PRACTICE EXAM 4: 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 student investigated movement of substances across a selectively permeable membrane. A length of dialysis tubing was tied at one end, filled with a solution containing 30% glucose and 5% starch, then tied at the other end. The filled tubing was rinsed and placed in a beaker of distilled water. After 24 hours, samples of the beaker water and the tubing contents were tested with Benedict's solution (which turns from blue to orange-red in the presence of glucose) and with Lugol's iodine solution (which turns from amber to blue-black in the presence of starch). The results are summarized below.

Stage of Cell Cycle	Number of Cells Observed
Interphase	84
Prophase	9
Metaphase	3
Anaphase	2
Telophase	2
Total cells counted	100

1. What is the main scientific question this investigation is designed to answer?

A. Whether starch molecules are larger than water molecules in solution

B. Which substances are able to pass through a selectively permeable membrane

C. Whether glucose can be chemically converted to starch within the tubing

D. How long it takes for distilled water to completely fill the dialysis tubing

2. The iodine test on the beaker water remained amber after 24 hours. This result best indicates that:

A. Starch molecules diffused freely into the surrounding distilled water beaker

B. Glucose was converted into starch by enzymes within the dialysis tubing

C. The membrane allowed all dissolved substances to pass through over time

D. Starch molecules were too large to pass through the pores of the membrane

3. Benedict's solution turned orange-red when added to a sample of the beaker water after 24 hours. This result is best explained by which process?

A. Diffusion of glucose molecules from higher to lower concentration across the membrane

B. Active transport of glucose molecules driven by ATP within the dialysis tubing

C. Osmosis of water molecules carrying dissolved starch out of the tubing into beaker

D. Endocytosis of glucose performed by living cells inside the dialysis tubing solution

4. The dialysis tubing in this investigation functions most similarly to which structure of a living cell?

A. The nucleus, which controls cellular activities and stores hereditary information

B. The mitochondrion, which produces ATP through aerobic cellular respiration

C. The cell membrane, which regulates the entry and exit of substances in the cell

D. The endoplasmic reticulum, which transports proteins throughout the cytoplasm

5. Suppose the same dialysis bag (still containing 30% glucose and 5% starch) were placed in a beaker of 50% glucose solution instead of distilled water. What would most likely happen to the bag?

A. The bag would swell as water moves into the bag from the surrounding beaker

B. The bag would shrink as water moves out of the bag into the surrounding beaker

C. The bag would remain unchanged because the membrane blocks all net flow

D. The bag would rupture as glucose moves rapidly into the dialysis tubing interior

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

Students examined a prepared slide of onion root tip cells under a high-power microscope. In a single field of view, they counted the number of cells that appeared in each stage of the cell cycle. The class data are summarized in the table below.

Time (min)	Activity	Heart Rate (bpm)
0	Resting (before exercise)	72
2	Jogging	118
4	Jogging	142
6	Jogging	148
8	Recovery (after exercise)	102
12	Recovery (after exercise)	78

6. The primary biological purpose of mitosis in a multicellular organism is to:

A. Produce new cells for the growth, repair, and replacement of body tissues

B. Generate genetic variation by reshuffling alleles between paired homologous chromosomes

C. Reduce the chromosome number of body cells from the diploid to the haploid state

D. Combine genetic material from two parents into a single fertilized zygote nucleus

7. During which phase of mitosis do chromosomes align along the equator of the dividing cell?

A. Prophase, when the nuclear membrane breaks down and the spindle fibers form

B. Anaphase, when the sister chromatids are pulled toward opposite poles of the cell

C. Telophase, when new nuclear membranes reform around the separated chromosome sets

D. Metaphase, when the chromosomes line up across the middle of the dividing parent cell

8. Based on the data, the stage in which onion root tip cells spend the greatest proportion of their cell cycle is:

A. Prophase, with roughly nine percent of the observed cells in that single phase

B. Metaphase, in which chromosomes are aligned along the cell's central equatorial plane

C. Interphase, during which the cell grows in size and replicates all of its DNA molecules

D. Anaphase, during which sister chromatids are separated to opposite poles of the cell

9. A tissue biopsy from a tumor shows a much higher proportion of cells in mitotic stages than is seen in normal healthy tissue. The most likely explanation for this difference is:

A. The tumor cells have lost the ability to undergo any further rounds of cell division

B. The tumor cells are producing more proteins for active transport across cell membranes

C. The tumor cells have lost the normal regulatory control over progression through the cell cycle

D. The tumor cells are entering meiosis instead of mitosis during their reproductive divisions

10. At the end of mitosis, the two daughter cells produced from one parent cell are best described as:

A. Genetically identical to the parent cell and to each other in chromosome number and content

B. Genetically distinct from the parent cell because of random crossing over between chromosomes

C. Haploid versions of the original parent cell that contain exactly half the chromosome number

D. Produced through the fusion of two different gametes during the process of fertilization

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

A student measured her resting heart rate and then her heart rate at intervals during and after a six-minute period of moderate jogging on a treadmill. Her resting heart rate, exercising heart rate, and recovery heart rate are recorded in the table below.

