PRACTICE EXAM 5: 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 tested four unknown food samples for the presence of biological macromolecules. Students placed a small portion of each sample into four separate test tubes and added a different indicator to each: Benedict's solution (which turns brick-red when heated in the presence of simple sugars), iodine (which turns blue-black in the presence of starch), biuret reagent (which turns violet in the presence of proteins), and Sudan III (which turns red-orange in the presence of lipids). The color results are summarized in the table below.

Sample	Benedict's (heated)	Iodine	Biuret	Sudan III
Sample 1	Brick-red (positive)	Yellow-brown (negative)	Blue (negative)	Pink (negative)
Sample 2	Blue (negative)	Blue-black (positive)	Blue (negative)	Pink (negative)
Sample 3	Blue (negative)	Yellow-brown (negative)	Violet (positive)	Pink (negative)
Sample 4	Blue (negative)	Yellow-brown (negative)	Blue (negative)	Red-orange (positive)

1. Which sample most likely contains a simple sugar such as glucose or fructose?

A. Sample 4, which turned red-orange when tested with the Sudan III indicator
B. Sample 1, which turned brick-red when heated with the Benedict's solution
C. Sample 2, which turned blue-black when tested with the iodine indicator
D. Sample 3, which turned violet when tested with the biuret reagent indicator

2. Which macromolecule is identified by a positive result with the iodine test?

A. Simple sugars such as glucose and fructose found in many ripe fruits
B. Lipids including triglycerides found in cooking oils and animal fats
C. Proteins composed of long chains of amino acid subunits joined together
D. Starch, a polysaccharide composed of many glucose units linked together

3. Sample 3 most likely contains protein. Which test result most directly supports this conclusion?

A. The violet color produced by the biuret reagent indicates the presence of peptide bonds
B. The brick-red color from the Benedict's solution indicates the presence of amino acid groups
C. The blue-black color from the iodine indicates the helical shape of the protein chains
D. The red-orange color from the Sudan III indicates the presence of long amino acid chains

4. Why must the Benedict's solution be heated to produce a positive result with a simple sugar?

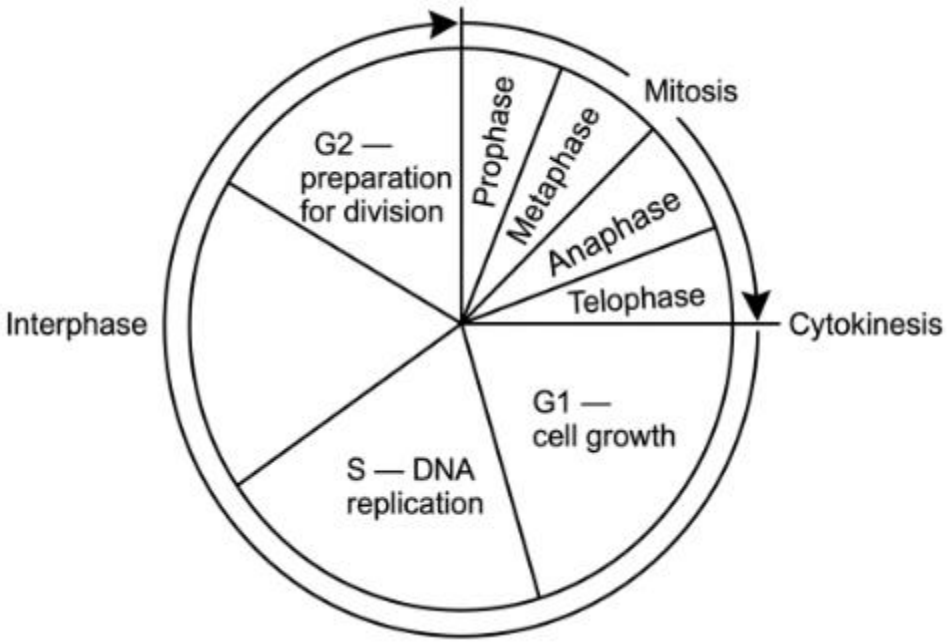
A. Heat causes the simple sugar to break down into smaller glucose units before the test reacts
B. Heat allows the indicator dye to penetrate through the cell membrane of the food sample
C. Heat provides the activation energy required for the reaction between the sugar and copper ions
D. Heat denatures any proteins present, which would otherwise interfere with the indicator color

5. A student tests a fifth sample and finds positive results for both Benedict's and biuret reagent. What is the best conclusion?

A. The sample is a single pure compound containing both sugar and protein groups bonded together
B. The sample contains a mixture of at least one simple sugar and at least one protein
C. The sample is contaminated and the results should be discarded as unreliable for analysis
D. The sample contains a starch molecule that has begun to break down into simpler sugars

Base your answers to questions 6 through 9 on the information below and on your knowledge of biology.

The cell cycle is the regular sequence of events through which a cell grows, copies its DNA, and divides into two new daughter cells. The diagram below shows the major phases of the cycle. Interphase is the longest part of the cycle and includes G1 (cell growth), S (DNA replication), and G2 (final preparation for division). Mitosis follows interphase and is divided into prophase, metaphase, anaphase, and telophase. Cytokinesis then divides the cytoplasm into two daughter cells. Specific regulatory proteins normally control whether a cell advances from one phase of the cycle to the next.



6. During which phase of the cell cycle is DNA copied?

A. The S phase of interphase, when each chromosome is replicated once before division
B. The G1 phase of interphase, when the cell grows and synthesizes new proteins
C. Anaphase of mitosis, when the sister chromatids separate to opposite poles of the cell
D. Cytokinesis, when the cell divides and the cytoplasm is split between the daughter cells

7. What is the most important outcome of mitosis followed by cytokinesis?

A. The production of four genetically unique daughter cells from one original parent cell
B. The reduction of the chromosome number from diploid to haploid in newly formed gametes
C. The formation of egg and sperm cells used in sexual reproduction across generations
D. The production of two genetically identical daughter cells from one original parent cell

8. Cancer cells often have defects in the proteins that regulate the cell cycle. Which outcome is most likely?

A. The cancer cells cannot replicate their DNA and stop dividing within several generations
B. The cancer cells revert to embryonic stem cells and stop expressing most of their genes
C. The cancer cells divide uncontrollably and form a growing mass of cells called a tumor
D. The cancer cells repair all of their genetic damage and divide at a much slower rate

9. A skin cell and a cell lining the small intestine both undergo mitosis throughout life. This continuing division is most important for:

A. Producing genetically diverse offspring for the population over many generations
B. Replacing damaged or worn-out cells in order to maintain healthy body tissues

C. Increasing the number of chromosomes contained in each successive daughter cell
D. Producing gametes used in sexual reproduction and the process of fertilization

Base your answers to questions 10 through 14 on the information below and on your knowledge of biology.

