

PRACTICE EXAM 9: LIVING ENVIRONMENT REGENTS SIMULATION

Time Allowed: 3 hours | Total Points: 85 | Passing: 65 scaled | Mastery: 85 scaled

PART A — CORE CONTENT MULTIPLE CHOICE (30 Questions, 30 Points)

Answer all questions in this part.

1. The statement "all cells come from preexisting cells" is a fundamental principle of the
 - A. theory of natural selection by Darwin
 - B. central dogma of molecular biology
 - C. germ theory of infectious disease
 - D. cell theory of biological life

2. The part of a plant cell that gives it shape and protects it is the
 - A. cell membrane, which is selectively permeable
 - B. cell wall, made of cellulose for rigid support
 - C. vacuole, which stores water in the cell
 - D. nucleus, which controls cell activities

3. A substance moves into a cell against its concentration gradient. This movement is best described as
 - A. active transport requiring ATP energy
 - B. simple diffusion down a gradient

- C. osmosis of water through aquaporins
- D. facilitated diffusion through proteins

4. An enzyme's three-dimensional shape can be disrupted by extreme heat in a process called

- A. catalysis of the enzyme reaction
- B. inhibition of the substrate binding
- C. denaturation of the enzyme protein
- D. saturation of the active site

5. When ATP is converted to ADP, the reaction

- A. releases energy that the cell can use
- B. requires energy added from sunlight
- C. produces a new DNA molecule for the cell
- D. forms a new protein chain at the ribosome

6. In a plant cell, the light reactions of photosynthesis take place in the

- A. nucleus of the plant cell
- B. cytoplasm surrounding the cell parts
- C. cell membrane of the plant cell
- D. thylakoid membranes of chloroplasts

7. In aerobic respiration, the majority of ATP is produced during

- A. glycolysis in the cell's cytoplasm
- B. the electron transport chain in mitochondria

- C. fermentation when oxygen is unavailable
- D. photosynthesis in the chloroplasts of plants

8. The nitrogen bases that pair together in DNA do so because they

- A. are exactly the same size and shape
- B. form covalent bonds with one another
- C. form complementary hydrogen bonds
- D. carry opposite electrical charges always

9. The process by which a DNA sequence is used to produce a complementary mRNA strand is called

- A. translation that occurs at the ribosome
- B. replication that occurs before cell division
- C. mutation that alters the original sequence
- D. transcription that occurs in the nucleus

10. A codon is a sequence of three nitrogen bases on mRNA that

- A. codes for one specific amino acid in a protein
- B. codes for an entire protein in a single sequence
- C. duplicates the DNA sequence exactly as written
- D. transports amino acids to the active ribosome

11. If a homozygous tall pea plant (TT) is crossed with a homozygous short pea plant (tt), the offspring will be

- A. 100% short with a homozygous recessive genotype
- B. 75% tall and 25% short in phenotype ratio

- C. 100% tall with a heterozygous Tt genotype
- D. 50% tall and 50% short in phenotype ratio

12. In a pedigree chart, a square symbol traditionally represents

- A. a female individual in the family
- B. a male individual in the family
- C. an offspring of unknown sex
- D. an unaffected individual only

13. Hemophilia is a sex-linked recessive disorder. A man with hemophilia will pass the disease allele to

- A. all of his daughters but none of his sons
- B. all of his sons but none of his daughters
- C. half of his sons and half of his daughters
- D. none of his children regardless of sex

14. A mutation in which an entire piece of one chromosome breaks off and attaches to another chromosome is called

- A. a point mutation changing a single base
- B. a deletion of a segment of bases
- C. a duplication adding extra DNA copies
- D. a translocation between two chromosomes

15. During mitosis, the chromosomes line up at the center of the cell during the stage called

- A. prophase, when chromosomes condense
- B. metaphase, when chromosomes align

- C. anaphase, when chromatids separate
- D. telophase, when daughter nuclei form

16. The exchange of genetic material between homologous chromosomes during meiosis is known as

- A. nondisjunction of unseparated chromosomes
- B. binary fission of the parent cell
- C. crossing over of chromatid segments
- D. random fertilization of the egg

