PRACTICE EXAM 6: 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.

Stomata are small pores in the epidermis of plant leaves that allow gas exchange between the leaf and the atmosphere. A biology class studied stomata by peeling thin transparent layers from the underside of a *Tradescantia* (spiderwort) leaf and observing them under a compound microscope. Each opening is bordered by two guard cells whose shape changes to open or close the pore. Students recorded the number of open stomata per square millimeter at different times of day on a single leaf kept under normal outdoor sunlight conditions.

Time of Day	Open Stomata per mm^2
6:00 AM (before sunrise)	3
9:00 AM	28
12:00 PM (noon)	35
3:00 PM	30
6:00 PM	8
9:00 PM	2

1. What is the primary function of the stomata in this leaf?

A. To absorb sunlight directly for the light reactions of photosynthesis
B. To pump water into the leaf from the surrounding atmosphere
C. To allow gas exchange between the leaf interior and the outside air
D. To produce glucose from carbon dioxide inside the guard cells

2. The data show that the number of open stomata is highest during the middle of the day. The best explanation is:

A. Daytime light triggers the guard cells to open, supporting photosynthesis
B. Heat from the sun mechanically forces the stomata apart on the leaf
C. Daytime air pressure pushes the pores open from outside the leaf
D. Stomata reopen automatically every six hours regardless of sunlight

3. When stomata are open, water vapor leaves the leaf at the same time gases are exchanged. This loss of water from the leaf is called:

A. Translocation, the movement of sugars through the phloem tissue
B. Respiration, the chemical release of energy stored in glucose
C. Osmosis, the diffusion of water across a semipermeable membrane
D. Transpiration, the evaporation of water from the leaf into the air

4. Under hot, dry conditions, many plants partially close their stomata during the middle of the day. This response best maintains homeostasis by:

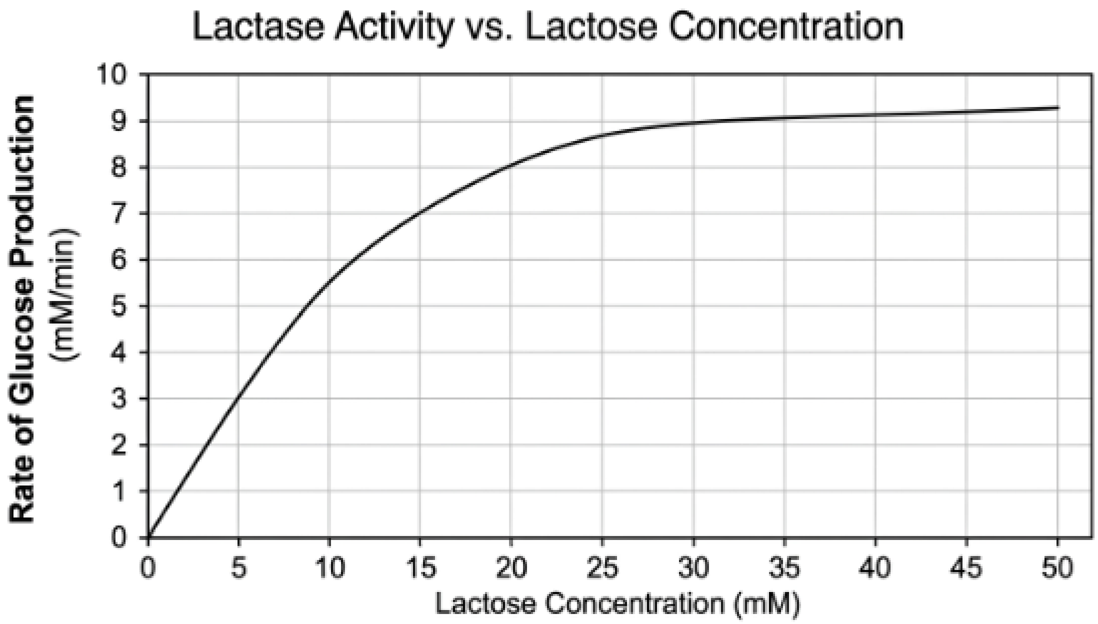
A. Increasing the rate of carbon dioxide entry into the leaf interior
B. Reducing water loss when the risk of dehydration is highest
C. Allowing more sunlight to enter the leaf for photosynthesis
D. Releasing more oxygen produced during the dark reactions

5. A student observes that the guard cells around an open stoma are curved outward and appear swollen. This shape change is best explained by:

A. Water entering the guard cells by osmosis, making them turgid
B. Guard cells producing extra cell wall material around the pore
C. The leaf actively heating the guard cells with stored energy
D. Carbon dioxide accumulating inside the guard cells from the air

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

Lactase is an enzyme that breaks lactose, the main sugar in milk, into glucose and galactose. To investigate how substrate concentration affects the rate of lactase activity, researchers prepared five test tubes, each containing the same amount of lactase enzyme but a different concentration of lactose. They measured the rate at which glucose was produced in each tube. The results appear in the graph below.