A short DNA gene segment is shown below along with the corresponding mRNA produced through transcription. At a ribosome, the mRNA is translated into a chain of amino acids, with each three-base codon specifying one amino acid. A simplified codon-to-amino acid table is provided for reference.

DNA template strand: 3′ — T A C G G C A T T — 5′
mRNA transcribed: 5′ — A U G C C G U A A — 3′

Codon	Amino Acid
AUG	Methionine (start)
CCG	Proline
CAG	Glutamine
GUG	Valine
UAA	Stop

10. The process by which a DNA sequence is used to produce a complementary mRNA molecule is called:

A. Transcription, which takes place in the nucleus of a eukaryotic cell
B. Translation, which takes place at ribosomes in the cell cytoplasm
C. Replication, which produces two identical DNA molecules from one
D. Mutation, which permanently alters the nucleotide sequence of a gene

11. Where does translation of the mRNA into a chain of amino acids take place?

A. In the cell nucleus, where the original DNA molecule remains located at all times
B. In the mitochondria, where most cellular respiration also takes place in animal cells
C. At the ribosomes, located either free in the cytoplasm or attached to the ER
D. In the Golgi apparatus, where finished proteins are sorted and packaged for export

12. Using the codon table, what is the amino acid sequence specified by the mRNA shown above?

A. Methionine — Valine — Glutamine, encoding three amino acids before any stop signal
B. Methionine — Glutamine — Proline, encoding three amino acids before any stop signal
C. Proline — Methionine — Stop, encoding two amino acids before reaching the stop signal
D. Methionine — Proline — Stop, encoding two amino acids before reaching the stop signal

13. At the ribosome, the codon CCG on the mRNA is read by a transfer RNA molecule carrying:

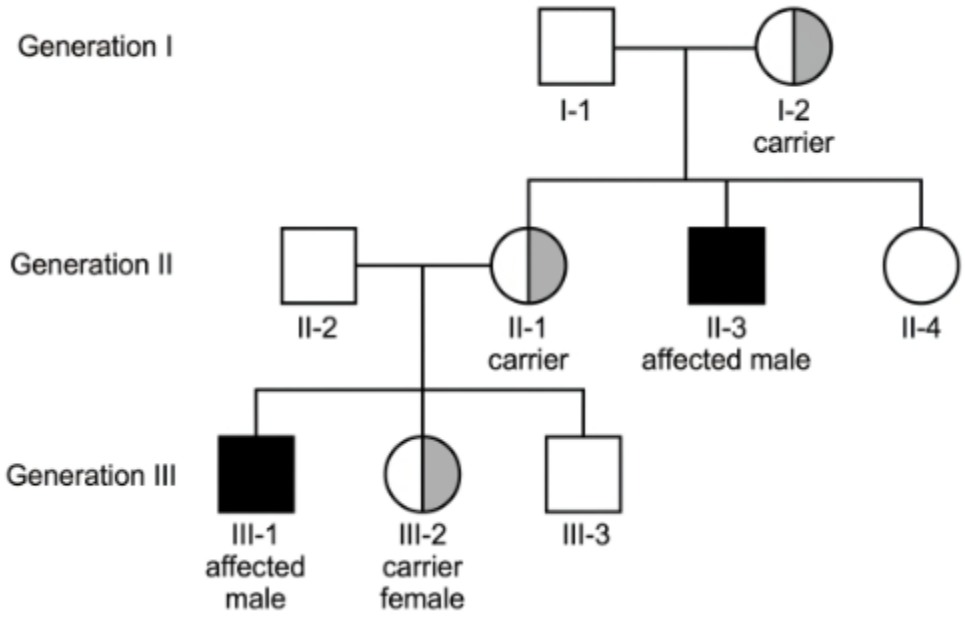
A. The anticodon CCG and the amino acid methionine bound at the opposite end
B. The anticodon GGC and the amino acid proline bound at the opposite end
C. The complementary DNA strand and the amino acid valine bound at the opposite end
D. The codon CCG and the amino acid glutamine bound at the opposite end of the strand

14. A point mutation changes the second mRNA codon from CCG to CAG. What is the most likely consequence?

A. A different amino acid (glutamine) is inserted in place of proline, changing the protein
B. The ribosome will be unable to read the mRNA past the position of the mutated codon
C. The DNA will be unable to undergo replication during the next cell cycle in this cell
D. The mRNA will be transported out of the cell and destroyed before any translation occurs

Base your answers to questions 15 through 19 on the information below and on your knowledge of biology.

The pedigree chart below shows the inheritance of red-green color blindness across three generations of one family. Red-green color blindness is caused by a recessive allele located on the X chromosome. In the chart, circles represent females and squares represent males. Unshaded shapes indicate unaffected individuals, fully shaded shapes indicate affected individuals, and half-shaded circles indicate known carrier females. Horizontal lines connect mated pairs, and vertical lines connect parents to their children.