17. Individuals in a population that are best suited to their environment are most likely to

- A. survive and pass their traits on to offspring
- B. produce fewer offspring than their competitors
- C. die out before they can reproduce successfully
- D. develop new traits during their own lifetimes

18. The appendix in humans and the pelvic bones in whales are best described as

- A. embryonic structures present only before birth
- B. analogous structures with similar functions
- C. homologous structures performing similar tasks
- D. vestigial structures with reduced or no function

19. The development of two new species from one ancestral species over many generations is known as

- A. extinction of the original ancestral species
- B. convergent evolution of two unrelated lineages

- C. divergent evolution into separate species
- D. adaptation to one specific environment

20. A population that has unlimited resources and no environmental restrictions would show

- A. logistic growth slowing at carrying capacity
- B. exponential growth with no upper limit
- C. a steady population size over a long time
- D. a sharp decline followed by extinction

21. In a food chain, the organisms that capture energy directly from sunlight are called

- A. producers at the base of the food chain
- B. primary consumers feeding on the producers
- C. secondary consumers feeding on herbivores
- D. decomposers breaking down the dead matter

22. Fungi and bacteria that break down dead organisms and return nutrients to the soil are called

- A. carnivores that eat other animals
- B. herbivores that eat only plants
- C. producers that perform photosynthesis
- D. decomposers that recycle nutrients

23. Two species of birds in the same forest both eat the same kind of insects. The interaction between these two bird species is best described as

- A. mutualism, in which both species benefit
- B. parasitism, in which one species harms the other

- C. competition for the same limited resource
- D. commensalism, in which only one benefits

24. In a forest ecosystem, when the rabbit population increases, the fox population is likely to

- A. decrease because of decreased food availability
- B. increase because of increased food availability
- C. remain unchanged because foxes do not eat rabbits
- D. move to a different ecosystem to find food

25. Lichens are often the first organisms to colonize bare rock surfaces. These pioneer species help create soil by

- A. slowly breaking down the rock as they grow on it
- B. transporting topsoil from neighboring locations
- C. producing seeds that germinate into soil layers
- D. trapping water that then turns rock into soil

26. The process by which water vapor in the atmosphere changes back into liquid form to make clouds is called

- A. evaporation from oceans and lakes
- B. precipitation in the form of rain and snow
- C. condensation in the cooler atmosphere
- D. transpiration from the leaves of plants

27. Nitrogen-fixing bacteria are essential to ecosystems because they

- A. break down dead plant tissue into soil materials

- B. consume nitrogen waste produced by animals
- C. produce oxygen for animals in the ecosystem
- D. convert atmospheric nitrogen into usable compounds

28. After a high-carbohydrate meal, the pancreas releases the hormone insulin, which causes

- A. blood sugar levels to rise dramatically
- B. body cells to absorb glucose from the blood
- C. the liver to release glucose into the blood
- D. the kidneys to filter glucose into urine

29. The heart's left ventricle has the thickest muscular wall because it

- A. pumps blood with the most force throughout the body
- B. holds the largest volume of blood among the chambers
- C. receives blood from the lungs at the highest pressure
- D. pumps blood only the short distance to the lungs

