PRACTICE EXAM 10: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

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 biology class observed cells from two sources under a compound light microscope. Students prepared one slide from a thin sample of cheek tissue (animal cells) and a second slide from a thin layer of *Elodea* (aquatic plant) leaf. Students recorded which structures they could clearly identify in each sample. The class data are summarized in the table below.

Structure Observed	Cheek Cells	*Elodea* Cells
Cell membrane	Visible	Visible
Nucleus	Visible	Visible (pushed to one side)
Cytoplasm	Visible	Visible
Cell wall	Not visible	Visible
Chloroplasts	Not visible	Visible (green, moving)
Large central vacuole	Not visible	Visible (large, central)

1. Which group of structures is unique to the *Elodea* (plant) cells in this lab?

A. The cell membrane, nucleus, and cytoplasm of the cells
B. The cell membrane and the visible nucleus only
C. The cytoplasm and the visible cell membrane outside it
D. The cell wall, chloroplasts, and large central vacuole

2. The chloroplasts visible in the *Elodea* cells are most directly involved in:

A. Breaking down glucose to release ATP for the cell's work
B. Capturing light energy to produce glucose by photosynthesis

C. Controlling the cell's activities and storing genetic material
D. Removing waste products from the cell's internal cytoplasm

3. The cell wall in plant cells differs from the cell membrane in that:

A. The cell wall is rigid and provides structural support to the cell
B. The cell wall is fluid and selectively permeable to all substances
C. The cell wall actively transports molecules using ATP energy
D. The cell wall controls the cell's genetic activities and replication

4. The nucleus, which was visible in both cell types, functions to:

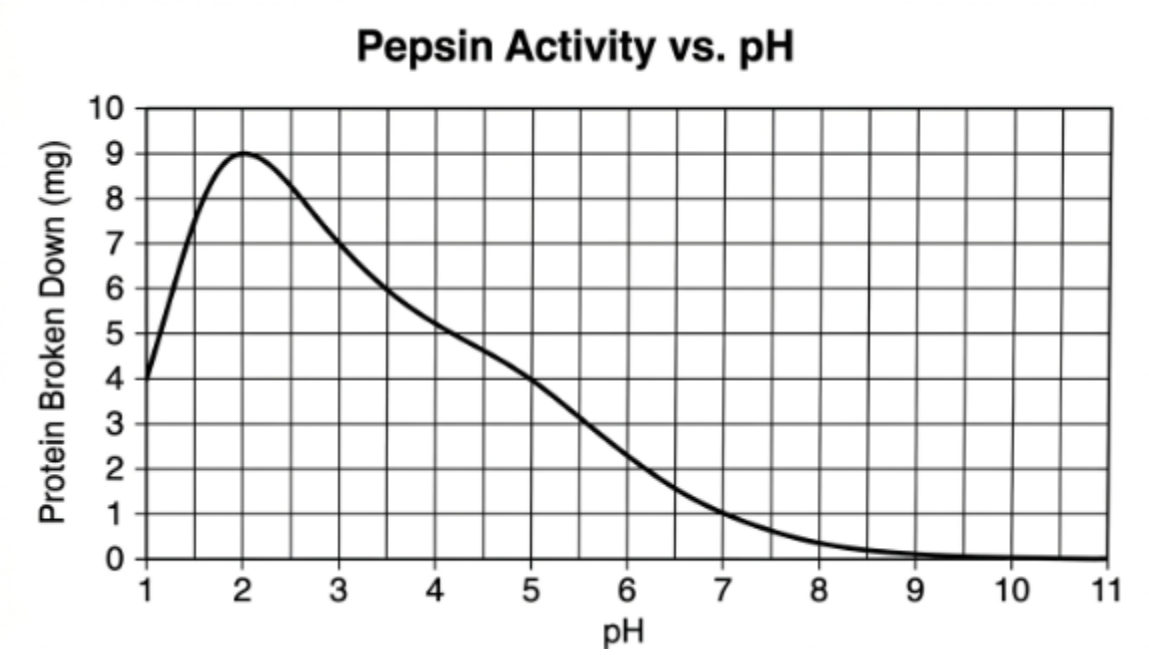
A. Produce ATP from the breakdown of glucose molecules in the cell
B. Package and ship proteins out of the cell through the membrane
C. Store the cell's genetic material and control its activities
D. Photosynthesize sugars when sufficient light is available to the cell

5. Both cheek cells and *Elodea* cells share a cell membrane. The cell membrane functions primarily to:

A. Synthesize glucose from carbon dioxide and water inside the cell
B. Regulate the movement of substances into and out of the cell
C. Provide rigid structural support to maintain the cell's shape
D. Store the cell's genetic material for the next round of division

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

Pepsin is a protein-digesting enzyme produced in the stomach. To study how pH affects pepsin activity, researchers placed equal amounts of pepsin and a standard protein substrate into five test tubes, each buffered to a different pH value. After 30 minutes at 37°C, students measured how much protein had been broken down in each tube. The results appear in the graph below.