15. What is the most likely genotype of the affected male in Generation II (individual II-3)?

A. X^BX^B, indicating that he is homozygous for the recessive colorblind allele
B. X^BY, indicating that he carries the dominant normal vision allele on his X chromosome
C. X^bY, indicating that he is hemizygous for the recessive colorblind allele on his X
D. X^BX^b, indicating that he is a heterozygous carrier of the colorblind allele on his X

16. Red-green color blindness is described as a "sex-linked" trait because:

A. The trait is expressed only in males and never in females in any human population
B. The gene is located on chromosome 21, which is one of the autosomal chromosomes
C. The trait is caused by a hormone produced by the sex organs during adolescence
D. The gene is located on the X chromosome, which is one of the two sex chromosomes

17. The carrier mother in Generation I (individual I-2) is unaffected by color blindness because:

A. Her second X chromosome carries the dominant normal allele, which masks the recessive
B. Her second X chromosome has been silenced and provides no genetic information at all
C. Females are protected from all X-linked diseases by hormones produced after puberty
D. The carrier state always provides complete immunity to expression of recessive alleles

18. The carrier mother in Generation II (individual II-1) has children with an unaffected male (II-2). What is the probability that any single son they have will be color blind?

A. 0%, since no recessive allele can be passed to any of the male offspring from either parent
B. 25%, because both parents are heterozygous for the colorblind allele on the X chromosome
C. 50%, since the mother has a one-half chance of passing the recessive X allele to her son
D. 100%, since all sons of a carrier mother are guaranteed to inherit the colorblind allele

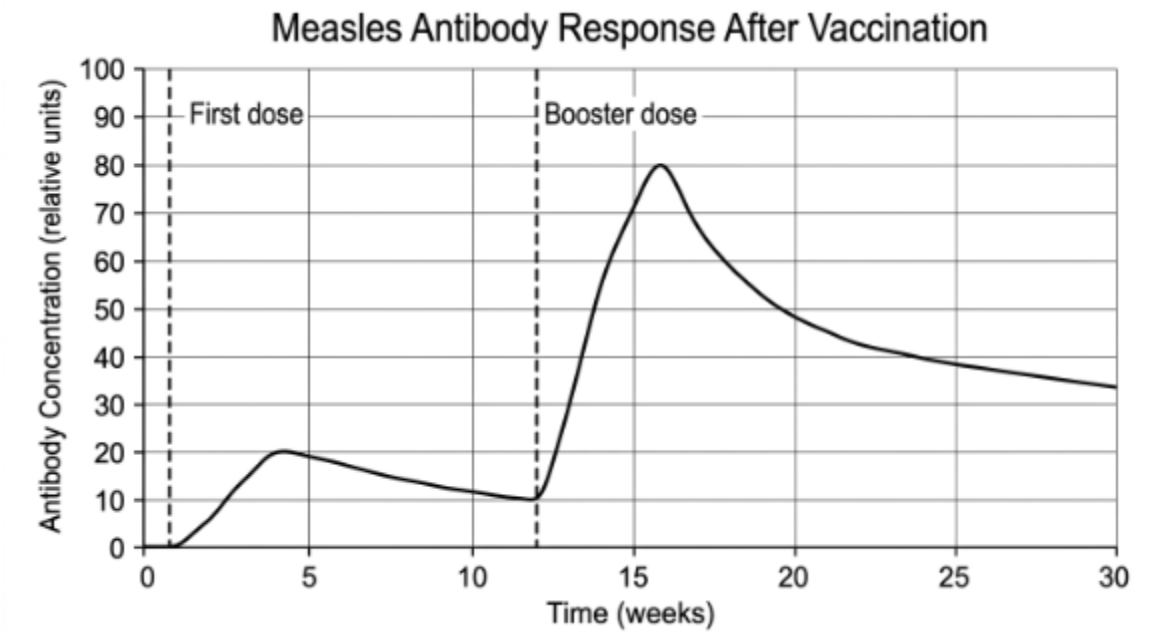
19. Compared with autosomal recessive disorders, X-linked recessive disorders typically show which pattern of inheritance?

A. The disorder appears equally often in males and females across the general population
B. The disorder appears more often in males than in females across the general population
C. The disorder appears more often in females than in males across the general population
D. The disorder appears only in carrier individuals who are themselves unaffected by symptoms

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

A young child receives a vaccine against measles. The vaccine contains weakened (attenuated) measles virus particles that cannot cause disease in a healthy child. After the first vaccine dose, the child's

immune system produces antibodies that recognize specific proteins on the measles virus surface. Several months later, the child receives a second (booster) dose. The graph below shows the concentration of measles-specific antibodies in the child's blood over time, before and after each vaccine dose.



20. The white blood cells that produce antibodies in response to the vaccine are:

A. Red blood cells, which carry oxygen and also produce specific defense molecules
B. Platelets, which clump together at injuries and produce immune defense molecules
C. Phagocytes, which engulf pathogens and directly produce specific antibody molecules
D. B lymphocytes, which produce antibodies specific to the pathogen that triggered them

21. Antibodies provide protection against the measles virus mainly by:

A. Binding to specific surface proteins on the virus and marking it for destruction
B. Producing more virus particles to compete with the original measles virus particles
C. Increasing the rate of mutation in the virus until it can no longer infect any cells
D. Converting all body cells into virus-resistant cells to prevent measles infection

22. The antibody response to the second (booster) dose was much faster and stronger than the response to the first dose. The most likely explanation is:

A. The second dose contained a much higher concentration of weakened virus particles
B. The first dose caused the child to become resistant to all viral pathogens permanently
C. Memory cells produced after the first dose allowed a rapid and stronger secondary response
D. The child's body temperature rose between doses, increasing the speed of the immune system

23. Vaccines containing weakened or inactivated pathogens work by:

A. Killing all pathogens currently in the body that match the type used in the vaccine
B. Replacing the immune system entirely with manufactured immune molecules in the blood
C. Transferring antibodies from another person's blood directly into the patient's body
D. Triggering the immune system to produce antibodies without causing the actual disease