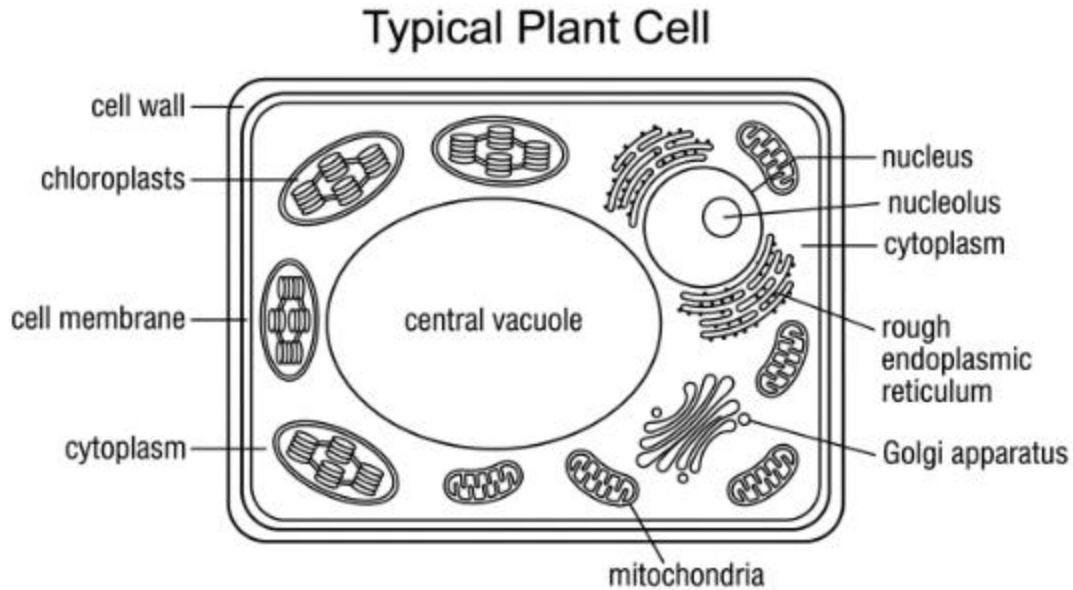
30. During inhalation, the diaphragm and rib muscles contract, causing the chest cavity to

- A. compress and force air out of the lungs
- B. remain unchanged with no air movement
- C. expand and draw air into the lungs
- D. fill with fluid pushed up from below

PART B-1 — DATA-BASED MULTIPLE CHOICE (13 Questions, 13 Points)

Answer all questions in this part. Base your answers to questions 31–34 on the diagram below and on your knowledge of biology.

31. A student examines a diagram of a plant cell.



In the diagram, the structure that captures light energy and converts it into chemical energy is the

- A. nucleus, which contains the cell's DNA
- B. chloroplast, which performs photosynthesis
- C. mitochondrion, which produces ATP energy
- D. central vacuole, which stores cell sap

32. Referring to the same diagram, the rigid outer structure that supports the plant cell and is absent in animal cells is the

- A. cell membrane, which surrounds every type of cell
- B. nucleus, which holds the cell's genetic material
- C. central vacuole, which stores fluid and waste
- D. cell wall, made of rigid cellulose for support

33. Referring to the same diagram, the central vacuole performs which of the following functions in the plant cell?

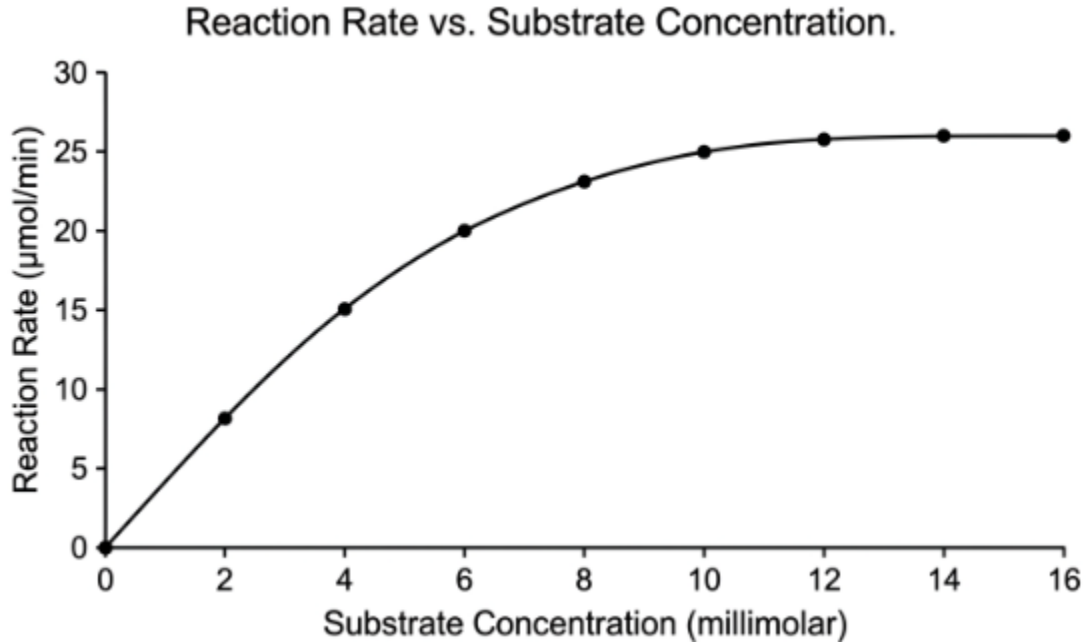
- A. storing water and helping maintain cell shape and turgor
- B. carrying out the reactions of photosynthesis directly
- C. producing the ATP energy needed by the cell
- D. assembling proteins from amino acid chains