Time (min)	Activity	Heart Rate (bpm)
0	Resting (before exercise)	72
2	Jogging	118
4	Jogging	142
6	Jogging	148
8	Recovery (after exercise)	102
12	Recovery (after exercise)	78

11. When blood returns from the lungs to the heart, it enters which chamber of the heart first?

A. The right atrium, which receives blood returning from the head and lower body tissues

B. The left atrium, which receives oxygen-rich blood arriving from the pulmonary veins

C. The right ventricle, which pumps blood out through the pulmonary artery to the lungs

D. The left ventricle, which pumps oxygen-poor blood out through the aorta to the body

12. Which statement best explains why the student's heart rate increased during the period of jogging?

A. Cooler air temperatures during exercise required the heart to pump warmer blood to extremities

B. The student's lungs produced less carbon dioxide and therefore required slower blood circulation

C. The student's skeletal muscles released hormones that slowed cellular respiration in the body

D. Working muscles required more oxygen, prompting faster oxygen delivery by the circulatory system

13. Red blood cells contribute to the body's response observed in the data primarily by:

A. Producing antibodies that protect skeletal muscle cells from bacterial infection during exercise

B. Releasing digestive enzymes that break down stored sugars circulating in the bloodstream

C. Manufacturing additional mitochondria for use by actively contracting skeletal muscle cells

D. Carrying oxygen via hemoglobin from the lungs to the body's actively working muscle tissues

14. A second student performs the same exercise but his heart rate is still 130 bpm at the 12-minute recovery point. Compared with the first student, this most likely indicates:

A. Lower cardiovascular fitness in the second student than in the first student tested

B. Higher cardiovascular fitness in the second student than in the first student tested

C. A nearly identical level of cardiovascular conditioning between the two students tested

D. A medical emergency requiring immediate cardiac surgery for the second student tested

15. Oxygen-poor blood returning from the body's tissues reaches the heart primarily through:

A. The pulmonary arteries, which carry blood from the right ventricle out to the lungs

B. The aorta, which carries blood from the left ventricle out to the rest of the body

C. The vena cava, which carries blood back from the body into the right atrium of the heart

D. The capillaries, which connect the arterioles directly to the venules within the body tissues

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

A segment of DNA contains the coding sequence shown below, read 3' to 5' on the template strand:

TAC – GGA – CCT – AAG – TTC – ACT

This segment is transcribed into a messenger RNA molecule and then translated into a short polypeptide chain. Use this information and your knowledge of biology to answer the following questions.

16. One key feature of the genetic code is that nearly all organisms — from bacteria to humans — use the same codons to specify the same amino acids. This pattern is best described as evidence that:

A. Each modern organism evolved its own unique system of protein synthesis entirely independently

B. The genetic code is essentially universal across nearly all known organisms on Earth today

C. Codons in eukaryotes specify completely different amino acids than the same codons in prokaryotes

D. Modern organisms cannot share any genes through any biological form of transfer between species

17. Translation of the messenger RNA into a polypeptide chain takes place at which cellular structure?

A. The ribosome, where transfer RNA molecules deliver amino acids to a growing polypeptide chain

B. The nucleus, where DNA is unwound and transcribed into messenger RNA by RNA polymerase

C. The Golgi apparatus, where finished proteins are packaged for export from the cell to outside

D. The mitochondrion, where ATP is generated from glucose through aerobic cellular respiration

18. A separate messenger RNA molecule is exactly 300 nucleotides long and contains no start or stop codons within its coding sequence. The maximum number of amino acids it could encode in the resulting polypeptide is:

A. 300 amino acids, since each nucleotide represents one separate amino acid in the chain

B. 150 amino acids, since the genetic code uses two nucleotides per individual amino acid

C. 100 amino acids, since each codon of three nucleotides specifies one amino acid in protein

D. 50 amino acids, since each amino acid requires six nucleotides in the messenger RNA sequence

19. Suppose a single nucleotide is accidentally deleted from the middle of a coding region of a gene. This change would most likely produce which type of mutation?

A. A silent mutation that produces no change at all in the final amino acid sequence

B. A substitution mutation that changes only the amino acid at that one specific position

C. A chromosomal mutation involving the deletion of entire chromosomes from each cell

D. A frameshift mutation that alters the reading frame of every codon from that point onward

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

A pedigree shows three generations of a family with several members affected by albinism, a condition in which the body produces little or no melanin pigment. In this family, affected individuals appear in both males and females across generations, and affected children sometimes appear in families in which neither parent is affected. None of the affected individuals are descended from a parent with the condition married to a parent unrelated to any known carrier.

20. Based on the pattern described above, the inheritance of albinism in this family is best classified as:

A. Sex-linked dominant, expressed more often in male offspring than in female offspring

B. Autosomal recessive, expressed only in individuals homozygous for the affected allele

C. Mitochondrial inheritance, passed only from mothers to all of their biological offspring

D. Autosomal dominant, expressed in every generation by heterozygous parent individuals

21. Two parents with normal pigmentation in this family have a child with albinism. What can be concluded about the genotypes of these two parents?