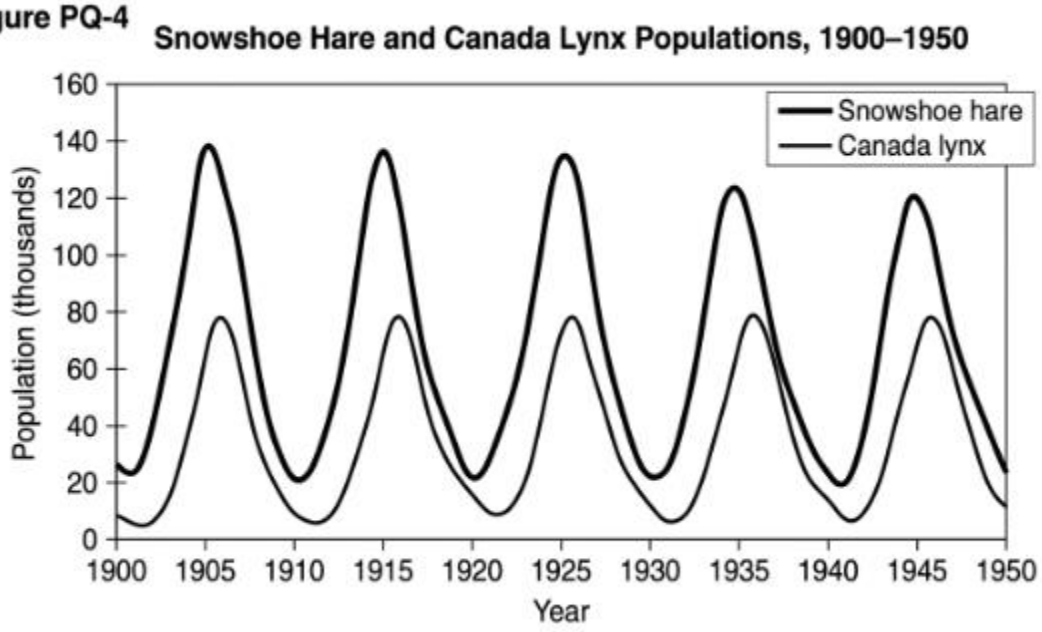
24. When a high percentage of a community is vaccinated, individuals who cannot be vaccinated may still be protected through:

A. Genetic inheritance of immunity from members of the surrounding vaccinated population
B. Herd immunity, in which widespread immunity reduces the circulation of the pathogen
C. Direct antibody production triggered by simple exposure to vaccinated individuals nearby
D. Passive transfer of immune cells from vaccinated individuals to unvaccinated individuals

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

The graph below shows changes in the populations of snowshoe hares and Canada lynx in a northern forest ecosystem over a 50-year period. The lynx is a predator of the hare, and the hare is the lynx's main prey species. Both populations show regular cycles. Hare populations peak roughly every 10 years, and lynx population peaks lag behind hare peaks by approximately one to two years.

Figure PQ-4



25. Which type of relationship best describes the interaction between the lynx and the hare?

A. Mutualism, in which both species benefit from their interaction over a long period
B. Commensalism, in which the lynx benefits while the hare is essentially unaffected

C. Predator-prey, in which the lynx feeds on the hare and influences hare population size
D. Competition, in which both species use the same resources from the surrounding habitat

26. What best explains why lynx population peaks lag one to two years behind hare peaks?

A. Lynx require abundant hares to support reproduction, so the lynx response is delayed
B. Hares migrate into the same area as the lynx with a delay of one to two years each cycle
C. The lynx population cannot begin to reproduce until the hare population starts declining
D. The hare population suddenly switches to an entirely new food source after each peak

27. When the hare population reaches a peak, what is the most likely immediate change in the lynx population?

A. The lynx population suddenly crashes due to overcrowding among predators of the same kind
B. The lynx population remains exactly stable because food is no longer a limiting factor at all
C. The lynx population shifts entirely to a new prey species available in the same ecosystem
D. The lynx population begins to grow because abundant prey can support more lynx individuals

28. What happens to the hare population shortly after the lynx population reaches a peak?

A. The hare population also peaks at exactly the same level as the lynx population
B. The hare population begins to decline because of increased predation by abundant lynx
C. The hare population stops cycling and stabilizes at a constant equilibrium level over time
D. The hare population evolves new fur colors that make individuals invisible to the lynx

29. What term describes the maximum population size of hares that the forest ecosystem can sustainably support over time?

A. Population density, the number of individuals per unit area in a given habitat at one time
B. Limiting factor, any condition that restricts the growth of a population over a period of time
C. Carrying capacity, the maximum population size that the environment can sustainably support
D. Logistic growth, the pattern of population growth that gradually approaches a fixed upper limit

Base your answers to questions 30 through 35 on the information below and on your knowledge of biology.

A botanist used a device called a potometer to measure how environmental conditions affect the rate of water uptake — and indirectly, the rate of transpiration — in a leafy plant cutting. The cut stem of the plant was sealed into a tube of water connected to a graduated capillary. As water evaporated from the leaves, more water moved up through the stem, and the position of an air bubble in the capillary tube was recorded each minute. The plant was exposed to four different conditions in turn, and the average rate of water uptake under each condition is shown below.

Condition	Rate of Water Uptake (mm/min)
Still air, room temperature	1.0
Moving air (fan), room temperature	3.2
Still air, warmer temperature	2.5
Still air, room temperature, leaves coated with petroleum jelly on the underside	0.1

30. Water lost from the plant during transpiration exits primarily through:

A. Stomata, small adjustable pores located mostly on the undersides of leaves
B. The cell walls of the root cortex, which are located underground in the soil
C. The phloem tubes, which transport sugars throughout the body of the plant
D. The waxy cuticle that covers the upper surface of most of the plant's leaves

31. Why did the rate of water uptake increase when a fan was used to move air across the leaves?

A. The fan provided additional kinetic energy directly to the water inside the plant stem
B. The fan removed humid air from near the leaves, steepening the water-vapor gradient
C. The fan caused the leaves to perform photosynthesis at a higher rate than normal
D. The fan provided extra oxygen which is required for water to move upward in the stem

32. Coating the underside of the leaves with petroleum jelly nearly stopped water uptake because the petroleum jelly:

A. Chemically converted water into oxygen gas before it could exit the leaf surfaces
B. Prevented sunlight from reaching the chloroplasts in the cells of the plant leaves
C. Caused the cells of the leaves to die within several minutes of being applied
D. Blocked the stomata, preventing water vapor from escaping out of the leaves