6. Based on the graph, the optimal pH for pepsin activity is approximately:

A. pH 2, which matches the highly acidic environment of the stomach
B. pH 5, the pH found in the early section of the small intestine
C. pH 7, which is the neutral pH at which most enzymes function best
D. pH 9, the basic pH typical of the human large intestine cavity

7. At pH 9, pepsin showed almost no activity. The most likely explanation is that:

A. Pepsin's active site became more efficient at higher pH conditions
B. The protein substrate completely dissolved before pepsin could act
C. The basic conditions caused pepsin to digest itself in the test tube
D. The pH change altered pepsin's shape, distorting its active site

8. In the human digestive system, pepsin is most active in the:

A. Mouth, where chewing breaks food into smaller pieces for swallowing
B. Small intestine, where most nutrient absorption takes place
C. Stomach, where strong acid creates the conditions pepsin needs
D. Large intestine, where water is absorbed from undigested food

9. If a small amount of sodium bicarbonate (a base) were added to a tube of pepsin at pH 2, the most likely result would be:

A. The pepsin would suddenly become more active than it was at pH 2
B. The pH would rise and the rate of pepsin activity would decrease
C. The pepsin would convert into a different enzyme entirely
D. The substrate would become a base and resist further digestion

10. The relationship between pepsin's shape and its activity best illustrates which biological principle?

A. The function of a protein depends on its three-dimensional shape
B. All proteins function equally well regardless of their shape
C. Enzymes are consumed in the reactions they catalyze in the body
D. Substrates always change shape to match the enzyme's active site

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

A biology class used a variegated leaf (a leaf with both green and white sections) from a geranium plant to investigate where photosynthesis occurs. The plant was placed in bright light for several hours, then a leaf was removed. The leaf was boiled briefly in alcohol to remove its color, then placed in an iodine solution, which turns blue-black wherever starch is present. The class results are shown below.

Region of Leaf	Color Before Iodine	Color After Iodine
Green areas	Green	Blue-black
White areas	White	Pale yellow-brown

11. The results of this experiment best support which conclusion?

A. Starch is produced equally in both the green and white regions of the leaf
B. Iodine causes photosynthesis to occur in the green parts of the leaf
C. Photosynthesis occurs in the green areas of the leaf, where chlorophyll is present
D. The white areas of the leaf are using starch faster than the green areas

12. The white areas of the variegated leaf did not turn blue-black because they:

A. Were too thin for the iodine solution to penetrate the cell layers
B. Were chemically destroyed during the boiling process in alcohol
C. Had already been used up earlier in the day by the plant's tissues
D. Lack chloroplasts and therefore cannot carry out photosynthesis

13. Boiling the leaf in alcohol is performed in order to:

A. Remove chlorophyll so the iodine color change is easier to see
B. Kill the leaf so that it stops carrying out cellular respiration
C. Convert the starch into glucose for easier detection by iodine
D. Soften the cell walls so chloroplasts can be removed by hand

14. The starch detected by iodine in the green areas was produced from glucose made by the plant. Glucose is the immediate product of:

A. Cellular respiration, which releases ATP from food molecules
B. Photosynthesis, which converts carbon dioxide and water into sugar

C. Transpiration, which moves water from the roots into the leaves
D. Translation, which builds amino acids into a chain of protein

15. If the same experiment were repeated using a plant that had been kept in the dark for two days, the most likely result would be:

A. The green areas would still turn dark blue-black with iodine
B. Both the green and white areas would turn equally dark blue-black
C. The green areas would no longer turn blue-black, as starch would have been used up
D. The white areas would turn dark blue-black instead of the green areas

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

When a person accidentally touches a sharp object, the hand is pulled away almost instantly, often before the brain registers any pain. This rapid response is called a reflex. The pathway involves three main types of neurons: a sensory neuron that carries the signal from the receptor in the skin, an interneuron in the spinal cord, and a motor neuron that sends a signal to the muscles of the arm. The brain receives information about the event afterward.

16. The receptor in this reflex pathway is located in the:

A. Spinal cord, where the interneuron connects the other neurons
B. Brain, which interprets the sensation of pain after the reflex
C. Arm muscles, where the response to the stimulus occurs visibly
D. Skin of the hand, where the sharp object first contacted the body

17. The signal traveling along the sensory neuron toward the spinal cord moves in the form of:

A. An electrical impulse along the length of the neuron's membrane
B. A chemical wave passing through the cytoplasm of one cell only
C. A hormone released into the bloodstream from a nearby gland
D. A pulse of light traveling between the receptor and the spine

18. The muscles of the arm respond to this reflex by:

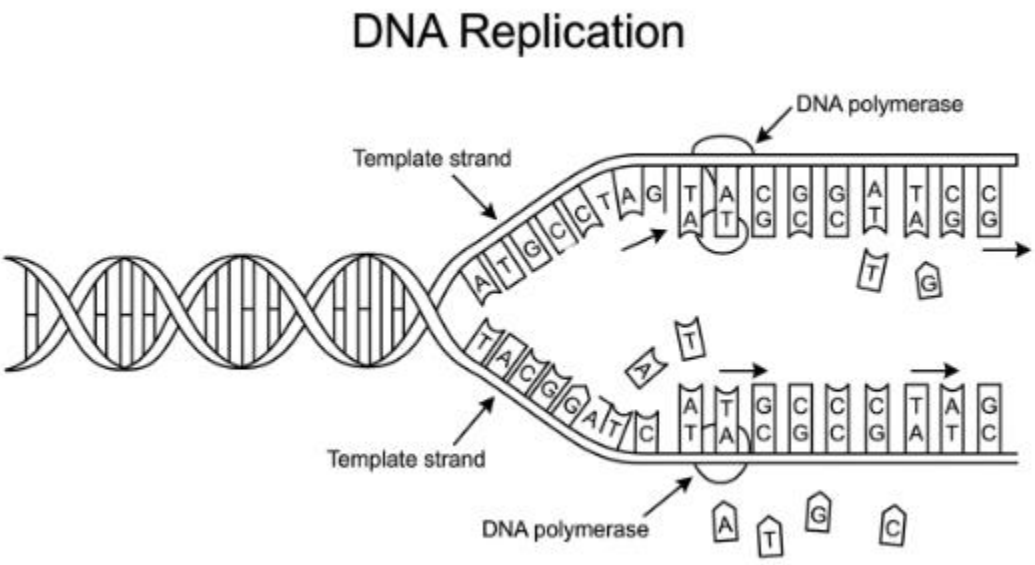
A. Producing new neurons to replace the ones used in the reflex
B. Contracting to pull the hand away from the source of harm
C. Releasing hormones that signal the brain to feel intense pain
D. Slowing down to give the brain time to assess the situation