A. Both parents must be homozygous dominant for the pigmentation gene in question

B. Both parents must be heterozygous carriers of the recessive albinism allele themselves

C. One parent must have albinism and the other must be a known carrier of the allele

D. The condition appeared only because of a new mutation occurring after fertilization

22. The parents in question 21 then plan another child. The probability that this next child will also have albinism is:

A. Approximately 25 percent, based on a standard heterozygous-by-heterozygous Mendelian cross

B. Approximately 50 percent, based on a standard dominant-by-recessive backcross between parents

C. Approximately 75 percent, since recessive alleles are dominant over normal pigmentation alleles

D. Approximately 0 percent, since the family has already produced one previously affected child

23. At the molecular level, albinism is most often caused by a defect in the gene that codes for:

A. A structural protein that gives mechanical strength to the cytoplasm of skin cells

B. A hormone that regulates the overall rate of mitosis in pigmented body tissues

C. An enzyme required for one of the steps in the biosynthesis of the pigment melanin

D. A receptor protein that binds sunlight at the surface of skin cells directly each day

24. A genetic counselor uses pedigree charts in clinical practice primarily to:

A. Reverse the effects of inherited disorders that have already appeared in a single family member

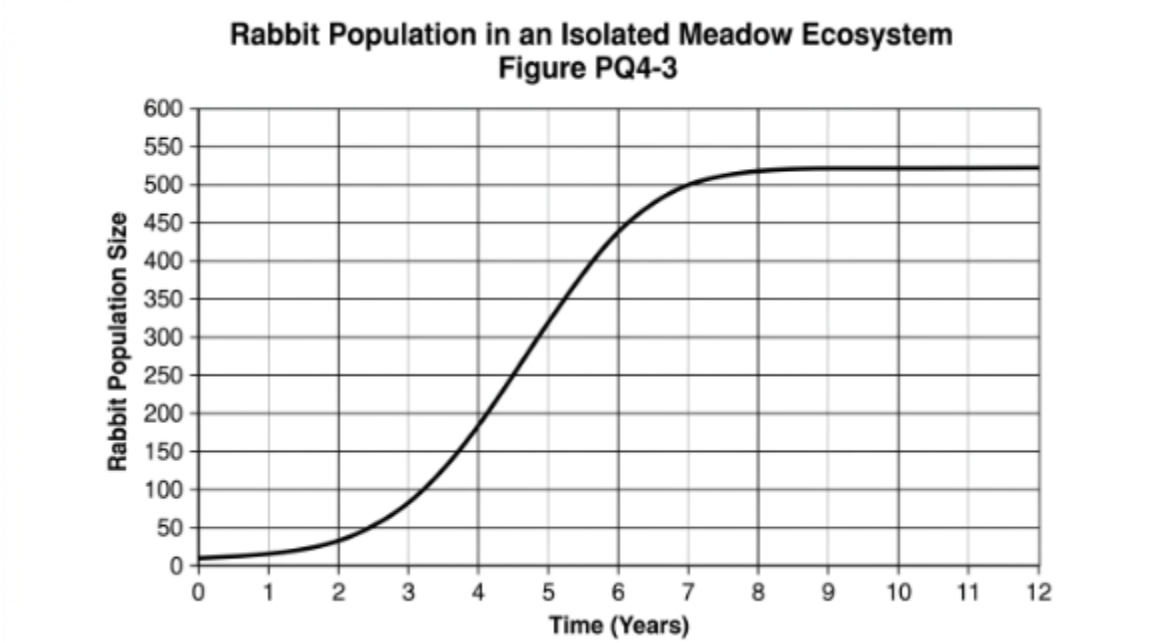
B. Confirm that an individual's observed traits were produced by environmental influences only

C. Identify the family members who are physically larger and stronger than the population average

D. Trace inheritance patterns through generations and estimate the risks to potential future children

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

Ecologists studying an isolated meadow ecosystem introduced 10 rabbits to the meadow in year 0. The rabbits had no natural predators in this meadow and an abundant supply of food. Population data were collected each year for 12 years. The graph below summarizes the results.



25. The overall pattern of population change shown in the graph is best described as:

A. Logistic growth, with a rapid early increase followed by a clear leveling-off phase over time

B. Exponential growth, with the rabbit population doubling at a constant rate each successive year

C. A steady linear increase in population size from year zero through year twelve of the study

D. A boom-and-bust cycle, with the population repeatedly rising and then crashing every few years

26. The maximum population size that the meadow environment can support over the long term is best described by which ecological term?

A. Density-independent limit, set entirely by sudden weather events and natural disaster events

B. Biotic potential, defined as the highest possible reproductive rate for a population in nature

C. Carrying capacity, the largest population size that the environment can sustainably support

D. Population pyramid, a graph showing the distribution of ages within a single population sample

27. As the rabbit population approaches the carrying capacity of the meadow, what happens to the population's growth rate?

A. The growth rate increases sharply because individuals are now older and reproduce more often

B. The growth rate decreases as resources become limiting and competition between rabbits intensifies

C. The growth rate remains constant from year to year regardless of population density in the meadow

D. The growth rate temporarily becomes negative for several years until the food supply returns

28. Which of the following pairs are best classified as density-dependent limiting factors on this rabbit population?

A. A sudden hailstorm and an unseasonable spring freeze that damage the meadow grasses each year

B. A wildfire that sweeps through the meadow and a flood that washes through the area in one season

C. Competition for limited grasses among the rabbits and the spread of contagious disease among rabbits

D. The average annual rainfall and the length of the daily photoperiod throughout the calendar year

29. A different population that experiences abundant resources, no predators, and no disease over a short period would most likely display which initial growth pattern?