6. Which conclusion is best supported by the data in the graph?

A. The rate of reaction decreases as lactose concentration increases
B. The rate of reaction is unrelated to lactose concentration at any value
C. The rate of reaction stays constant across all lactose concentrations
D. The rate increases with lactose concentration but levels off at high values

7. The leveling off of the curve at high lactose concentrations is best explained by:

A. The lactose molecules forming clumps too large to fit the active site
B. The lactase enzyme breaking down at higher substrate concentrations
C. Nearly all lactase enzyme active sites becoming occupied with substrate
D. The product glucose interfering with the enzyme's catalytic activity

8. If researchers added more lactase enzyme to a tube already at 50 mM lactose, the most likely result would be:

A. The reaction rate would decrease because the enzymes would compete
B. The reaction rate would increase because more active sites are available
C. The reaction rate would not change because lactose has already saturated
D. The lactose would convert back into starch within the test tube

9. People who are lactose intolerant typically produce little or no lactase as adults. As a result, undigested lactose:

A. Passes into the large intestine, where bacteria ferment it and produce gas
B. Accumulates in the bloodstream and is excreted unchanged by the kidneys

C. Crystallizes inside the stomach lining and prevents further digestion
D. Is converted directly into glucose by stomach acid in the small intestine

10. The breakdown of lactose into glucose and galactose by lactase is best classified as:

A. A synthesis reaction that combines smaller molecules into a larger one
B. A hydrolysis reaction that splits a molecule using water
C. A photosynthesis reaction that uses sunlight as the energy source
D. A respiration reaction that releases ATP from broken chemical bonds

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

A biology class measured the rate of photosynthesis in *Elodea* (a common aquatic plant) by counting the number of oxygen bubbles released from a freshly cut stem each minute. The *Elodea* was submerged in water mixed with different concentrations of sodium bicarbonate ($NaHCO_3$), which provides dissolved carbon dioxide for the plant. Light intensity and temperature were held constant throughout all trials. The class data are shown below.

Sodium Bicarbonate (%)	Bubbles per Minute
0.0	4
0.5	15
1.0	28
2.0	41
4.0	43

11. Which variable was being changed (the independent variable) in this investigation?

A. The number of oxygen bubbles released by the cut stem each minute
B. The temperature of the water surrounding the submerged *Elodea*
C. The intensity of the light shining on the experimental setup
D. The concentration of sodium bicarbonate dissolved in the water

12. The bubbles released from the *Elodea* stem are primarily composed of:

A. Oxygen gas, a product of the light-dependent reactions of photosynthesis
B. Carbon dioxide gas, released from the bicarbonate as it dissolves
C. Hydrogen gas, produced when water molecules split in chloroplasts
D. Nitrogen gas, absorbed from the water and released through the stem

13. The data show only a small increase between 2.0% and 4.0% sodium bicarbonate. The most likely reason for this leveling off is:

A. Bicarbonate at high concentration begins to destroy the *Elodea* cells
B. Oxygen bubbles cannot be counted accurately above 40 per minute
C. Another factor, such as light intensity, has become the limiting factor
D. Carbon dioxide reverses the photosynthesis process at high amounts

14. If this experiment were repeated using boiled (dead) *Elodea*, the most likely result would be:

A. The bubble rate would increase at every bicarbonate concentration
B. No bubbles would be produced regardless of the bicarbonate level
C. The bubble rate would double at the highest bicarbonate level only
D. The bubbles produced would be carbon dioxide instead of oxygen

15. The overall chemical equation that best summarizes photosynthesis is:

A. glucose + oxygen → carbon dioxide + water + chemical energy
B. glucose + carbon dioxide → oxygen + water + ATP energy
C. oxygen + water → glucose + carbon dioxide + chemical energy
D. carbon dioxide + water → glucose + oxygen, using light energy

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

When a person is exposed to a pathogen for the first time, the immune system produces specialized proteins called antibodies that bind to the pathogen and help eliminate it. Vaccines work by introducing a weakened, killed, or fragment form of a pathogen, allowing the immune system to mount a response without causing disease. Researchers measured the level of antibodies in a patient's blood after a vaccination, and again after a later exposure to the actual pathogen. The data are shown below.