19. Reflexes such as this one have evolved primarily because they:

A. Allow the brain to process sensory information at higher speed
B. Increase the time required to respond to a dangerous stimulus
C. Provide a fast response that helps protect the body from harm
D. Conserve energy by eliminating the need for any muscle action

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

Before a cell divides, it must accurately copy its DNA. The diagram below represents a section of a DNA molecule being replicated. The original double helix has been "unzipped" by enzymes, and free nucleotides are pairing with the exposed bases on each template strand. Once replication is complete, the cell can proceed through mitosis to produce two genetically identical daughter cells.



20. The enzyme shown at each replication fork, DNA polymerase, functions to:

A. Add complementary nucleotides to each template strand of the DNA
B. Break apart the sugar-phosphate backbone of the original strands
C. Convert the messenger RNA into a strand of complementary DNA
D. Join two protein chains together into a finished enzyme product

21. In the original double helix, an adenine (A) on one strand pairs with which base on the other strand?

A. Cytosine, by means of three hydrogen bonds between the bases
B. Guanine, by means of two hydrogen bonds between the bases
C. Another adenine, forming an unusual pairing between the strands
D. Thymine, by means of two hydrogen bonds between the bases

22. After replication, each new DNA molecule contains:

A. Two completely new strands and none of the original DNA strands
B. One original strand and one newly synthesized complementary strand
C. Two completely original strands and none of the new nucleotides
D. A random mixture of pieces of original and newly made nucleotides

23. The cell carries out DNA replication before mitosis because:

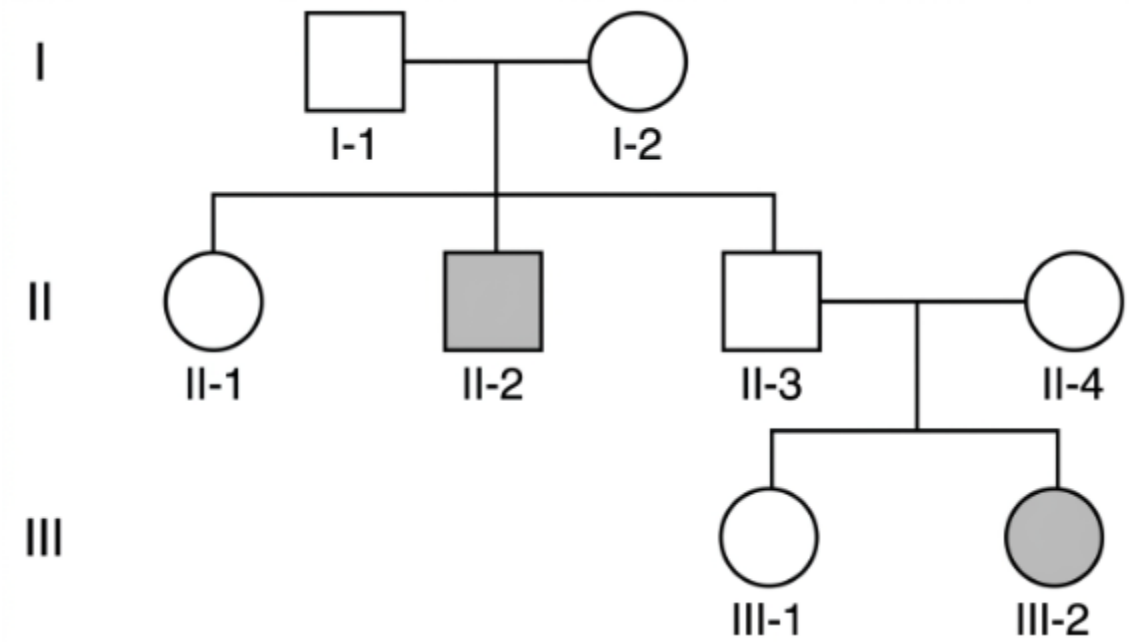
A. The cell needs additional DNA to use as energy during the division
B. The cell will discard half of its original DNA after mitosis occurs
C. Each daughter cell must receive a complete copy of the genetic material
D. The DNA must be broken down so it can fit through the new cell wall

24. Mitosis is best described as a process that produces:

A. Four daughter cells, each with half the chromosomes of the parent
B. Two daughter cells, each with half the chromosomes of the parent
C. Four daughter cells, each genetically different from the parent cell
D. Two daughter cells that are genetically identical to the parent cell

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

The pedigree chart below traces the inheritance of a single human trait through three generations of one family. Affected individuals are shaded; unaffected individuals are unshaded. Females are represented by circles and males by squares. The trait is inherited as a simple recessive trait carried on an autosome (not on a sex chromosome).