A. A steady decline as the population uses up its initial reproductive potential entirely within years

B. A linear increase, in which the population grows by the same number of individuals each generation

C. Boom-and-bust cycles driven by repeated outbreaks of contagious disease within the population over time

D. Exponential growth, in which the population's numbers increase at an accelerating rate over time

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

Researchers studying ground finches on the Galapagos Islands have documented more than a dozen finch species, each with a distinctive beak shape suited to a particular diet. Some species have small, slender beaks for picking insects, others have heavy, blunt beaks for crushing tough seeds, and still others have intermediate beaks for a variety of foods. Genetic studies have shown that all of these finch species share

a common ancestor from the South American mainland that arrived on the Galapagos several million years ago.

30. The variety of beak shapes among finch species on the Galapagos Islands is best explained by:

A. Natural selection, with different food sources favoring different beak shapes on different islands

B. Inheritance of acquired beak shapes that individual finches developed during their own lifetimes

C. Spontaneous generation of new finch species from nonliving material in each separate island habitat

D. A single coordinated mutation that produced every beak shape simultaneously in just one generation

31. During a severe drought on one island, only large, hard-shelled seeds remained as a food source. Which outcome would researchers most likely observe in the finch population on that island in the next generation?

A. The average beak size in the next generation would decrease because the available seeds are bigger

B. Every surviving finch would have an identical beak size regardless of its parental genotypes inherited

C. The total finch population on the island would increase dramatically due to abundant high-quality seeds

D. The average beak size in the next generation would increase because larger-beaked birds survived best

32. Genetic evidence supports the conclusion that all Galapagos finch species are descended from:

A. Several unrelated ancestral species that colonized the islands separately at very different times

B. A single ancestral finch species that originally arrived on the islands from the South American mainland

C. Bird species that originated locally on the Galapagos Islands several billions of years ago in deep history

D. Introduced bird species brought intentionally by sailors traveling across the Pacific Ocean centuries ago

33. On one Galapagos island, two finch species coexist by feeding on different sizes of seeds. This division of resources between the two species is best described as:

A. Convergent evolution, in which unrelated species develop similar physical traits over long periods of time

B. Symbiosis, in which two species depend directly on each other for nutrition and survival in shared habitat

C. Niche partitioning, in which different species use different resources to reduce direct competition between them

D. Predation, in which one species directly consumes another species within a shared ecological habitat

34. Which type of evidence most directly supports the conclusion that all Galapagos finch species share a recent common ancestor?

A. Strong similarities in the DNA sequences shared across all of the finch species studied across the islands

B. The fact that all of the finch species have feathers, wings, and a beak that they use for feeding daily

C. Fossils found in South America that show finches feeding on grass seeds in open meadows long ago

D. The fact that finches today can eat many of the same crops grown on farms thousands of miles away

35. Suppose two finch populations on different islands diverge for so long that they can no longer interbreed and produce fertile offspring when later reunited. This outcome best illustrates:

A. Acclimation, the short-term physiological adjustment of one individual organism to a new local climate

B. Coevolution, in which two interacting species evolve in response to each other over many generations

C. Inheritance of acquired characteristics, as originally proposed by Lamarck in early evolutionary theory work

D. Speciation, the formation of one or more new species from a single ancestral population over long time

36. The original variation in beak size and shape that natural selection acted upon in the ancestral finch population arose primarily from:

A. Conscious decisions by individual birds to change their own beak shape during their daily feeding

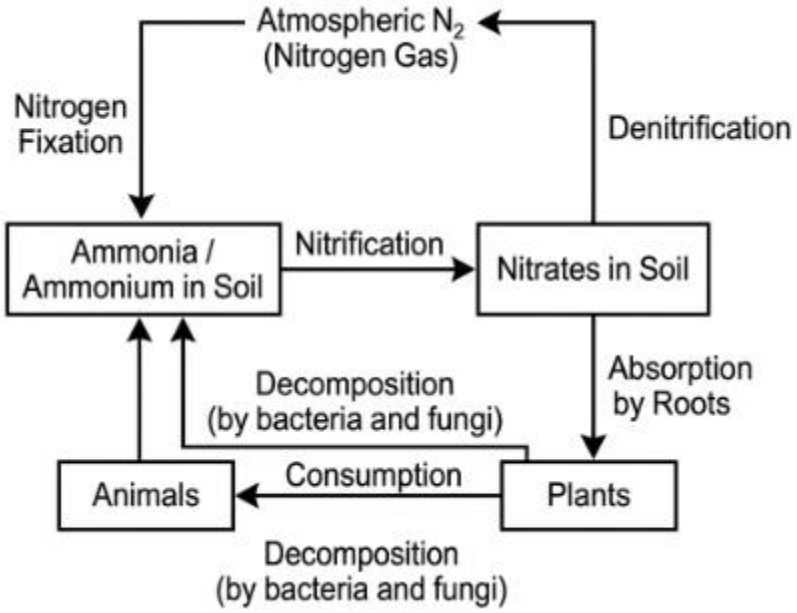
B. Random mutations and the reshuffling of alleles during sexual reproduction over many generations of birds

C. The direct effects of island climate, which physically reshaped the beaks of mature adult finches each year

D. Coordinated changes in DNA produced by environmental signals received by parent birds during life

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

A simplified diagram of the nitrogen cycle is shown below. Nitrogen gas (N_2) makes up about 78% of Earth's atmosphere, but most organisms cannot use nitrogen in this form. Specialized bacteria, lightning, and human-made fertilizers convert N_2 into forms (such as ammonia, ammonium, and nitrate) that plants can absorb through their roots. Animals obtain nitrogen by eating plants or other animals. Decomposers return nitrogen from dead organisms to the soil.