33. The plant tissue that conducts water from the roots upward to the leaves is:

A. Phloem, a tissue made of living cells that transports sugars throughout the plant
B. Cambium, an actively dividing tissue that produces new wood and bark each year
C. Xylem, a tissue made of hollow non-living cells that conducts water upward
D. Epidermis, a single outer cell layer that protects the leaf and stem surfaces

34. Increasing the temperature of the surrounding air increased the rate of water uptake because:

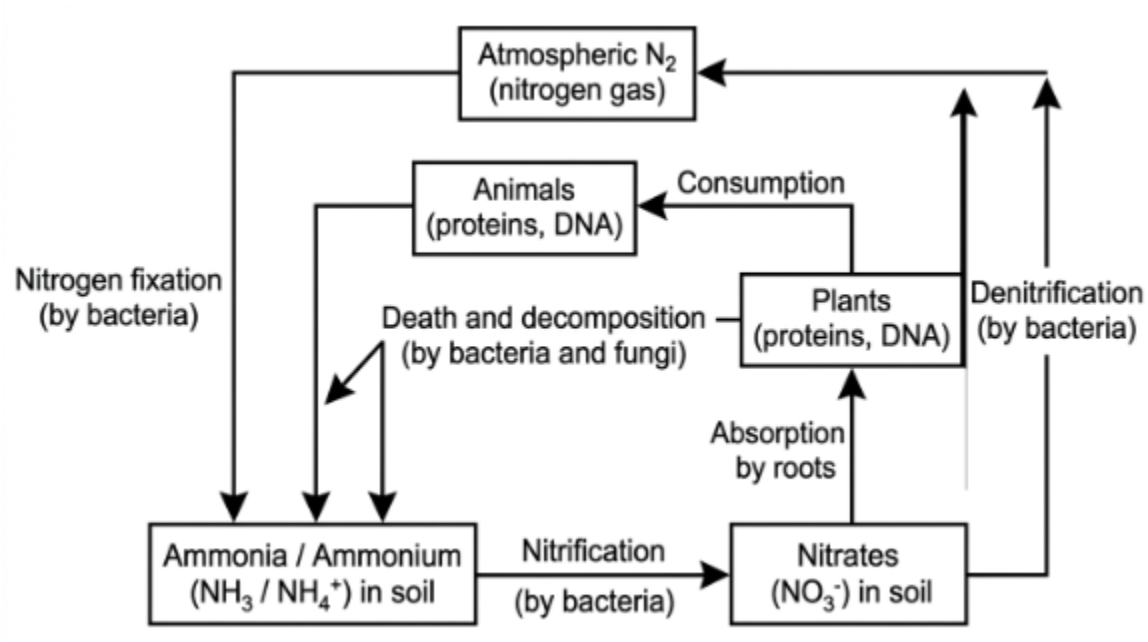
A. Higher temperatures increase the rate at which water evaporates from the leaf surface
B. Higher temperatures cause the stomata to close, trapping water inside the plant
C. Higher temperatures damage the root hairs, allowing more water to escape upward
D. Higher temperatures reduce the surface tension of water inside the xylem vessels

35. What is the most important benefit that transpiration provides to the plant?

A. Transpiration provides the carbon dioxide needed for photosynthesis inside the leaves
B. Transpiration pulls water and dissolved minerals upward from the roots to the leaves
C. Transpiration produces the oxygen gas released into the air by photosynthesizing leaves
D. Transpiration directly produces the glucose used as fuel by all of the plant's cells

Base your answers to questions 36 through 40 on the information below and on your knowledge of biology.

Although nitrogen gas (N_2) makes up about 78 percent of Earth's atmosphere, most organisms cannot use it directly. Nitrogen must first be converted into usable compounds such as ammonia or nitrates before it can be incorporated into proteins and nucleic acids. The nitrogen cycle moves nitrogen between the atmosphere, soil, and living organisms through several biological and physical processes. The simplified diagram below shows the main steps of the cycle.



36. Why can most living organisms not use atmospheric nitrogen gas directly?

A. Atmospheric nitrogen gas is too small a molecule to be absorbed by cells in any organism
B. Atmospheric nitrogen gas is too toxic to be taken into the living cells of any organism
C. Atmospheric nitrogen gas is found only in the upper atmosphere, far above living organisms
D. The triple bond in nitrogen gas is very strong and requires specialized enzymes to break

37. What is the role of nitrogen-fixing bacteria in the nitrogen cycle?

A. They consume nitrates from the soil and release atmospheric nitrogen back into the air
B. They convert ammonia in the soil into nitrates that are then absorbed by plant roots
C. They convert atmospheric nitrogen gas into ammonia, a form usable by living organisms
D. They break down dead plant and animal matter, returning nitrogen compounds to the soil

38. Plants obtain the nitrogen they need to build proteins and nucleic acids primarily by:

A. Absorbing nitrates and ammonium ions from the soil through their root systems
B. Absorbing nitrogen gas directly from the atmosphere through their leaf surface pores
C. Capturing insects and digesting them to obtain nitrogen from animal tissue at the roots
D. Producing their own nitrogen compounds through photosynthesis using sunlight and water

39. Decomposers such as bacteria and fungi contribute to the nitrogen cycle by:

A. Converting nitrate molecules in the soil directly back into atmospheric nitrogen gas
B. Producing nitrogen gas inside their cells and releasing it into the surrounding soil
C. Synthesizing new proteins from atmospheric nitrogen for direct uptake by plant roots
D. Breaking down dead organisms and waste, returning nitrogen compounds to the soil

40. What is the role of denitrifying bacteria in this cycle?

A. They convert nitrogen gas in the atmosphere into ammonia that plants can readily absorb
B. They convert nitrates in the soil back into nitrogen gas that is released to the atmosphere
C. They break down proteins in dead organisms, releasing free amino acids into the soil
D. They produce ammonia from amino acids during the decomposition of animal waste material

Base your answers to questions 41 through 45 on the information below and on your knowledge of biology.