34. Referring to the same diagram, the organelle in which proteins are synthesized for use in the cell is identified as

- A. the central vacuole storing cell contents
- B. the chloroplast performing photosynthesis
- C. the rough endoplasmic reticulum with ribosomes
- D. the cell wall surrounding the entire cell

Base your answers to questions 35–37 on the graph below and on your knowledge of biology.

35. A student measures the rate of an enzyme-catalyzed reaction at different substrate concentrations while keeping enzyme concentration constant.



Based on the graph, the reaction rate reaches its maximum value of approximately

- A. 8 µmol/min at low substrate concentration
- B. 15 µmol/min at moderate substrate concentration
- C. 20 µmol/min at moderate substrate concentration
- D. 26 µmol/min at high substrate concentration

36. Based on the same graph, the reaction rate levels off at high substrate concentrations because

- A. all of the substrate molecules have been used up entirely
- B. all of the enzyme active sites are occupied at the same time
- C. the enzyme molecules have all been denatured by the substrate
- D. the temperature of the reaction has dropped sharply at this point

37. Based on the same graph, doubling the substrate concentration from 2 mM to 4 mM causes the reaction rate to

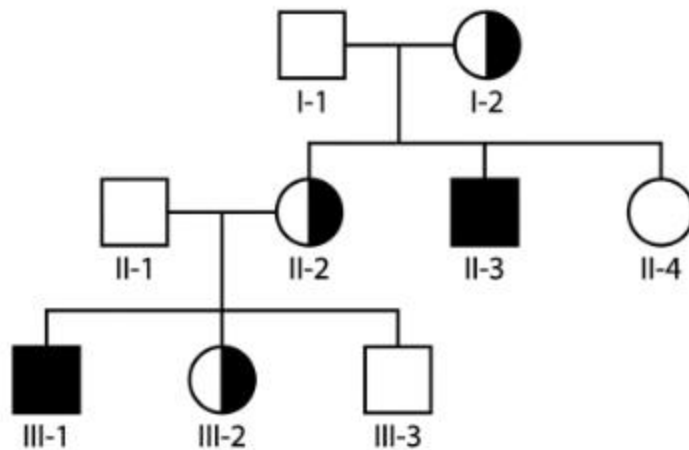
- A. nearly double, indicating substrate-limited conditions

- B. decrease significantly because of substrate excess
- C. remain exactly the same as at 2 mM concentration
- D. quadruple in proportion to the substrate increase

Base your answers to questions 38–40 on the pedigree below and on your knowledge of biology.

38. A pedigree shows the inheritance of hemophilia, an X-linked recessive disorder, in a family.

Pedigree of X-linked Hemophilia



Filled = affected (hemophilia); Half-filled circle = carrier female;
Unfilled = unaffected; Square = male; Circle = female.

Based on the pedigree, the genotype of the carrier female I-2 must be

- A. $X^H X^H$, with two normal dominant alleles
- B. $X^h X^h$, with two recessive disease alleles
- C. $X^H X^h$, with one normal and one recessive allele
- D. $X^H Y$, with the normal allele on her X chromosome

39. Based on the same pedigree, if a carrier female ($X^H X^h$) and an unaffected male ($X^H Y$) have a son, the probability that the son will have hemophilia is