Event	Days After Vaccination	Antibody Level (relative units)
Vaccination given	0	0
First response peaks	14	30
Antibody level falls	60	8
Exposure to actual pathogen	180	8
Second response peaks	187	95

16. The proteins produced by the immune system that specifically bind to invading pathogens are called:

A. Antibodies, which are produced by certain types of white blood cells
B. Antigens, which are foreign markers on the surface of the pathogen
C. Hormones, which are released into the blood by the endocrine glands
D. Enzymes, which catalyze food digestion in the small intestine

17. The second response, after exposure to the actual pathogen, was both faster and stronger than the first response. The best explanation for this pattern is:

A. The actual pathogen carried a stronger version of the original antigen
B. The body had run out of weakened pathogen left from the vaccine
C. Immune memory cells from the first response recognized the pathogen quickly
D. The bloodstream still contained leftover antibodies from the original vaccine

18. A vaccine that uses a weakened form of a pathogen relies on the principle that:

A. The weakened pathogen will reproduce inside the body and cause illness
B. The immune system can build a response to safe forms of the pathogen
C. The vaccine will kill any disease-causing pathogen already in the body
D. The body will absorb the vaccine pathogen directly without responding

19. If a similar vaccine were developed for an entirely different virus, which feature would be most essential for the vaccine to provide long-term protection?

A. The vaccine must contain living cells that grow inside the patient's body
B. The vaccine must lower the patient's body temperature for several weeks
C. The vaccine must prevent all future exposures to any kind of pathogen
D. The vaccine must include antigens that match those on the target virus

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

A short segment of DNA on the template (antisense) strand reads:

3' – T A C G G A C T T A A C – 5'

This segment is transcribed into messenger RNA, which is then translated at a ribosome into a chain of amino acids. The simplified codon table below shows the amino acids coded by the relevant mRNA codons.

mRNA Codon	Amino Acid
AUG	Methionine (Start)
CCU	Proline

GAA	Glutamic Acid
UUG	Leucine

20. The first step in producing a protein from this DNA segment is:

A. Replication, which produces two identical DNA strands from the original
B. Translation, which occurs at the ribosome in the cytoplasm of the cell
C. Transcription, which produces mRNA from the DNA template strand
D. Mutation, which alters the original nucleotide sequence of the DNA

21. What is the mRNA sequence produced from the DNA template above?

A. 5' – A U G C C U G A A U U G – 3'
B. 5' – A T G C C T G A A T T G – 3'
C. 5' – T A C G G A C T T A A C – 3'
D. 5' – U A C G G A C U U A A C – 3'

22. Using the codon table, the order of amino acids assembled into the resulting protein is:

A. Methionine – Glutamic Acid – Proline – Leucine
B. Methionine – Proline – Glutamic Acid – Leucine
C. Proline – Methionine – Leucine – Glutamic Acid
D. Leucine – Glutamic Acid – Proline – Methionine

23. Translation of an mRNA molecule into a protein occurs at which cellular structure?

A. The nucleus, which contains the cell's genetic material
B. The mitochondria, which produce ATP for the cell
C. The Golgi apparatus, which packages cellular products
D. The ribosomes, in the cytoplasm or on the rough endoplasmic reticulum

24. A mutation changes the second mRNA codon from CCU to CCA. Both CCU and CCA code for proline. The most likely effect on the resulting protein is:

A. The protein will be completely nonfunctional due to a major shape change
B. The mRNA will not be transcribed at all from the DNA template strand
C. The protein will have the same amino acid sequence and likely function normally
D. The ribosome will stop translation immediately at the mutation site

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

In humans, blood type is determined by a single gene with three alleles: I^A and I^B (which are codominant with each other), and i (which is recessive to both). The possible genotypes and their corresponding blood types are shown below.

Genotype	Blood Type
I^A I^A or I^A i	Type A
I^B I^B or I^B i	Type B
I^A I^B	Type AB
ii	Type O

A father with blood type AB (genotype I^A I^B) and a mother with blood type O (genotype ii) plan to have children together.

25. Which blood types are possible among the children of this couple?

A. Only type AB, because the father is type AB
B. Type A or Type B, but not Type AB or Type O
C. Type AB or Type O, but not Type A or Type B
D. All four blood types (A, B, AB, and O) are possible

26. The fact that a person with genotype I^A I^B has blood type AB, expressing both A and B markers, is an example of:

A. Codominance, in which both alleles are fully expressed in the phenotype
B. Incomplete dominance, in which the phenotype is a blend of two alleles
C. Complete dominance, in which one allele masks the expression of the other
D. Sex linkage, in which the trait is carried on the X chromosome

27. A child of this couple has blood type A. The genotype of the child must be:

A. I^A I^A, because both A alleles must have come from the parents
B. I^A I^B, because the child received the A allele from the father
C. ii, because Type A can be produced by no alleles at all in some cases
D. I^A i, because the A came from the father and the i came from the mother