25. Since II-2 is affected and his parents I-1 and I-2 are both unaffected, what must be true of the parents' genotypes?

A. Both parents must be homozygous dominant for the trait
B. Both parents must be homozygous recessive for the trait
C. Both parents must be affected by the trait but show no symptoms
D. Both parents must be heterozygous carriers of the recessive allele

26. III-2 is affected, but her parents II-3 and II-4 are both unaffected. The genotype of II-3 must therefore be:

A. Homozygous dominant, since II-3 shows no symptoms of the trait
B. Heterozygous, carrying one dominant and one recessive allele
C. Homozygous recessive, since the trait is recessive in the family
D. Carrying the allele on his Y chromosome alone, not on an autosome

27. If unaffected individual II-1 is found to be a heterozygous carrier and marries an unaffected heterozygous carrier from an unrelated family, what is the probability that any one child will be affected?

A. 25%, the expected ratio from a cross of two heterozygous carriers
B. 50%, the expected ratio when only one parent is a heterozygous carrier
C. 75%, the expected ratio when both parents are homozygous recessive
D. 100%, since the trait is present somewhere in the family pedigree

28. A genetic counselor concludes that this trait is autosomal recessive rather than X-linked recessive. The strongest evidence in this pedigree is that:

A. The affected individuals appear only in the second generation of the family
B. There are more shaded males than shaded females in the pedigree shown
C. An affected female (III-2) appeared from two unaffected parents
D. The affected individuals share genes with their unaffected parents

29. The allele responsible for this trait is described as recessive. A recessive allele:

A. Will always be expressed whenever it is present in the genotype
B. Is found only on the Y chromosome of human males in families
C. Codes for a stronger protein than its dominant counterpart codes for
D. Is expressed only when no dominant allele is present in the genotype

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

Whales are mammals that live entirely in the ocean. Fossil evidence shows that whales evolved from four-legged, land-dwelling ancestors that lived about 50 million years ago. Modern whales still have small bones inside their bodies that are no longer used for walking but that match the bones of the hind limbs in their fossil ancestors. Whales also share many features with other mammals, including warm blood, hair (in some species, at least during early development), and lungs.

30. The small internal bones in modern whales that match the hind-limb bones of their land-dwelling ancestors are best described as:

A. Analogous structures, which evolved independently for similar functions
B. Vestigial structures, which are reduced remnants of ancestral structures
C. Acquired structures, which form anew in each generation of whales
D. Convergent structures, which appear in unrelated species over time

31. The fact that whales share warm blood, lungs, and (in some species) hair with land mammals is best explained by:

A. Common ancestry with other mammals at some point in the past
B. Direct movement of whales between land and sea every generation
C. Whales adapting their cells to be exactly like those of all mammals
D. Random chance that produced the same features in unrelated groups

32. The fossil record of whale ancestors provides evidence that:

A. Whales have not changed in any meaningful way over millions of years
B. Whales were originally created with the exact form they have today

C. Whales evolved from four-legged ancestors over millions of years
D. Whales and fish share recent common ancestors in the ocean environment

33. Modern whales and modern dolphins share many features because:

A. They evolved their similar features by completely independent paths
B. They share a relatively recent common ancestor in their evolutionary history
C. They live in the same lake environment and copy each other's traits
D. Their environments forced their cells to produce the same proteins

34. A scientist compares the DNA sequences of whales and several other groups of animals. Which result would best support the idea that whales evolved from land-mammal ancestors?

A. The DNA sequence of whales is completely identical to that of fish
B. The DNA of whales is more similar to insect DNA than to mammal DNA
C. Whales have no DNA in common with any other vertebrate species
D. Whale DNA is more similar to land-mammal DNA than to fish DNA

35. Comparing the bones of a whale flipper, a bat wing, and a human arm shows similar arrangements of bones even though the limbs are used for very different purposes. These limbs are best described as:

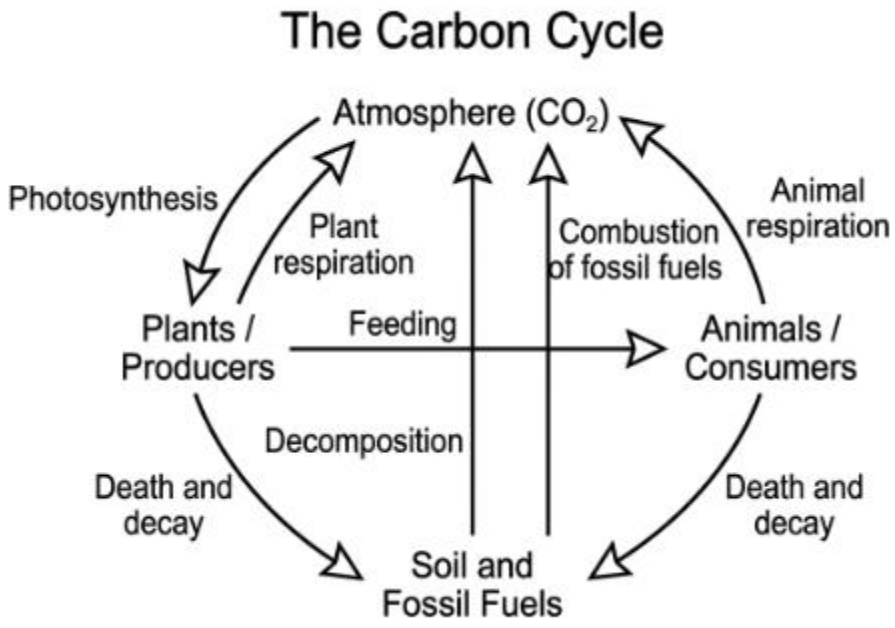
A. Homologous structures, indicating descent from a common ancestor
B. Analogous structures, indicating no common ancestor at all
C. Acquired structures, developed individually during each lifetime
D. Vestigial structures, no longer functional in any modern animal