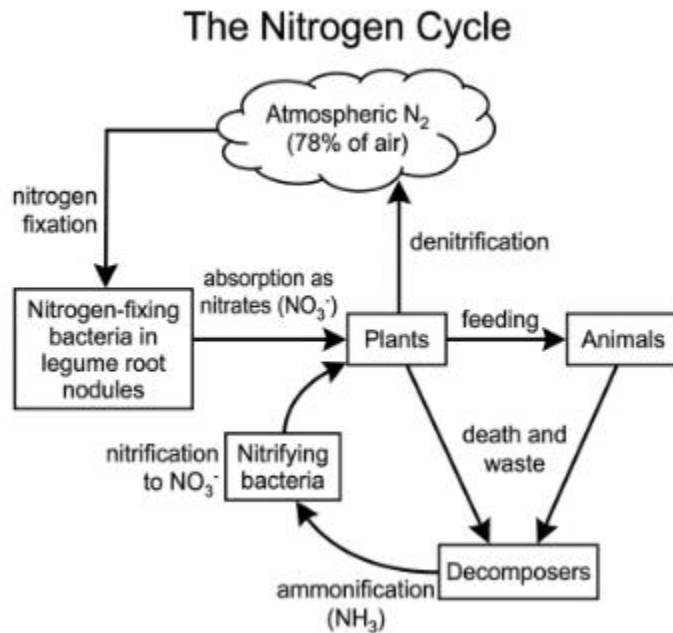
- A. 0% chance of hemophilia in any son
- B. 50% chance of hemophilia in any son
- C. 25% chance of hemophilia in any son
- D. 100% chance of hemophilia in any son

40. Based on the same pedigree, an affected male such as II-3 must have inherited the X^h allele from

- A. his mother, who carried the recessive allele
- B. his father, who passed an X chromosome to him
- C. both parents through codominant inheritance
- D. a new mutation that occurred at his conception

Base your answers to questions 41–43 on the diagram below and on your knowledge of biology.

41. A student examines a diagram of the nitrogen cycle.



Based on the diagram, the process that converts atmospheric nitrogen gas into a form usable by plants is

- A. denitrification by soil bacteria into the air
- B. ammonification by decomposers of dead matter
- C. nitrogen fixation by symbiotic bacteria in nodules
- D. nitrification of waste compounds in the soil

42. Based on the same diagram, nitrogen returns to the atmosphere through the process of

- A. ammonification of dead organic matter
- B. nitrification carried out by soil bacteria
- C. nitrogen fixation by symbiotic bacteria
- D. denitrification by certain soil bacteria

43. Based on the same diagram, decomposers contribute to the nitrogen cycle by

- A. converting nitrogen gas directly into plant matter
- B. converting nitrogen in dead matter into ammonia (NH_3)
- C. absorbing nitrates from the soil for use in their cells
- D. releasing oxygen as a waste product of decay

PART B-2 — MIXED FORMAT (12 Questions, 12 Points)

Answer all questions in this part.

44. A scientist proposes a new explanation for a natural phenomenon based on observations and prior knowledge. This explanation is best described as

- A. a hypothesis to be tested by experiment
- B. a fact established without need for testing
- C. a control variable in the experiment

D. a conclusion drawn from completed work

45. Which of the following is the best example of a controlled experiment?

- A. observing the natural behavior of a species in the field
- B. studying photographs of an ecosystem from a distance
- C. asking many people their opinion about a scientific issue
- D. testing one variable while keeping all others constant

46. In an $Aa \times Aa$ cross, the probability of an offspring with the dominant phenotype is

- A. 25% of the offspring show the dominant trait
- B. 50% of the offspring show the dominant trait
- C. 75% of the offspring show the dominant trait
- D. 100% of the offspring show the dominant trait

47. The polymerase chain reaction (PCR) is used in DNA technology primarily to

- A. cut DNA at specific recognition sites in the strand
- B. produce many copies of a specific DNA segment
- C. translate mRNA codons into amino acid sequences
- D. join two DNA fragments together end to end

48. In a sample of DNA, 30% of the bases are guanine. According to Chargaff's rules, the percentage of adenine in the same sample is

- A. 20% adenine in the sample
- B. 30% adenine in the sample
- C. 60% adenine in the sample

D. 70% adenine in the sample

49. The Hardy-Weinberg principle states that, in a stable population, allele frequencies will remain unchanged unless

- A. all members of the population are genetically identical
- B. only natural selection acts on the population
- C. the population becomes infinitely large in size
- D. evolutionary forces such as mutation or migration act on it