28. The trait of blood type is physically determined by:

A. The number of red blood cells produced per minute by the body
B. The shape of the hemoglobin molecule inside the red blood cells
C. The protein markers (antigens) on the surface of red blood cells
D. The amount of plasma circulating in the bloodstream of the person

29. During fertilization, a sperm cell from this father carrying the I^A allele combines with an egg cell from this mother carrying the i allele. The resulting zygote has:

A. Only the I^A allele, because the i allele cannot survive in the zygote
B. Both the I^A and i alleles, producing the genotype I^A i
C. Three alleles, including I^A from each parent and i from the mother
D. No blood type, because the alleles must combine after birth occurs

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

On a Galapagos island, a population of seed-eating finches faced a severe drought that wiped out most of the small, soft seeds the birds usually ate. During the drought, the only seeds available were the large, hard seeds of a single shrub species. Researchers measured the average beak depth of finches in the population both before and after the drought, and again in the next generation. The results are shown below.

Time Point	Average Beak Depth (mm)	Sample Size (birds)
Before drought (Year 1)	8.6	750
After drought (Year 2)	9.4	90
Next generation (Year 3)	9.2	220

30. The increase in average beak depth from Year 1 to Year 2 is best explained by which statement?

A. Finches with deeper beaks were better able to crack hard seeds and survive
B. Finches with shallower beaks grew their beaks larger during the drought
C. All finches in the population had identical beaks before the drought began
D. The drought caused new beak shapes to appear by direct chemical change

31. The shift in the average beak size of the population from Year 1 to Year 3 is best classified as an example of:

A. Convergent evolution, in which unrelated species develop similar traits
B. Genetic drift, in which traits change purely by random chance alone
C. Natural selection, in which favored heritable traits become more common
D. Acquired traits, in which features develop and are passed during life

32. The variation in beak depth observed in the original finch population most likely arose from:

A. Finches deliberately changing their beak size based on the seeds available
B. The Galapagos environment imprinting beak shapes on each new hatchling
C. Cross-breeding between finches and other unrelated bird species nearby
D. Random mutations and genetic recombination accumulated over generations

33. If conditions returned to normal and small seeds again dominated the island, the average beak depth in future generations would most likely:

A. Continue to increase indefinitely because beak depth always increases
B. Decrease over time as smaller beaks again become favored by selection
C. Remain at 9.2 mm forever because evolution moves only in one direction
D. Drop to zero because all the deep-beaked finches would suddenly die off

34. Two finch populations on different Galapagos islands develop different beak shapes because they feed on different seed types. Over many generations, the populations may eventually become so different that they can no longer interbreed. This process is best called:

A. Speciation, the formation of new species from a common ancestor
B. Migration, the regular movement of organisms between distinct regions
C. Hybridization, the breeding of two clearly different species together
D. Extinction, the permanent loss of all members of a single species

35. Charles Darwin's observations of the Galapagos finches contributed most directly to his theory of:

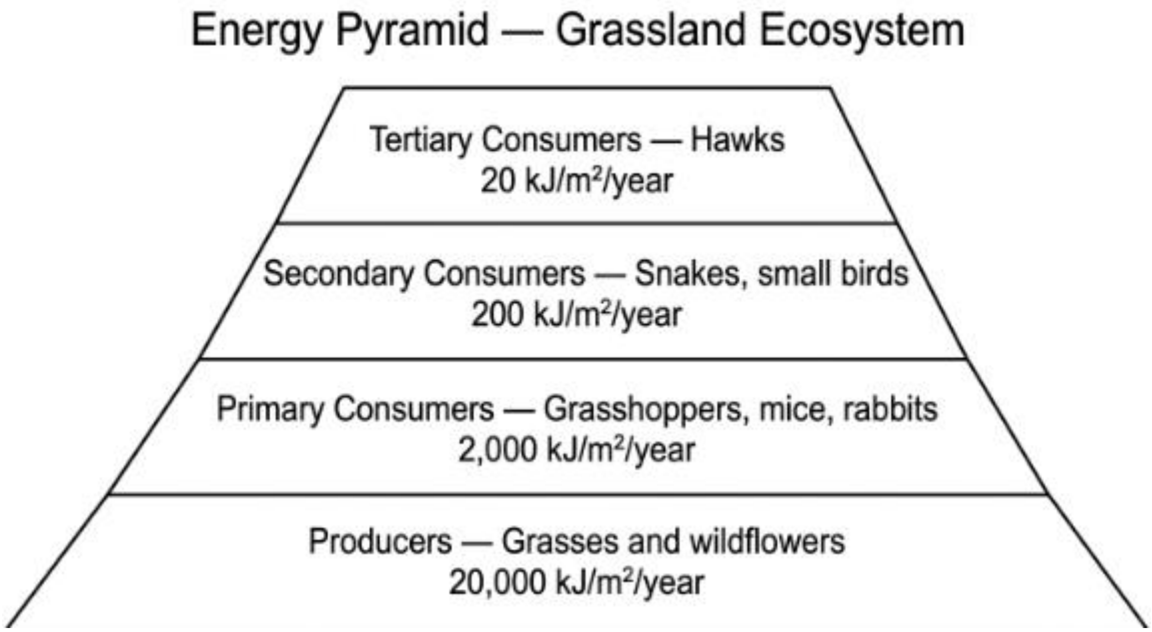
A. Genetic inheritance, including the patterns described by Gregor Mendel
B. The cell theory, which describes the basic unit of all living things
C. Evolution by natural selection, which explains how species change over time
D. The germ theory of disease, which identifies microbes as causes of illness