37. The process labeled "Nitrogen Fixation" in this diagram most directly converts:

A. Nitrate ions in the soil into nitrogen gas that is released back into the atmosphere each day

B. Nitrogen-containing organic material in dead organisms into nitrate ions in the surrounding soil

C. Plant tissue containing nitrogen into pure ammonia gas released directly back into the atmosphere

D. Atmospheric nitrogen gas (N_2) into ammonia or ammonium compounds usable by living organisms

38. Most biological nitrogen fixation on land is carried out by bacteria that live in close association with which structures?

A. The leaves of large trees, where the bacteria are exposed to sunlight and to atmospheric gases

B. The stems of woody perennials, where the bacteria are sheltered inside the tough protective bark layer

C. The root nodules of legumes such as soybeans, peas, clover, alfalfa, and several similar related plants

D. The seeds of grasses, where the bacteria are stored along with starch reserves for the future plant

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

A. Producing nitrogen gas from sunlight and water in a process closely similar to photosynthesis in plants

B. Removing nitrogen permanently from the soil and storing all of it in their own dead and dried bodies

C. Breaking down nitrogen compounds in dead organisms and returning ammonia or ammonium to the soil

D. Converting ammonia back to atmospheric nitrogen gas through the action of their digestive enzymes alone

40. Without nitrogen-fixing bacteria, agricultural crop plants would most likely:

A. Struggle to obtain enough usable nitrogen to build the proteins and nucleic acids the plant needs

B. Continue to grow normally because plants can absorb nitrogen gas directly through their leaf surfaces

C. Produce more seeds and fruit because soil nitrogen levels would no longer be limiting their growth

D. Switch to obtaining nitrogen by directly consuming small soil animals through their root tip cells

41. Runoff from heavily fertilized agricultural fields can introduce large amounts of nitrate into nearby lakes and rivers. The most common ecological consequence is:

A. A long-term increase in oxygen levels caused by rapid photosynthesis from the aquatic plants present

B. Algal blooms that consume oxygen as they die and decompose, suffocating fish and many other animals

C. A rapid drop in water temperature caused by nitrogen reacting chemically with the cool surface water

D. A permanent rise in the pH of the affected water, making it strongly basic and undrinkable for animals

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

A vaccine introduces a weakened, killed, or molecular component of a pathogen into the body without causing the full disease. The immune system responds to this exposure by producing specific antibodies and memory cells. Later, if the person is exposed to the actual pathogen, the immune system can respond much more quickly and strongly than during the first exposure, often preventing illness altogether.

42. A vaccine helps protect a person from future infection primarily by:

A. Killing all microbes already present in the person's bloodstream at the time of vaccination given

B. Providing the person with antibiotics that destroy bacterial pathogens during any later exposure event

C. Triggering the immune system to produce memory cells targeted to a specific pathogen for the future

D. Permanently changing the DNA of all the person's body cells so they directly resist the pathogen

43. Cells of the immune system that produce and release antibodies into the bloodstream are best identified as:

A. Red blood cells, which carry oxygen and small amounts of carbon dioxide throughout the body's tissues

B. B lymphocytes, which differentiate into plasma cells that secrete specific protein antibodies for defense

C. Skin epithelial cells, which form a continuous protective barrier across the outer surface of the body

D. Liver hepatocytes, which detoxify harmful substances and store excess glucose as glycogen polymers

44. A person who has fully recovered from a particular viral infection is often immune to that same virus for many years. The most likely explanation is that:

A. Memory cells from the original infection mount a fast and strong response upon any later re-exposure

B. The original virus that infected the person now lives harmlessly in the person's bloodstream forever

C. The person's body permanently increases its overall internal body temperature against any future infection

D. The person's red blood cells produce fresh new antibodies daily for the entire rest of their adult life

45. Antibodies recognize and bind to specific pathogens because each antibody has a binding site that is shaped to fit:

A. Any pathogen that happens to be circulating in the bloodstream at the moment of an active infection

B. The general outer membrane structure shared in common by all viruses and bacterial cells alike together

C. Sugar molecules in the bloodstream that mark the cells as belonging to the original host organism itself

D. A specific antigen molecule on the surface of the pathogen, like a lock that matches one specific key

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

Average global temperatures have risen since the mid-1900s, and these changes are already affecting ecosystems and the species that live in them. Many species are shifting their ranges toward cooler regions, others are altering the timing of seasonal behaviors such as migration and breeding, and some are declining sharply in numbers as their habitats are disrupted. Scientists, engineers, and policymakers are working to monitor these changes and design responses to them.