36. The diversity of mammals — including whales, bats, deer, and humans — that share a common ancestor is best explained by:

A. Each species being designed from scratch with no shared history at all
B. Mammals replacing each other in cycles of birth and death across time
C. Adaptive radiation, in which descendants of a common ancestor adapt to different environments
D. Mammals living in the same lake environment and converging to look alike

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

The carbon cycle describes how carbon atoms move between living organisms, the atmosphere, the oceans, and the Earth itself. The diagram below shows the major processes that move carbon between these reservoirs.



37. According to the diagram, carbon enters the bodies of plants directly from the atmosphere through which process?

A. Plant respiration, which releases stored carbon back into the air
B. Feeding, which transfers carbon from one organism to the next
C. Combustion, which releases carbon from stored fossil fuels
D. Photosynthesis, which uses CO_2 from the air to build glucose

38. Carbon is transferred from plants to animals primarily through which process shown in the diagram?

A. Photosynthesis, by which plants exchange carbon with animals
B. Feeding, in which animals consume plant material containing carbon
C. Combustion, which releases carbon stored in fossil fuels deep underground
D. Decomposition, which breaks down dead plant material in soil

39. The combustion of fossil fuels affects the carbon cycle by:

A. Releasing large amounts of CO_2 that had been stored underground for millions of years
B. Removing CO_2 from the atmosphere and locking it underground permanently
C. Converting fossil fuels into living plants and animals through chemical change
D. Storing carbon in the bodies of plants for the next several centuries

40. The role of decomposers in the carbon cycle, as shown in the diagram, is to:

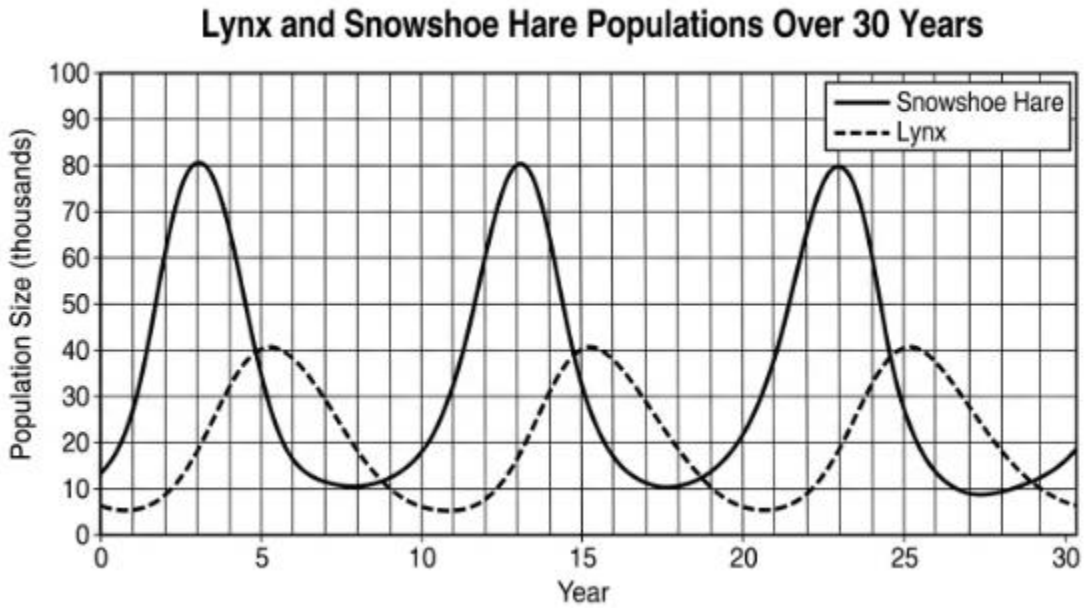
A. Capture solar energy and store carbon in the form of glucose in plants
B. Transfer carbon directly from the atmosphere into the bodies of animals
C. Break down dead organisms and return CO_2 to the atmosphere
D. Burn fossil fuels and release carbon back into the deep soil layers

41. Which process in the diagram both removes carbon from the atmosphere and uses light energy to do so?

A. Animal respiration, which exchanges gases with the atmosphere
B. Photosynthesis, which uses light to convert CO_2 into glucose
C. Combustion, which converts fossil fuels into atmospheric carbon
D. Decomposition, which transfers carbon from soil into the atmosphere

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

Researchers tracked the population sizes of lynxes (a predator) and snowshoe hares (their main prey) in a northern forest ecosystem over 30 years. The two species showed a repeating cyclical pattern, with peaks and valleys lined up in a regular way. The graph below summarizes the data.