36. Which observation would most strongly support the conclusion that the beak-depth changes are heritable rather than acquired during the finches' lifetimes?

A. Beak depth changes throughout the lifetime of each individual finch
B. The finches feed exclusively on the largest seeds during the drought year
C. Deeper-beaked finches build larger nests than shallower-beaked finches
D. Offspring of deep-beaked parents tend to have deeper beaks than offspring of shallow ones

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

The diagram below shows an energy pyramid for a simplified grassland ecosystem. Each level lists the total amount of energy (in kilojoules per square meter per year) stored in the organisms at that trophic level.



37. The energy stored in the producers of this grassland ecosystem ultimately comes from:

A. The chemical breakdown of organic material left in the soil by decomposers
B. The sun, captured by photosynthesis and stored in plant tissue as chemical energy
C. The respiration of the primary consumers that feed on the producers
D. The decay of dead grasshoppers and rabbits left in the grassland habitat

38. Based on the values in the pyramid, what percentage of the energy stored in the producers is passed on to the primary consumers?

A. About 10%, consistent with the average energy transfer between trophic levels
B. About 25%, the standard percentage of energy passed up a food chain
C. About 50%, since half of the energy is used and half passed up the pyramid
D. About 90%, since most of the energy is efficiently transferred to consumers

39. Why does the amount of available energy decrease at each higher level of the pyramid?

A. Organisms at higher levels are smaller and require less energy to live
B. The sun provides less energy directly to organisms at higher levels
C. Most energy at each level is used for life processes and lost as heat
D. Producers absorb energy from consumers as it travels up the pyramid

40. If all the hawks in this ecosystem were removed, the most likely short-term effect would be:

A. The grass population would decrease because grasses depend on hawks for pollination
B. The populations of snakes and small birds would increase due to reduced predation

C. The grasshoppers and rabbits would immediately become producers themselves
D. The producers would lose energy because they depend on hawks to recycle nutrients

41. The pyramid does not include decomposers. The role of decomposers in this ecosystem is to:

A. Capture solar energy and convert it into glucose at the base of the pyramid
B. Compete with hawks for prey at the top of the food chain of the system
C. Provide additional sunlight to producers when light levels are too low
D. Break down dead organisms and return nutrients to the soil for producers

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

After a volcanic eruption covers an area with fresh lava, the bare rock initially has no soil and no plants. Within several decades, lichens slowly break down the rock surface and form the earliest patches of soil. Mosses then grow in the thin soil layer. Over the next several hundred years, grasses, shrubs, and small trees appear in succession, and eventually a mature forest may develop. Ecologists have studied this pattern at several volcanic sites around the world.

42. The pattern of ecological change described in this scenario is best classified as:

A. Primary succession, which begins on a surface with no pre-existing soil
B. Secondary succession, which begins in a disturbed area where soil remains
C. Convergent evolution, in which unrelated species develop similar traits
D. Ecological niche partitioning, which divides resources among similar species

43. The lichens that first colonize the bare lava are best classified as:

A. Climax species, which form the final stable community of the succession
B. Decomposer species, which break down dead matter in the deep soil layer
C. Pioneer species, which can survive in harsh conditions with few resources
D. Keystone species, which have a disproportionate effect on the entire community

44. As lichens and mosses slowly break down the rock surface, they contribute most directly to the development of the ecosystem by:

A. Providing food to the primary consumers throughout the area
B. Releasing oxygen needed for the survival of all soil microbes
C. Forming a dense canopy that shades the bare rock below
D. Producing thin layers of soil that later plants can take root in

45. A community of grasses and shrubs gradually gives way to a mature forest in which oak and pine trees dominate. The mature forest stage of this succession is best described as:

A. A pioneer community, just beginning to colonize the harsh environment
B. A climax community, relatively stable under the local conditions over time
C. A transitional community, expected to change drastically within one year
D. A disturbed community, recently affected by a strong environmental event

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

An invasive aquatic plant species has been accidentally introduced into a freshwater lake. The plant grows rapidly, forming dense floating mats that shade out native aquatic plants below and lower the oxygen content of the water beneath the mats. Local scientists and engineers are designing strategies to monitor the spread of the invasive plant and to protect the native species in the lake.