Symbiosis describes close, long-term ecological relationships between two different species. Mutualism benefits both species involved. Commensalism benefits one species while leaving the other essentially unaffected. Parasitism benefits one species while harming the other. The table below describes four ecological relationships observed in different ecosystems.

Relationship	Description
Relationship 1	Clownfish live among the stinging tentacles of a sea anemone, gaining protection from predators while keeping the anemone's tentacles free of debris and small parasites
Relationship 2	Cattle egrets follow grazing cattle and feed on insects that the cattle disturb while moving; the cattle themselves are not affected by the birds' presence
Relationship 3	Tapeworms live in the intestines of a host mammal, absorbing nutrients from the host's digested food and causing weight loss and weakness in the host

Relationship 4	Bees visit flowers to collect nectar, and as they move from flower to flower they transfer pollen, allowing the plants to reproduce sexually

41. Relationship 1 between the clownfish and the sea anemone is best classified as:

A. Commensalism, since the clownfish benefits while the anemone is essentially unaffected
B. Parasitism, since the clownfish gains protection at the expense of the sea anemone
C. Mutualism, since both the clownfish and the anemone benefit from the relationship
D. Competition, since both species compete for the same resources in their habitat

42. Relationship 2 between cattle egrets and cattle is best classified as:

A. Commensalism, since the egret benefits while the cattle are essentially unaffected
B. Mutualism, since the egrets clean parasites off the cattle while gaining food themselves
C. Parasitism, since the egrets reduce the amount of food available for cattle to eat
D. Predation, since the egrets actively hunt and consume the cattle as a major food source

43. Relationship 3 between the tapeworm and the host mammal is best classified as:

A. Mutualism, since both species benefit from sharing nutrients inside the host's intestine
B. Parasitism, since the tapeworm benefits while harming the host mammal's overall health
C. Commensalism, since only the tapeworm benefits but the host mammal is unaffected
D. Competition, since the tapeworm and the host compete for the same digested food

44. Relationship 4 between bees and flowering plants is best classified as:

A. Parasitism, since the bees steal valuable resources from the flowering plant species
B. Predation, since the bees consume and destroy the flowers as their main food source
C. Commensalism, since the bees benefit but the plants are essentially unaffected at all
D. Mutualism, since the bees gain nectar while the plants are pollinated and able to reproduce

45. Across all four relationships, which feature most clearly distinguishes mutualism from commensalism?

A. Mutualism requires that the two species live inside the bodies of one another at all times
B. Mutualism requires that one species be a plant and that the other species be an animal
C. Mutualism benefits both of the species, while commensalism benefits only one species
D. Mutualism is permanent in nature, while commensalism lasts only for one season per year

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

Each year, millions of hectares of tropical rainforest are cleared for agriculture, timber, and urban development. Researchers monitoring a cleared region of the Amazon rainforest have documented sharp declines in local species diversity, increased runoff and soil erosion, and reduced rainfall in some downwind regions. Engineers and ecologists have proposed several approaches to slow or reverse these effects, including selective logging, large-scale reforestation, and the establishment of legally protected areas.

46. Why does deforestation typically cause a sharp decline in local biodiversity?

A. Many specialized species lose the habitat and food resources they require to survive
B. The remaining trees produce excess oxygen, which is toxic to most rainforest species
C. The reduced canopy temperature destroys the eggs of all rainforest insect species
D. Deforestation triggers harmful genetic mutations in wildlife that reduce overall fitness

47. Why does deforestation typically increase soil erosion in the cleared region?

A. The soil becomes too cold to retain water once the protective canopy has been removed
B. The remaining roots release chemicals that break down soil particles into smaller pieces
C. The cleared region absorbs more sunlight, which evaporates the soil minerals into the air
D. Without root systems to hold soil and canopy to slow rainfall, runoff carries soil away

48. Deforestation can reduce rainfall in some downwind regions because:

A. Cleared land releases stored salt into the atmosphere, blocking moisture from clouds
B. Trees normally release water vapor through transpiration, contributing to local rainfall
C. Cleared land cools the surrounding air, preventing the formation of any rain clouds
D. Trees absorb rainfall before it can reach the ground, increasing downwind moisture levels

49. How does large-scale deforestation contribute to rising atmospheric CO_2?

A. Cleared land releases nitrogen compounds that combine with oxygen to form CO_2 directly
B. The remaining trees absorb less CO_2 because of increased sunlight reaching the canopy
C. Burning and decay of the cleared trees releases stored carbon into the atmosphere as CO_2
D. Cleared land produces methane gas, which is then converted to atmospheric CO_2 by sunlight

50. When evaluating reforestation as a long-term strategy to address deforestation, the most important trade-off to weigh is:

A. The balance among ecological benefit, cost, land availability, and time to maturity
B. The visual appearance of the new planted forest compared to the original rainforest cover
C. The number of academic papers published about the reforestation project each year
D. The level of public interest in tree planting expressed on social media each month

Practice Exam 5 — Full Explained Answer Key

1. B — A positive Benedict's reaction (brick-red after heating) is the classic test for reducing sugars such as glucose and fructose. Only Sample 1 produced this result, identifying it as the simple sugar. The other indicators in Sample 1 remained negative, ruling out starch, protein, and lipid.

2. D — Iodine reacts with the helical structure of starch to produce a distinctive blue-black color, making it the standard indicator for polysaccharide starch. Simple sugars, proteins, and lipids do not produce this reaction. The blue-black result in Sample 2 therefore identifies it as containing starch.

3. A — The biuret reagent reacts with peptide bonds between amino acids, producing a violet color in the presence of proteins. Because Sample 3 turned violet with biuret while remaining negative for the other indicators, it must contain a protein. This test is widely used for general protein detection.

4. C — The reaction between reducing sugars and the copper(II) ions in Benedict's solution requires heat to provide the activation energy needed to reduce Cu^{2+} to Cu^{+}, which precipitates as brick-red copper(I) oxide. Without heating, the reaction proceeds too slowly to give a visible color change. This is why Benedict's testing is always done in a hot water bath.