42. The lynx population peaks several years after the snowshoe hare population peaks. This pattern is best explained by:

A. The hares respond directly to the size of the lynx population every year
B. The lynxes consume plants and react to changes in plant abundance only
C. The two populations have no actual ecological connection in this forest
D. Abundant hares allow the lynx population to grow shortly after a hare peak

43. When the hare population drops sharply, the lynx population tends to drop as well a short time later because:

A. Reduced prey availability lowers the lynxes' food supply and survival rate
B. Lynxes migrate out of the forest each time the hares begin to decrease

C. The hares produce a chemical that directly poisons the lynx population
D. Lynxes immediately turn into producers and stop eating any animals

44. The repeating oscillations shown in the graph are an example of:

A. A complete loss of biodiversity caused by changes in predator-prey numbers
B. Random fluctuations with no biological relationship between the two species
C. Predator-prey population cycles, in which the two populations rise and fall together
D. Convergent evolution between the two species occurring over a single decade

45. If a disease drastically reduced the snowshoe hare population for many years, the most likely effect on the lynx population would be:

A. The lynx population would immediately increase to record-high levels
B. The lynx population would decline due to reduced food availability
C. The lynxes would become producers and survive without any prey
D. The lynx population would remain unchanged for many decades

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

Since the start of the industrial era, large quantities of fossil fuels have been burned for energy. This combustion releases greenhouse gases, especially carbon dioxide (CO_2), into the atmosphere. Greenhouse gases trap heat near the Earth's surface, gradually raising global average temperatures. The warming has been linked to melting glaciers, rising sea levels, and shifts in the distribution of plant and animal species. Scientists and engineers are developing technologies to monitor greenhouse gas emissions and to reduce the rate at which they are added to the atmosphere.

46. The main source of the recent increase in atmospheric CO_2 is:

A. The natural respiration of living animals in tropical forest ecosystems
B. The decomposition of dead leaves in a single growing season's leaf litter
C. Volcanic eruptions that occur regularly across all continents each year
D. The combustion of fossil fuels for energy, transportation, and manufacturing

47. Greenhouse gases such as CO_2 raise global average temperatures by:

A. Trapping heat radiated from the Earth's surface within the atmosphere
B. Reducing the amount of solar radiation that reaches the Earth from space
C. Cooling the Earth's surface by reflecting sunlight back into space
D. Removing oxygen from the atmosphere and replacing it with carbon

48. One observed consequence of rising global temperatures is:

A. A widespread decrease in the level of CO_2 already in the atmosphere
B. An overall decrease in the average temperature of the global oceans
C. The melting of glaciers and ice sheets, contributing to rising sea levels
D. A reduction in the number of severe weather events seen each year

49. An engineering team is designing a system to monitor greenhouse gas emissions from a city. Which design feature would most directly meet this goal?

A. A large reservoir designed to store rainwater across the metropolitan area
B. A network of CO_2 sensors placed throughout the city to log gas levels
C. A wind turbine that generates electricity from the city's prevailing winds
D. A geothermal pump that heats and cools several individual buildings

50. When comparing competing strategies to reduce greenhouse gas emissions, which factor is most important to consider as a trade-off?

A. The brand of equipment used in each different proposed technology
B. The aesthetic appearance of the equipment installed throughout the city
C. The number of patents the engineering firm has filed in the past year
D. The balance among effectiveness, cost, environmental impact, and feasibility

Practice Exam 10 – Full Answer Key with Explanations

1. D — Cell walls, chloroplasts, and large central vacuoles are characteristic of plant cells but absent in animal cells. The cheek cells observed in the lab lacked all three of these structures. This is the foundational distinction between plant and animal cell types.

2. B — Chloroplasts contain the green pigment chlorophyll and are the site of photosynthesis, where light energy is captured to produce glucose from carbon dioxide and water. They are found only in photosynthetic organisms such as plants and algae. Their movement (cyclosis) helps distribute them where light is most available.

3. A — The plant cell wall is a rigid layer made primarily of cellulose that surrounds the cell membrane and provides shape and structural support. The cell membrane, by contrast, is fluid and selectively permeable. The rigidity of the wall is what keeps plant cells from bursting when they take up water.

4. C — The nucleus contains the cell's DNA and directs all cellular activities by controlling which proteins are produced. It is enclosed by a nuclear envelope with pores that regulate molecular traffic. Both plant and animal cells contain a nucleus, which is why it was visible in both samples.

5. B — The cell membrane is a selectively permeable barrier that controls which substances enter and leave the cell through diffusion, osmosis, and active transport. This regulation is essential for maintaining homeostasis inside the cell. Every living cell, plant or animal, has a cell membrane.

6. A — The graph peaks at pH 2, which matches the highly acidic environment of the human stomach, where pepsin is naturally secreted. Enzymes evolve to function best at the pH found in their normal location. This is why pepsin (stomach) and trypsin (intestine) have very different pH optima.

7. D — Strongly basic conditions disrupt the hydrogen bonds that maintain pepsin's three-dimensional structure, distorting the active site so it can no longer bind substrate. This loss of shape is called denaturation. Once denatured, the enzyme cannot catalyze the reaction even if substrate is abundant.