46. The invasive plant is most likely to outcompete native species in this lake because it:

A. Reproduces rapidly and has no natural predators or pathogens in the lake
B. Cannot survive in the temperatures or pH conditions found in the lake
C. Produces large amounts of oxygen that the native species depend on
D. Decomposes much faster than the native plants in the same lake

47. The dense floating mats reduce oxygen in the water below mainly by:

A. Producing carbon dioxide gas from photosynthesis in the surface mats
B. Releasing toxic chemicals that destroy all aquatic oxygen molecules
C. Blocking sunlight so that submerged plants cannot photosynthesize
D. Absorbing dissolved oxygen through their floating leaves and stems

48. The loss of native plant species under the mats is most likely to affect biodiversity in the lake by:

A. Increasing overall biodiversity due to the addition of one new species
B. Decreasing biodiversity as native species lose habitat and disappear
C. Leaving biodiversity unchanged because the invasive plant fills the same role
D. Doubling biodiversity because the invasive plant adds two new niches

49. An engineering team designs a monitoring program for the lake. Which design feature would most directly support the goal of tracking the spread of the invasive plant?

A. A single ground-level photograph taken once every ten years from the shore
B. A wind speed monitor placed at the surface of the water in the deepest area
C. A water temperature sensor anchored only at the deepest point of the lake
D. Regular aerial or satellite imagery that maps the extent of mats over time

50. When comparing competing engineering or management strategies to control the invasive plant, which factor is most important to consider as a trade-off?

A. The balance among effectiveness, cost, impact on native species, and feasibility
B. The number of news articles written about the lake in the past year
C. The aesthetic appearance of the equipment used in the management program
D. The number of patents that the management team has filed in the past decade

Practice Exam 6 – Full Answer Key with Explanations

1. C — Stomata are pores in the leaf epidermis that allow gases (CO_2 in, O_2 out, water vapor out) to diffuse between the leaf interior and the atmosphere. Without stomata, photosynthesis would be impossible because CO_2 could not reach the inner leaf cells. Gas exchange is their defining function.

2. A — Light is the main environmental signal that triggers guard cells to take up potassium ions and water, swelling and opening the stomata. Maximum stomatal opening at midday coincides with peak photosynthesis, when the leaf has the greatest demand for CO_2. The response synchronizes gas exchange with photosynthetic need.

3. D — Transpiration is the evaporation of water from inside the leaf into the atmosphere through open stomata. As gases move in and out, water vapor diffuses out from the moist surfaces of mesophyll cells. This is the primary route of water loss in plants.

4. B — Closing stomata reduces transpiration when air is hot and dry and the risk of dehydration is highest. The plant accepts a temporary reduction in CO_2 intake to preserve water balance. This trade-off is a homeostatic response to environmental stress.

5. A — Guard cells absorb water by osmosis when potassium ions accumulate inside them, making the cells turgid. Because of the uneven thickness of their walls, the cells curve outward and pull the pore open. Turgor pressure is the mechanism behind stomatal opening.

6. D — The curve rises rapidly at low lactose levels then flattens at high concentrations — the classic enzyme saturation pattern. As substrate increases, reaction rate eventually plateaus because the enzyme can no longer process additional substrate. This is a fundamental observation of enzyme kinetics.

7. C — At high substrate concentrations, nearly every lactase active site is already occupied with a lactose molecule. Additional lactose cannot increase the rate because there are no free active sites available. The reaction rate is now limited by the amount of enzyme present.

8. B — Saturation means lactose is not the limiting factor — enzyme is. Adding more lactase provides more active sites, so more lactose molecules can be processed simultaneously, raising the rate. Enzyme concentration sets the ceiling once substrate is in excess.

9. A — Without lactase, lactose passes undigested into the large intestine, where bacteria ferment it. Fermentation produces gases such as hydrogen, methane, and CO_2, along with short-chain acids that cause bloating, cramping, and diarrhea. These are the classic symptoms of lactose intolerance.

10. B — Hydrolysis is a reaction that splits a larger molecule by adding a water molecule across a chemical bond. Lactase catalyzes this break, separating lactose into glucose and galactose. All major digestive enzymes catalyze hydrolysis reactions.

11. D — The independent variable is the variable the experimenter deliberately manipulates between trials. Here, bicarbonate concentration was changed while light and temperature were held constant. The bubble rate is the dependent variable that responds to this change.