5. B — Each indicator reacts only with its specific macromolecule, so simultaneous positive results identify the presence of both classes of molecule. Positive Benedict's and biuret responses indicate a mixture of at least one reducing sugar and at least one protein. Many real foods (such as milk or beans) routinely give multiple positive results for this reason.

6. A — DNA replication occurs during the S (synthesis) phase of interphase, when each chromosome is duplicated exactly once to prepare for division. Replication outside of S phase would disrupt the orderly progression of the cell cycle. This timing ensures every daughter cell receives a complete genome.

7. D — Mitosis followed by cytokinesis produces two daughter cells that are genetically identical to each other and to the parent cell. This is fundamentally different from meiosis, which produces four genetically variable haploid gametes. Identical-copy production is essential for growth and tissue maintenance.

8. C — Cell cycle checkpoint proteins normally prevent inappropriate progression through the cycle; when these regulators are damaged, cells divide without restraint and accumulate as a tumor. Loss of regulatory control — not loss of replication ability — is the defining feature of cancer. This explains why mutations in genes such as p53 are so commonly found in cancers.

9. B — Body tissues like skin and intestinal lining are continuously worn away or shed and must be replaced by mitotic division of nearby cells. Mitosis produces the identical replacement cells these tissues require. Without ongoing mitosis, normal tissue maintenance and wound healing would be impossible.

10. A — Transcription is the process by which an mRNA strand is built using a DNA template, and in eukaryotic cells it takes place inside the nucleus where the DNA is housed. The mRNA then exits the nucleus to be translated. Replication and translation are separate processes with distinct products.

11. C — Translation — the assembly of an amino acid chain from an mRNA template — occurs at ribosomes, which are either free in the cytoplasm or bound to the rough endoplasmic reticulum. The ribosome reads codons in groups of three and links the corresponding amino acids. Without ribosomes, protein synthesis cannot occur.

12. D — Reading the mRNA 5′-AUG-CCG-UAA-3′ codon by codon and consulting the table gives methionine (AUG), proline (CCG), and stop (UAA). The stop codon terminates translation without adding an amino acid, so only methionine and proline are incorporated. The resulting protein chain is only two amino acids long.

13. B — Each tRNA carries an anticodon complementary and antiparallel to its mRNA codon, plus the specific amino acid that codon encodes. The anticodon for CCG is GGC, and the codon CCG specifies proline in the genetic code. Codon–anticodon pairing is the basis of the genetic code's accuracy.

14. A — Changing CCG to CAG substitutes one amino acid (proline) with another (glutamine) at that position in the protein. Because amino acid changes can alter protein folding and function, this missense mutation can have significant biological consequences. The ribosome continues reading without trouble; only the encoded amino acid changes.

15. C — Because males have only one X chromosome, an affected male carries one copy of the recessive allele on his X and a Y from the father — written X^bY and described as hemizygous. There is no second X to mask the recessive allele, so the trait is expressed. This hemizygous condition is why X-linked recessive disorders are far more common in males.

16. D — A trait is called sex-linked when its gene resides on one of the sex chromosomes; for red-green color blindness the gene is on the X chromosome. Its inheritance pattern therefore differs by sex. The term refers strictly to chromosomal location, not to expression by sex alone.

17. A — A heterozygous female has one X with the recessive colorblind allele (X^b) and one X with the dominant normal allele (X^B); the dominant allele directs the production of functional photoreceptor pigment. The recessive allele is masked, so she has normal color vision but can pass X^b to offspring. This is the standard definition of a carrier for an X-linked recessive trait.

18. C — A carrier mother (X^BX^b) passes either X^B or X^b with equal probability, and any son receives a Y from the father. The son's phenotype therefore depends entirely on which X he receives from the mother, giving a 50 percent chance of being color blind. This is the classic outcome for sons of a carrier mother and an unaffected father.

19. B — Because males only need to inherit one copy of an X-linked recessive allele to be affected, while females need two copies, the disorder appears far more often in males. Carrier females usually outnumber affected females. This sex bias is a hallmark of X-linked recessive inheritance.

20. D — B lymphocytes are the white blood cells that recognize specific antigens and differentiate into plasma cells that secrete antibodies tailored to those antigens. This specificity is the basis of the adaptive immune response. Red cells, platelets, and phagocytes do not produce antibodies.

21. A — Antibodies are Y-shaped proteins whose binding sites lock onto specific surface antigens of a pathogen, neutralizing it and tagging it for destruction by phagocytes and the complement system. This targeted binding is the central mechanism of antibody-mediated immunity. Antibodies do not directly destroy viruses on their own.

22. C — After the first dose, the immune system produces memory B cells specific to the measles antigens; these cells respond rapidly and strongly upon re-exposure to the booster dose. The result is the larger, faster antibody peak seen on the graph. This memory response is the basis for the long-lasting protection vaccines provide.

23. D — Weakened or inactivated pathogens cannot cause disease but still present recognizable antigens to the immune system, which responds by producing specific antibodies and memory cells. This trains the body to respond rapidly to future real infections. The patient gains immunity without ever experiencing the disease itself.

24. B — Herd immunity occurs when enough of a population is immune that a pathogen cannot spread efficiently, indirectly protecting individuals who cannot be vaccinated themselves (such as infants or the immunocompromised). High vaccination coverage interrupts chains of transmission. This is why population-level vaccination thresholds are a major public-health goal.

25. C — The lynx is a carnivore that depends on snowshoe hares as its main prey, and changes in hare abundance drive changes in lynx abundance. This is the textbook predator-prey relationship. The data set is the classic Hudson's Bay fur-trade record used in ecology courses.

26. A — Lynx reproduction and survival depend on hare availability, so it takes time for an increase in hares to translate into more lynx offspring reaching adulthood. The lynx peak therefore trails the hare peak by one to two years. Time delays of this kind are typical of predator-prey population cycles.

27. D — When hares are abundant, lynx have ample food, leading to better reproductive success and reduced mortality, so the lynx population begins to grow. This is the upswing portion of the predator's cycle. Food availability is the limiting factor that drives the predator response.

