rise → hare numbers fall → lynx numbers fall → hare numbers rise again. Each population's size is shaped by the other's. This mutual regulation is the defining feature of predator–prey dynamics and was first formalized mathematically by Lotka and Volterra.

**42. B** — Without the natural greenhouse effect, average global temperatures would be well below freezing and most of Earth's water would be locked up as ice. The greenhouse effect makes liquid water possible across most of the planet's surface, which in turn makes life possible. This natural warming is essential — it is the human-driven intensification that is problematic.

**43. A** — Burning coal, oil, and natural gas releases CO<sub>2</sub> that was sequestered in the Earth for hundreds of millions of years. This release vastly outpaces the rate at which the carbon cycle can absorb CO<sub>2</sub> and has driven atmospheric CO<sub>2</sub> to levels not seen in at least 800,000 years. It is the primary driver of recent climate change.

**44. C** — As CO<sub>2</sub> builds up, more outgoing infrared radiation is trapped, raising global temperatures. The resulting warming melts ice, causes sea level to rise, and shifts climate patterns regionally. These effects are now observable across all major Earth systems.

**45. D** — Effective climate strategies aim to reduce greenhouse gas emissions: switching to renewable energy, conserving and restoring forests, and improving efficiency all do this. Burning more coal would do the opposite — it would increase emissions, not reduce them. Therefore D is the EXCEPT (the non-strategy).

**46. B** — Pulling your hand away from a hot stove happens automatically through a spinal reflex arc, before conscious awareness of the pain. The brain is not consulted before the response begins. This speed is the whole point of reflexes — they minimize damage from sudden harmful stimuli.

**47. A** — The neuron is the fundamental signaling cell of the nervous system; it transmits both electrical signals along its membrane and chemical signals across synapses. All nervous-system function ultimately

depends on neurons. The other choices are either subcellular components or different types of biological molecules.

**48. D** — Dendrites are the branching extensions of a neuron that receive incoming signals from other neurons or from sensory receptors. The signal then travels through the cell body and out the axon. Recognizing the parts of a neuron is foundational to understanding nervous-system communication.

**49. C** — In a typical reflex arc, the signal travels from the sensory receptor → sensory neuron → spinal cord (with an interneuron) → motor neuron → muscle. The brain may be informed afterward, but the response itself bypasses higher brain centers. This is what makes a reflex arc both fast and stereotyped.

**50. B** — A reflex arc routes the signal through the spinal cord instead of the brain, eliminating the time required for conscious processing. This rapid response is critical when even a fraction of a second matters — pulling a hand from a hot stove, withdrawing a foot from a sharp object, or blinking against a sudden threat to the eye.