12. A — During the light-dependent reactions of photosynthesis, water molecules are split, releasing oxygen as a byproduct. The bubbles rising from an illuminated cut *Elodea* stem are this oxygen. This is the basis of the standard *Elodea* photosynthesis demonstration.

13. C — When CO_2 is abundant (from high bicarbonate), photosynthesis becomes limited by some other factor — most likely light intensity, since light was held constant at a moderate level. The law of limiting factors states that the slowest-supplied requirement controls the overall rate. Adding more of a non-limiting factor produces little additional response.

14. B — Boiled *Elodea* is dead: its enzymes are denatured and its chloroplasts cannot function. Without active photosynthetic machinery, no oxygen is produced regardless of CO_2 supply. This confirms that living, functional tissue is required for the reaction observed.

15. D — The overall equation for photosynthesis is $6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$, driven by light energy captured by chlorophyll. Carbon dioxide and water are the reactants; glucose and oxygen are the products. Option D correctly identifies the reactants, products, and energy source.

16. A — Antibodies are Y-shaped proteins produced by B lymphocytes (a type of white blood cell) that bind specifically to antigens on pathogens. They mark invaders for destruction by other immune cells. Antibody production is the hallmark of the adaptive immune response.

17. C — Memory B and T cells produced during the first immune response persist in the body and recognize the same antigen rapidly upon re-exposure. They quickly produce large amounts of specific antibody, generating a faster and stronger second response. This immunological memory is the basis of vaccine protection.

18. B — Vaccines present antigens in a safe form — weakened, killed, or fragment — so the immune system can mount a response without the pathogen causing illness. The body forms antibodies and memory cells against those antigens. Protection is established before any natural exposure.

19. D — Antibody binding is specific: a vaccine only produces protection against pathogens whose antigens it actually presents to the immune system. Memory cells formed against vaccine antigens will recognize the live virus only if the antigens match. This specificity is the central principle of vaccine design.

20. C — Transcription is the first step of protein synthesis: an mRNA strand is built using DNA as a template inside the nucleus. The mRNA then exits the nucleus and is translated at the ribosome. Without transcription, no genetic information can reach the protein-building machinery.

21. A — Pairing each base on the template strand 3'-TACGGACTTAAC-5' with its RNA complement (A↔U, T↔A, G↔C, C↔G) yields 5'-AUGCCUGAAUUG-3'. The mRNA is antiparallel to the template and uses uracil instead of thymine. This is the correctly oriented mRNA sequence.

22. B — Reading the mRNA 5' to 3' in three-base codons gives AUG–CCU–GAA–UUG. The codon table translates these to Methionine–Proline–Glutamic Acid–Leucine. Ribosomes always read mRNA in the 5'-to-3' direction.

23. D — Translation takes place at ribosomes, which can float freely in the cytoplasm or attach to the rough endoplasmic reticulum. Ribosomes read mRNA codons and link the corresponding amino acids into a polypeptide. They are the universal site of protein synthesis.

24. C — Because both CCU and CCA code for proline, the change does not alter the amino acid sequence — a silent mutation. The resulting protein has the same primary structure and is expected to function normally. The redundancy of the genetic code buffers many DNA changes in this way.

25. B — The father (I^A I^B) passes either I^A or I^B; the mother (ii) can only pass i. Offspring genotypes are therefore I^A i (Type A) or I^B i (Type B), in roughly equal numbers. Neither Type AB nor Type O is possible from this cross.

26. A — In codominance, both alleles are fully and simultaneously expressed in the heterozygote. A person with genotype I^A I^B produces both A and B antigens on their red blood cells, giving Type AB blood. Codominance differs from incomplete dominance, which produces a blended phenotype.

27. D — A Type A child must carry at least one I^A allele. Since the mother (ii) can only contribute i and the father (I^A I^B) can contribute I^A, the only possible Type A genotype here is I^A i. No other genotype is consistent with this cross.

28. C — ABO blood type is determined by carbohydrate antigens (A and B) attached to glycoproteins on the surface of red blood cells. The I^A and I^B alleles code for slightly different enzymes that add different sugars to these markers. This is why ABO matching is critical for safe blood transfusion.

29. B — Each parent contributes one allele through their gamete. An I^A allele from the sperm combines with an i allele from the egg, producing the diploid genotype I^A i. This is the basic mechanism of Mendelian inheritance through sexual reproduction.

30. A — During the drought, only large hard seeds were available, and finches with deeper, stronger beaks could crack them and survive while shallow-beaked birds starved. The surviving population was dominated by deep-beaked individuals, raising the average. Selection acted on pre-existing variation in beak depth.