8. C — Pepsin is secreted into the stomach along with hydrochloric acid, which creates the pH 1.5–2 environment pepsin requires. When food enters the small intestine, pancreatic bicarbonate neutralizes the acid and other proteases (such as trypsin) take over digestion. Location and pH are tightly linked in the digestive tract.

9. B — Adding a base raises the pH away from pepsin's optimum of pH 2, reducing enzyme activity. As pH moves toward neutral or basic, the enzyme's shape begins to distort and its rate falls. This is the chemical principle behind antacid medications that neutralize stomach acid.

10. A — Pepsin's ability to bind and break down protein substrates depends on the precise three-dimensional fit of its active site. When shape is disrupted (by extreme pH, temperature, or chemicals), function is lost. Structure-function relationships are central to all of molecular biology.

11. C — Only the green regions turned blue-black with iodine, showing that starch was produced only where chlorophyll was present. Chlorophyll is required to capture the light energy that drives photosynthesis. The white regions, lacking chlorophyll, produced no starch.

12. D — White regions of variegated leaves lack chloroplasts and therefore have no chlorophyll, so they cannot carry out photosynthesis. With no glucose produced and stored as starch, iodine has nothing to react with and produces no blue-black color. This directly identifies chloroplasts as essential for photosynthesis.

13. A — Boiling the leaf in alcohol dissolves chlorophyll out of the tissue, bleaching the leaf. Without the green color, the dark blue-black iodine reaction is much easier to see. Alcohol is flammable, so the leaf is normally heated indirectly in a water bath.

14. B — Photosynthesis combines carbon dioxide and water using light energy to produce glucose, a simple sugar. The plant then links glucose molecules together into starch for storage in the leaf and other tissues. Iodine detects this stored starch as evidence that photosynthesis has occurred.

15. C — Without light, photosynthesis stops and no new starch is produced; the plant gradually uses up its stored starch through respiration and growth. After two days in darkness, starch reserves are largely depleted. This "destarching" step is often used as a control in classroom photosynthesis experiments.

16. D — The receptor in any reflex is the structure that first detects the stimulus, which here is the sharp object pressing on the skin. Specialized sensory receptors in the skin detect pressure, temperature, and pain. They initiate the action potential that travels along the sensory neuron.

17. A — Nerve signals travel along neurons as electrical impulses (action potentials) caused by rapid ion movement across the cell membrane. These impulses move very quickly from receptor to spinal cord. Chemical signaling (neurotransmitters) is used only at synapses between neurons.

18. B — Motor neurons stimulate the arm muscles to contract, pulling the hand away from the painful stimulus. Muscle contraction is the response in this reflex arc. Because the signal does not need to travel all the way to the brain, the contraction occurs very quickly.

19. C — Reflexes bypass higher brain processing, allowing the body to respond to dangerous stimuli in a fraction of a second. By the time the brain registers pain, the hand has already been withdrawn from harm. This speed is the clear evolutionary advantage of reflex pathways.

20. A — DNA polymerase moves along each template strand and adds complementary nucleotides one at a time, pairing A with T and G with C. This builds the new strand using the original as a guide. DNA polymerase is the central enzyme of DNA replication.

21. D — In DNA, adenine pairs with thymine through two hydrogen bonds, and guanine pairs with cytosine through three hydrogen bonds. This complementary base pairing is the foundation of accurate replication and transcription. It is also why the two DNA strands are antiparallel and held together stably.

22. B — DNA replication is semiconservative: each new double helix consists of one original (template) strand and one newly synthesized complementary strand. This was demonstrated by the Meselson-Stahl experiment. The semiconservative pattern ensures high-fidelity transmission of genetic information.

23. C — Mitosis must distribute a complete genome to each daughter cell, so the DNA must be fully copied before division begins. Replication occurs during the S phase of the cell cycle, before mitosis. Without replication, daughter cells would receive only half the DNA and could not function.

24. D — Mitosis produces two daughter cells that are genetically identical to each other and to the original parent cell, each with the same chromosome number. This contrasts with meiosis, which produces four genetically different cells with half the chromosome number. Mitosis is the basis of growth, tissue repair, and asexual reproduction.

25. D — Two unaffected parents who produce an affected child for a recessive trait must each be heterozygous carriers (Aa × Aa). Each must have passed a recessive allele to II-2. This is the standard Mendelian explanation for a "skipped generation" pattern in autosomal recessive traits.

26. B — III-2 is affected, so she must be homozygous recessive (aa) — meaning each of her parents contributed one recessive allele. Since II-3 is unaffected, he must carry one dominant and one recessive allele, making him heterozygous (Aa). Heterozygotes are also called carriers.

27. A — A cross between two heterozygous carriers (Aa × Aa) produces a 1:2:1 genotypic ratio: 1 AA : 2 Aa : 1 aa. Only the homozygous-recessive offspring (1 in 4) show the trait, giving a 25% probability. This is the classic Mendelian outcome for autosomal recessive disorders.

28. C — Under X-linked recessive inheritance, an affected female requires a recessive allele on both X chromosomes, which means her father must also be affected. Since both of III-2's parents are unaffected, X-linked inheritance is highly unlikely, and autosomal recessive inheritance fits. This is the most diagnostic feature in the pedigree.

29. D — A recessive allele is expressed only when no dominant allele is present, so the trait appears only in homozygous-recessive individuals (aa). Heterozygotes (Aa) appear unaffected because the dominant allele masks the recessive one. This is the basic definition of dominance and recessiveness in Mendelian genetics.