46. As average global temperatures rise, many terrestrial animal and plant species are observed to be:

A. Permanently disappearing from cooler regions and moving toward warmer tropical equatorial zones worldwide

B. Migrating downward to lower elevations to escape the colder air found at the tops of high mountain ranges

C. Shifting their ranges toward higher latitudes or higher elevations in order to track the cooler conditions

D. Remaining in their identical historical ranges with no measurable change in distribution over recent decades

47. Polar species such as polar bears are considered especially vulnerable to climate change because:

A. Melting sea ice reduces the platforms they depend on for hunting seals and resting between dives

B. Warmer air temperatures cause their thick insulating fur coats to permanently fall out within one season

C. Their primary food source is freshwater fish, which cannot survive in the saltier surrounding ocean water

D. Polar bears require year-round direct sunlight, which decreases sharply as the sea ice cover decreases

48. A species that cannot migrate quickly enough or adapt evolutionarily to rapid climate change is most likely to experience:

A. A short-term spike in population size, followed by a return to its historical average in just one generation

B. A permanent increase in offspring survival rates due to the warmer overall environmental conditions presented

C. A reduction in genetic variation, followed by complete population recovery within a single later generation

D. Local extinction in regions where conditions move outside its tolerance range for survival and reproduction

49. Coral bleaching events have become more frequent in recent decades as ocean temperatures continue to rise. A coral bleaching event occurs when:

A. Heavy rains wash large quantities of fertile soil from the land onto shallow coastal coral reef areas

B. Heat stress causes corals to expel the symbiotic algae that normally live inside the coral animal tissues

C. Coral polyps die instantly when the surrounding ocean water temperatures rise above twenty-five degrees Celsius

D. Increased ocean salinity dissolves the calcium carbonate skeletons of all reef-building coral species worldwide

50. Which human activity contributes most directly to the rise in atmospheric carbon dioxide that drives recent climate change?

A. The construction of underground subway transit systems in densely populated urban centers around the world

B. The widespread installation of solar panels and wind turbines used to generate clean electrical power

C. The use of small-scale residential composting bins to recycle yard waste and household food waste at home

D. The burning of fossil fuels such as coal, oil, and natural gas for energy production and transportation use

Practice Exam 4: Life Science: Biology Simulation – Answer Key with Explanations

1. B — Which substances are able to pass through a selectively permeable membrane. The investigation places a known mixture of large molecules (starch) and small molecules (glucose) inside the bag and uses indicators to detect movement. The setup directly tests permeability differences based on molecular size, which is the defining feature of a selectively permeable membrane.

2. D — Starch molecules were too large to pass through the pores of the membrane. Iodine is the indicator for starch, and an amber result in the beaker means no starch crossed into the surrounding water. Starch is a large polysaccharide, so its inability to diffuse out demonstrates that the dialysis tubing's pores are too small to allow it through.

3. A — Diffusion of glucose molecules from higher to lower concentration across the membrane. Benedict's solution turning orange-red in the beaker confirms glucose moved out of the tubing into the surrounding water. Glucose is a small monosaccharide that moves down its concentration gradient by passive diffusion, requiring no ATP.

4. C — The cell membrane, which regulates the entry and exit of substances in the cell. Dialysis tubing is a synthetic selectively permeable barrier that allows some molecules through while blocking others,

mirroring how a living cell membrane controls movement of substances. The other listed structures perform unrelated functions inside the cell.

5. B — The bag would shrink as water moves out of the bag into the surrounding beaker. A 50% glucose surrounding solution is hypertonic relative to the 30% glucose inside the bag, so water moves by osmosis from the lower solute concentration (inside) to the higher solute concentration (outside). Net water loss causes the bag to lose volume and shrink.

6. A — Produce new cells for the growth, repair, and replacement of body tissues. Mitosis generates two genetically identical daughter cells, which is exactly what multicellular organisms need for tissue growth, wound healing, and routine cell replacement. Meiosis, not mitosis, handles gamete formation and genetic variation.

7. D — Metaphase, when the chromosomes line up across the middle of the dividing parent cell. The defining event of metaphase is alignment of chromosomes along the cell's equatorial (metaphase) plate by spindle fibers. This alignment ensures each daughter cell will receive exactly one copy of every chromosome during the next phase.

8. C — Interphase, during which the cell grows in size and replicates all of its DNA molecules. The data show 84 of 100 cells in interphase, far more than any mitotic phase. Because the proportion of cells in a phase reflects the time spent there, interphase is by far the longest portion of the cell cycle.

9. C — The tumor cells have lost the normal regulatory control over progression through the cell cycle. Cancer is fundamentally a disease of unregulated cell division, caused by mutations in genes that normally stop or pause the cell cycle at checkpoints. A high proportion of mitotic cells in a tumor directly reflects this loss of control.

10. A — Genetically identical to the parent cell and to each other in chromosome number and content. Mitosis is preceded by DNA replication and followed by an equal division of sister chromatids, so each daughter cell receives the same chromosome set as the parent. This genetic fidelity is what makes mitosis suitable for growth and repair.

11. B — The left atrium, which receives oxygen-rich blood arriving from the pulmonary veins. Blood from the lungs travels through the pulmonary veins directly into the left atrium. From there it passes into the left ventricle, which pumps oxygen-rich blood out to the body through the aorta.

12. D — Working muscles required more oxygen, prompting faster oxygen delivery by the circulatory system. Exercising skeletal muscles consume oxygen rapidly for aerobic respiration and produce more carbon dioxide. The heart increases its rate to deliver oxygen and remove CO_2 faster, matching circulation to metabolic demand.