31. C — Natural selection occurs when individuals with favorable heritable traits survive and reproduce more than others, shifting trait frequencies in subsequent generations. The drought favored deep beaks, and offspring inherited the trait, raising the next generation's average. The Galapagos finches are a classic textbook example.

32. D — Genetic variation arises from random mutations during DNA replication and from recombination during meiosis. Some finches inherited combinations of alleles producing deeper beaks. Natural selection then acted on this preexisting variation; the environment did not create the trait.

33. B — If small seeds again became the main food source, shallower beaks would be favored because they handle small seeds more efficiently. Over generations, the average beak depth would shift back down. Natural selection works in whichever direction the environment favors.

34. A — Speciation is the formation of new species when populations diverge enough that they can no longer interbreed and produce fertile offspring. Isolated populations under different selective pressures accumulate distinct genetic and morphological differences over time. This is the standard model of allopatric speciation.

35. C — Darwin observed that Galapagos finches varied across islands in beak shape and size in ways that matched their food sources. These observations were central to his theory that species change over time through natural selection on heritable variation. The finches remain one of the most cited examples of evolution.

36. D — A heritable trait is passed from parents to offspring through genes, not learned or acquired during life. If deep-beaked parents tend to produce deep-beaked offspring, the trait must have a genetic basis. Heritability is required for natural selection to change a population over generations.

37. B — Producers capture solar energy through photosynthesis and store it as chemical energy in glucose and other organic molecules. This stored energy then flows through every higher trophic level. Almost every ecosystem on Earth is ultimately powered by the sun.

38. A — Dividing 2,000 kJ (primary consumers) by 20,000 kJ (producers) gives 0.10, or 10%. This matches the well-known "10% rule" of ecological energy transfer between trophic levels. About 90% of the energy at each level is lost or used by the level itself.

39. C — Most of the energy organisms consume at each trophic level is used for life processes (movement, growth, maintenance) and ultimately lost as heat through cellular respiration. Only about 10% becomes stored tissue available to the next predator. This is why energy pyramids narrow sharply toward the top.

40. B — Removing the hawks removes predation pressure from snakes and small birds, allowing their populations to grow. This is a typical top-down effect of losing an apex predator, and it can cascade through the food web. Such effects are often unintentional consequences of predator removal.

41. D — Decomposers such as bacteria and fungi break down dead organisms and waste, releasing nutrients like nitrogen and phosphorus back into the soil. Producers then absorb these recycled nutrients to grow. Without decomposers, nutrients would remain locked in dead matter and the ecosystem would eventually fail.

42. A — Primary succession begins on lifeless surfaces with no pre-existing soil, such as bare rock from a volcanic eruption. Soil must develop before most plants can take root. This distinguishes primary succession from secondary succession, which begins where soil is already present.

43. C — Pioneer species are the first organisms to colonize a harsh, resource-poor environment. Lichens are classic pioneers because they tolerate extreme conditions, can grow on bare rock, and begin to break it down chemically. They prepare the surface for later successional stages.

44. D — As lichens and mosses chemically and physically break down rock, mineral particles mix with their decaying organic matter to form thin layers of soil. This soil retains water and nutrients, enabling grasses, shrubs, and eventually trees to take root. Soil formation is the key transition between bare rock and a vegetated community.

45. B — A climax community is the mature, relatively stable end stage of succession, well-adapted to local climate and soil conditions. A mature oak-pine forest that persists for decades fits this description. Climax communities still change but much more slowly than earlier successional stages.

46. A — Invasive species often succeed because they reproduce rapidly and lack the natural predators, parasites, and pathogens that controlled them in their native range. Freed from these checks, they outcompete native species for light, space, and nutrients. This is the standard explanation for biological invasion success.

47. C — The dense floating mats block sunlight from reaching the water below, preventing submerged plants from carrying out photosynthesis. With less photosynthesis, less oxygen is released into the water, and dissolved oxygen levels fall. Decomposition of dying native plants further depletes oxygen.

48. B — Biodiversity refers to the variety of species in an ecosystem. When an invasive species outcompetes and eliminates several native species, the lake loses unique forms of life, and overall biodiversity declines. Lower biodiversity weakens ecosystem stability and resilience.

49. D — Aerial or satellite imagery can cover the entire lake at regular intervals, allowing scientists to map and compare the extent of mats over time. This directly measures the spatial spread of the invasive plant. Single ground photographs or single-point sensors cannot capture how mats expand across the lake.

50. A — Sound engineering decisions weigh multiple criteria together: how well a solution works, what it costs, how it affects native species, and whether it can realistically be implemented. A strategy that excels in one criterion but fails in others may not be the best overall choice. Balanced trade-off analysis guides good environmental management.