30. B — Vestigial structures are reduced, often nonfunctional remnants of features that were fully functional in evolutionary ancestors. Whale hind-limb bones are a classic example, providing strong anatomical evidence of descent from four-legged ancestors. Vestigial features are one of Darwin's key lines of evidence for evolution.

31. A — Shared features such as warm blood, lungs, and hair indicate inheritance from a common ancestor that already possessed those traits. All mammals share these characteristics because they descended from the same ancestral lineage. Common descent is the simplest explanation for shared, complex features across related groups.

32. C — The whale fossil record documents a series of transitional forms — including *Pakicetus* and *Ambulocetus* — showing gradual change from four-legged land mammals to fully aquatic species over tens of millions of years. These intermediate fossils directly demonstrate evolutionary transition. Whale evolution is among the best-documented examples in the fossil record.

33. B — Whales and dolphins are both cetaceans and share a relatively recent common ancestor, which is why they share so many anatomical, physiological, and genetic features. Closer evolutionary relationships correspond to greater similarity in traits. This is the central principle of common descent.

34. D — Greater DNA similarity reflects more recent shared ancestry. If whale DNA is most similar to that of land mammals, this indicates a closer common ancestor with land mammals than with fish — exactly what fossil evidence already suggests. Molecular evidence and fossil evidence together build very strong evolutionary trees.

35. A — Homologous structures share the same underlying skeletal pattern even though their functions differ, reflecting inheritance from a common ancestor. The whale flipper, bat wing, and human arm all share the same basic arrangement of bones. This is one of the strongest comparative-anatomy evidences for evolution.

36. C — Adaptive radiation is the diversification of one ancestral species into many descendant species adapted to different environments and ecological roles. The wide variety of mammals today reflects this

process operating over tens of millions of years. The Galapagos finches are a smaller-scale example of the same evolutionary pattern.

37. D — Photosynthesis is the process by which plants absorb atmospheric CO_2 and combine it with water using light energy to build glucose. The carbon atoms from CO_2 become incorporated into the plant's organic molecules. This step is the main entry point of inorganic carbon into the biological part of the cycle.

38. B — When animals eat plants, they ingest the carbon stored in plant tissues. Some of this carbon is incorporated into the animal's body and some is released as CO_2 through respiration. Feeding is the main pathway by which carbon moves from producers to consumers in the food web.

39. A — Fossil fuels store carbon that was removed from the atmosphere by organisms living hundreds of millions of years ago. Burning them rapidly releases this ancient carbon as CO_2, adding it to the modern atmosphere far faster than natural processes can remove it. This is the primary driver of the recent rise in atmospheric CO_2.

40. C — Decomposers such as bacteria and fungi break down dead organisms and waste, releasing the stored carbon as CO_2 through their own respiration. This returns carbon to the atmosphere and prevents it from staying locked in dead matter. Decomposition closes the loop in the carbon cycle.

41. B — Photosynthesis is the only process in the diagram that both removes CO_2 from the atmosphere and uses sunlight as its energy source. Plants use captured light to power the conversion of CO_2 and water into glucose. This dual role makes photosynthesis the central energy- and carbon-fixing process of the biosphere.

42. D — More hares mean more food for lynxes, leading to higher lynx survival and reproduction. The lynx population grows in response, but with a lag of one to two years for the population effect to appear. This time-lag is a defining feature of predator-prey cycles.

43. A — Lynxes depend on hares as their main food source, so a drop in the hare population reduces the lynxes' food supply and survival rate. With fewer hares to eat, fewer lynxes survive and reproduce, and the lynx population falls. This tight food dependence is what links the two oscillating curves.

44. C — Repeating, lagged oscillations of predator and prey populations are the textbook signature of predator-prey cycles. As prey numbers rise, predators rise; as predators consume prey, prey numbers fall, and predators then fall in turn. The lynx-hare data are the classic example of this cyclical pattern.

45. B — If hares were eliminated for many years, lynxes would lose their main food supply, causing widespread starvation and a population crash. Predators cannot persist without their prey, even if individuals briefly switch to alternate foods. This illustrates the strong dependence of predators on prey availability.

46. D — The main cause of the recent increase in atmospheric CO_2 is the burning of fossil fuels in transportation, power generation, and industry. Volcanic and biological sources also release CO_2 but at

much smaller rates than human fossil fuel combustion. Isotopic and emissions data confirm the human source.

47. A — Greenhouse gases such as CO_2 allow short-wave solar radiation to pass through the atmosphere but absorb the long-wave infrared heat radiating back from the Earth's surface. This re-radiated heat is trapped in the atmosphere, raising the average surface temperature. This is the greenhouse effect.

48. C — Warmer temperatures cause glaciers and polar ice sheets to melt and ocean water to expand thermally, both contributing to rising sea levels. Higher seas threaten coastal cities, ecosystems, and freshwater supplies. This is one of the most directly observed and measured consequences of climate change.

49. B — A network of CO_2 sensors throughout the city directly measures the variable of interest — greenhouse gas concentrations — and provides real-time data to track emissions across locations and over time. This information can guide emissions reduction policies. The other options do not measure greenhouse gases.

50. D — Engineering decisions involve balancing how effective a solution is against its cost, its environmental impact, and how practical it is to implement at scale. A solution that excels at one criterion but fails on others is rarely the best overall choice. Sound engineering weighs all relevant trade-offs together.