13. D — Carrying oxygen via hemoglobin from the lungs to the body's actively working muscle tissues. Each red blood cell is packed with hemoglobin, which binds oxygen in the lungs and releases it in tissues where oxygen levels are lower. During exercise, this transport role becomes critical to keep aerobic respiration running in the working muscles.

14. A — Lower cardiovascular fitness in the second student than in the first student tested. Fitter individuals recover toward resting heart rate more rapidly because their hearts and circulatory systems are more efficient. A heart rate still at 130 bpm six minutes after stopping exercise indicates the heart is taking longer to meet recovery demand, a sign of lower conditioning.

15. C — The vena cava, which carries blood back from the body into the right atrium of the heart. The superior and inferior vena cava collect oxygen-poor blood from the upper and lower body and deliver it to the right atrium. From there blood passes to the right ventricle and out to the lungs via the pulmonary artery.

16. B — The genetic code is essentially universal across nearly all known organisms on Earth today. Bacteria, plants, fungi, and animals all use the same codon-to-amino-acid assignments, which is why genes can be transferred between species in biotechnology. This universality is strong evidence that all life shares a common ancestor.

17. A — The ribosome, where transfer RNA molecules deliver amino acids to a growing polypeptide chain. Ribosomes read mRNA codons and catalyze peptide bond formation between amino acids delivered by tRNAs. This site of protein synthesis is the same in both prokaryotes and eukaryotes.

18. C — 100 amino acids, since each codon of three nucleotides specifies one amino acid in protein. The genetic code is read in triplets, so $300 \div 3 = 100$ codons, each coding for one amino acid. This 3-to-1 ratio is a fundamental property of the genetic code.

19. D — A frameshift mutation that alters the reading frame of every codon from that point onward. Deleting one nucleotide shifts how the ribosome groups the remaining bases into triplets, so every codon downstream of the deletion is altered. Frameshift mutations usually produce a completely different and nonfunctional protein.

20. B — Autosomal recessive, expressed only in individuals homozygous for the affected allele. The condition appears in both sexes equally and can skip generations, with affected children born to unaffected parents — the classic signature of an autosomal recessive trait. Both parents must carry a copy of the recessive allele to produce an affected child.

21. B — Both parents must be heterozygous carriers of the recessive albinism allele themselves. Because albinism is autosomal recessive, an affected child must inherit one recessive allele from each parent. Since neither parent shows the condition, each parent must be a heterozygous carrier (Aa).

22. A — Approximately 25 percent, based on a standard heterozygous-by-heterozygous Mendelian cross. A cross between two carriers ($Aa \times Aa$) produces offspring in a 1:2:1 genotype ratio (AA:Aa:aa), so 1 in 4 children are predicted to be homozygous recessive and therefore affected. Each pregnancy is an independent event with the same 25% risk.

23. C — An enzyme required for one of the steps in the biosynthesis of the pigment melanin. Most cases of albinism result from a mutation in a gene coding for an enzyme such as tyrosinase, which catalyzes a key step in converting tyrosine into melanin. Without a functional enzyme, melanin synthesis is reduced or blocked.

24. D — Trace inheritance patterns through generations and estimate the risks to potential future children. Pedigrees show how a trait moves through a family across generations, which lets a counselor identify the inheritance pattern (dominant, recessive, sex-linked) and calculate the probability of affected offspring. This is the central clinical use of pedigree analysis.

25. A — Logistic growth, with a rapid early increase followed by a clear leveling-off phase over time. The graph shows a classic S-shaped curve: slow start, rapid exponential-like rise, then a plateau around 520 rabbits. This S-shape is the signature of logistic growth as a population approaches carrying capacity.

26. C — Carrying capacity, the largest population size that the environment can sustainably support. Carrying capacity (K) is set by available resources such as food, water, space, and shelter. On the graph it corresponds to the plateau where births and deaths balance each other out.

27. B — The growth rate decreases as resources become limiting and competition between rabbits intensifies. As density rises, individuals must share food and space, which lowers reproduction and raises mortality. The net result is a steadily slowing growth rate that approaches zero at carrying capacity.

28. C — Competition for limited grasses among the rabbits and the spread of contagious disease among rabbits. Density-dependent factors have stronger effects as population density rises, which is exactly how competition for food and infectious disease behave. Weather events and photoperiod affect populations regardless of density and are therefore density-independent.

29. D — Exponential growth, in which the population's numbers increase at an accelerating rate over time. When resources are unlimited and mortality is low, each generation produces more offspring than the previous one, yielding a J-shaped curve. This pattern continues only until some limiting factor begins to slow growth.

30. A — Natural selection, with different food sources favoring different beak shapes on different islands. On each island, finches whose beaks matched the locally available food survived and reproduced more successfully, passing those traits to offspring. Over many generations, this differential survival produced the variety of specialized beak shapes seen today.

31. D — The average beak size in the next generation would increase because larger-beaked birds survived best. Selection pressure from large, hard seeds favors finches with bigger, stronger beaks; small-beaked birds cannot crack the seeds and reproduce less. Because beak size is heritable, the next generation inherits more large-beak alleles, shifting the average upward.