28. B — A large lynx population consumes hares at a high rate, eventually exceeding the hare reproductive rate and driving the hare population downward. This is the classic feedback that creates the oscillation. Once hares decline, lynx soon follow.

29. C — Carrying capacity is the maximum population size that an environment can sustain indefinitely given available resources, often abbreviated K. It is the ceiling around which logistic growth oscillates. Recognizing K is fundamental to understanding population regulation.

30. A — Stomata are adjustable pores typically located on the lower leaf epidermis through which gas exchange and water-vapor loss occur. The waxy cuticle and surrounding cells limit loss elsewhere on the leaf, making stomata the main exit point for transpired water. This is why blocking the lower surface so dramatically reduces transpiration.

31. B — Moving air sweeps away the humid layer that builds up next to the leaf surface, maintaining a steep water-vapor concentration gradient between the leaf interior and the surrounding atmosphere. A steeper gradient drives a higher rate of diffusion and therefore faster transpiration. This is why wind dries plants out so quickly.

32. D — Petroleum jelly forms a physical barrier across the stomatal pores, preventing water vapor from diffusing out of the leaf. With the main exit route sealed, transpiration nearly stops and water uptake drops to a trickle. This confirms that stomata are the principal site of water loss.

33. C — Xylem is composed of hollow, non-living tubular cells (tracheids and vessel elements) that conduct water and dissolved minerals upward from roots to leaves. Phloem, in contrast, carries sugars throughout the plant. The directional, one-way water transport is the defining feature of xylem.

34. A — Higher temperatures increase the kinetic energy of water molecules, raising the rate at which liquid water evaporates from the moist surfaces of mesophyll cells inside the leaf. More rapid evaporation drives more rapid replacement from the xylem stream. Temperature is therefore a major environmental control on transpiration rate.

35. B — As water evaporates from the leaves, cohesion among water molecules generates a continuous "transpirational pull" that draws water and dissolved minerals up the xylem from the roots. This is the central mechanism by which plants distribute mineral nutrients absorbed in the soil. Without transpiration, long-distance water transport in tall plants would be impossible.

36. D — The two atoms in N_2 are held together by a triple covalent bond that is one of the strongest bonds in chemistry, requiring large amounts of energy to break. Most organisms lack the specialized enzymes (nitrogenases) needed to break this bond. As a result, atmospheric N_2 is biologically inaccessible to nearly all organisms.

37. C — Nitrogen-fixing bacteria — such as *Rhizobium* in legume root nodules — use the enzyme nitrogenase to convert atmospheric N_2 into ammonia (NH_3), the first biologically usable form of nitrogen. This step is the gateway that brings nitrogen into the food web. Without nitrogen fixation, plant growth would be severely limited.

38. A — Plants absorb nitrogen from the soil mainly as nitrate (NO_3^-) and ammonium (NH_4^+) ions taken up by their roots and assimilated into amino acids inside plant cells. They cannot use atmospheric N_2 directly. Soil nitrogen availability is therefore a major limit on plant productivity.

39. D — Decomposers break down proteins and nucleic acids in dead organisms and waste, releasing ammonia and other nitrogen-containing compounds back into the soil (a process called ammonification). This recycled nitrogen becomes available again to plants. Without decomposers, nitrogen would remain locked in dead biomass.

40. B — Denitrifying bacteria use nitrate as an electron acceptor under low-oxygen (anaerobic) conditions, converting NO_3^- back into atmospheric N_2. This step returns fixed nitrogen to the atmospheric reservoir and closes the cycle. Denitrification is especially important in waterlogged soils and sediments.

41. C — In a mutualistic relationship, both partners receive measurable benefits. The clownfish gains protection from predators among the anemone's stinging tentacles, and the anemone receives cleaning of debris and parasites along with deterrence of fish that nibble its tentacles. Both partners benefit, which is the hallmark of mutualism.

42. A — Commensalism is a relationship in which one species clearly benefits while the other is essentially unaffected. The egrets gain easy access to disturbed insects, while the cattle neither gain nor suffer measurable cost. This is the classic example used to define commensalism.

43. B — Parasitism is a relationship in which one species benefits at the direct expense of the other. Tapeworms absorb the host's nutrients and cause weight loss, weakness, and other health effects. The asymmetric harm to the host is what distinguishes parasitism from mutualism or commensalism.

44. D — Pollination benefits both partners: the bee obtains nectar and pollen as food, while the plant gets its pollen transported to other flowers, enabling sexual reproduction. Both gain measurable fitness benefits. Bee-flower pollination is a textbook example of mutualism.

45. C — The two relationships differ in how the second species fares. In mutualism, both partners benefit, while in commensalism only one benefits and the other is unaffected. The presence or absence of benefit to the second species is the defining distinction between these categories.

46. A — Many rainforest species are highly specialized for the specific microhabitats, food plants, or hosts found only in intact forest. When the forest is cleared, these resources disappear, and specialist species cannot survive in the altered habitat. Habitat loss is the leading cause of species extinction worldwide.

47. D — Tree roots physically bind soil particles together, and the forest canopy intercepts rain before it strikes the ground, slowing its impact. Removing both protections allows raindrops to dislodge soil and rapid runoff to wash it away. The result is severe erosion in newly cleared land.

48. B — Tree leaves continuously release water vapor through transpiration, contributing moisture to the atmosphere that can later condense and fall as rain downwind. Removing large forest tracts reduces this moisture input and can lower downwind rainfall. This atmospheric water-cycling role of forests is well-documented for the Amazon basin.

49. C — Tropical forests store enormous amounts of carbon in living biomass. When trees are burned for clearing or left to decompose, that carbon is rapidly oxidized and released to the atmosphere as CO_2. Deforestation is therefore a significant source of anthropogenic greenhouse-gas emissions.

50. A — Engineering and ecological projects must balance multiple competing factors: how well the project restores ecosystem function, what it costs, how much land is available, and how long replanted trees take to mature into functional forest. Optimizing only one criterion ignores the rest and leads to poor outcomes. Systems-level evaluation is central to environmental decision-making.