32. B — A single ancestral finch species that originally arrived on the islands from the South American mainland. Genetic sequencing shows all Galapagos finches share a very close common ancestor, consistent with one founding population. This is a classic example of adaptive radiation from a single colonizing species.

33. C — Niche partitioning, in which different species use different resources to reduce direct competition between them. When two species use the same habitat but specialize on different food sizes or types, direct competition is reduced and both species can coexist. This resource division is a common evolutionary outcome of intense interspecific competition.

34. A — Strong similarities in the DNA sequences shared across all of the finch species studied across the islands. Shared DNA sequences are the most direct molecular evidence of common ancestry because closely related species share more recent genetic inheritance. Shared general features like having beaks or feathers are too broad to demonstrate recent common ancestry.

35. D — Speciation, the formation of one or more new species from a single ancestral population over long time. Reproductive isolation — the inability to interbreed and produce fertile offspring — is the defining criterion of separate biological species. When isolated populations diverge to that extent, speciation has occurred.

36. B — Random mutations and the reshuffling of alleles during sexual reproduction over many generations of birds. Heritable variation, the raw material for natural selection, originates from random DNA mutations and from recombination of parental alleles in offspring. Selection then acts on this pre-existing variation, rather than producing variation on demand.

37. D — Atmospheric nitrogen gas (N_2) into ammonia or ammonium compounds usable by living organisms. Nitrogen fixation is the conversion of inert N_2 into reactive nitrogen forms (NH_3 or NH_4^+) carried out by specialized bacteria and, on a smaller scale, by lightning. Without this step, atmospheric nitrogen would be biologically unavailable to most organisms.

38. C — The root nodules of legumes such as soybeans, peas, clover, alfalfa, and several similar related plants. Rhizobium bacteria form a symbiotic partnership with legume roots, living in nodules where they convert N_2 into ammonia in exchange for sugars from the plant. This relationship is the primary route by which biological nitrogen fixation enters terrestrial ecosystems.

39. C — Breaking down nitrogen compounds in dead organisms and returning ammonia or ammonium to the soil. Decomposers digest proteins and nucleic acids in dead tissue and waste, releasing nitrogen as ammonia (ammonification). This recycled nitrogen becomes available again to plants and the broader food web.

40. A — Struggle to obtain enough usable nitrogen to build the proteins and nucleic acids the plant needs. Plants cannot directly use atmospheric N_2; they depend on fixed forms such as ammonium and nitrate supplied largely by nitrogen-fixing bacteria. Without those bacteria, soil nitrogen would quickly become a major limiting factor for crop growth.

41. B — Algal blooms that consume oxygen as they die and decompose, suffocating fish and many other animals. Excess nitrate fuels rapid algal growth (eutrophication); when the algae die, decomposing bacteria consume large amounts of dissolved oxygen. The resulting hypoxic conditions kill fish and create "dead zones."

42. C — Triggering the immune system to produce memory cells targeted to a specific pathogen for the future. Vaccines expose the immune system to antigens without causing disease, prompting production of antibodies and long-lived memory B and T cells. On real exposure, those memory cells respond rapidly and strongly, often preventing illness entirely.

43. B — B lymphocytes, which differentiate into plasma cells that secrete specific protein antibodies for defense. Activated B cells become plasma cells, which mass-produce antibodies specific to a recognized antigen. These antibodies circulate in the blood and mark pathogens for destruction.

44. A — Memory cells from the original infection mount a fast and strong response upon any later re-exposure. After an infection clears, a subset of B and T cells persists as memory cells specific to that pathogen. On re-exposure, these memory cells rapidly proliferate and produce a stronger, faster response — the basis of long-term immunity.

45. D — A specific antigen molecule on the surface of the pathogen, like a lock that matches one specific key. Each antibody has a unique binding site shaped to recognize one particular antigen. This lock-and-key specificity is what allows the immune system to distinguish among countless different pathogens.

46. C — Shifting their ranges toward higher latitudes or higher elevations in order to track the cooler conditions. As regions warm, species track their preferred temperature range by moving poleward or upslope. This pattern has been documented in many plant, insect, bird, and mammal populations worldwide.

47. A — Melting sea ice reduces the platforms they depend on for hunting seals and resting between dives. Polar bears hunt seals from the surface of sea ice, which is shrinking in both extent and duration each year. Loss of ice forces longer swims and reduced hunting opportunities, threatening survival and reproduction.

48. D — Local extinction in regions where conditions move outside its tolerance range for survival and reproduction. Each species has a limited range of temperature, moisture, and other conditions in which it can survive. When climate change shifts conditions outside that tolerance and the species cannot move or evolve fast enough, populations die out locally.

49. B — Heat stress causes corals to expel the symbiotic algae that normally live inside the coral animal tissues. Reef-building corals host photosynthetic zooxanthellae that provide most of the coral's energy and color. Elevated water temperatures disrupt this symbiosis; the coral expels the algae, turns white, and may starve if conditions do not improve.

50. D — The burning of fossil fuels such as coal, oil, and natural gas for energy production and transportation use. Combustion of fossil fuels releases vast amounts of stored carbon as CO_2, which is the largest human-caused contributor to rising atmospheric greenhouse gas concentrations. Reducing fossil fuel use is therefore central to mitigating climate change.