50. A virus that destroys helper T cells of the human immune system is

- A. the influenza virus causing seasonal flu
- B. the rhinovirus that causes the common cold
- C. the human immunodeficiency virus (HIV)
- D. the bacterium causing tuberculosis disease

51. A scientist is studying an ecosystem where one species of fish has been introduced from another part of the world. The most likely long-term impact is

- A. an immediate increase in native fish populations
- B. disruption of native species through new competition
- C. complete recovery to the original ecosystem balance
- D. no measurable change to the ecosystem at all

52. The biome characterized by very cold winters, short cool summers, and dominated by needle-leaved evergreen trees is the

- A. taiga biome of northern coniferous forests

- B. tropical rainforest near the equator zone
- C. desert biome of dry interior regions
- D. savanna of African grasslands and trees

53. A keystone predator helps maintain biodiversity in its ecosystem by

- A. eliminating all other consumers in the area entirely
- B. eating every organism in the ecosystem equally
- C. preventing all evolution from occurring in the ecosystem
- D. preventing one competitor species from dominating

54. The most direct effect of cutting down a forest to plant agricultural crops on the local ecosystem is

- A. an immediate increase in biodiversity of the area
- B. better adapted species moving rapidly into the area
- C. loss of habitat for many of the native species
- D. greater stability of the ecosystem after rapid recovery

55. The activity that releases the most greenhouse gases into Earth's atmosphere on a global scale is

- A. respiration by all aerobic organisms naturally
- B. burning of fossil fuels for energy production
- C. eruption of volcanoes releasing carbon gases
- D. decomposition of dead organic plant matter

PART C — EXTENDED CONSTRUCTED RESPONSE (17 Questions, 17 Points)

Answer all questions in this part.

56. The S phase of the cell cycle is critical because during this phase

- A. DNA is replicated in preparation for cell division
- B. the cell divides into two new daughter cells
- C. chromosomes are pulled apart by spindle fibers
- D. the cell cytoplasm divides into two halves

57. A diploid human body cell contains 46 chromosomes. After meiosis II, each daughter cell will contain

- A. 92 chromosomes, double the parent cell number
- B. 46 chromosomes, the same as the parent cell
- C. zero chromosomes if the process completes properly
- D. 23 chromosomes, half the parent cell number

58. Two genes located close together on the same chromosome are most likely to be

- A. assorted independently of one another in meiosis
- B. found on different homologous chromosomes from start
- C. inherited together as linked genes during meiosis
- D. carried on the Y chromosome of male mammals

59. A population of dark moths becomes more common in an industrial area as pollution darkens the tree bark around them. This is an example of

- A. directional selection favoring one extreme of a trait
- B. stabilizing selection favoring an intermediate trait
- C. disruptive selection favoring two extremes simultaneously
- D. artificial selection performed by human breeders

60. Genetic engineering can be used to insert a gene from one organism into the DNA of another organism. An example of this technology is

- A. dogs bred over generations for specific traits
- B. bacteria genetically modified to produce human insulin
- C. natural selection of antibiotic-resistant bacteria
- D. a wild rose plant pollinated by an insect

61. In a stable predator-prey relationship, the size of the predator population is closely tied to

- A. the average size of the predator's territory
- B. the speed at which prey reproduce yearly
- C. the temperature of the local environment
- D. the size of the prey population available

62. A scientist proposes that competition between two species can lead to one species being eliminated from the area. This outcome is best described as

- A. mutualism that benefits both species involved
- B. coevolution between the two competing species
- C. competitive exclusion of the less successful species
- D. commensalism where neither species is affected

63. In humans, the organ that filters waste from the blood and produces urine is the

- A. kidney, located in the lower back area
- B. liver, located in the upper abdomen area
- C. pancreas, located behind the stomach area
- D. spleen, located in the upper-left abdomen area

64. The greenhouse effect occurs when

- A. ozone in the upper atmosphere traps incoming sunlight
- B. atmospheric gases trap heat radiating from Earth's surface
- C. ice caps reflect incoming sunlight back into space
- D. clouds prevent sunlight from reaching the surface entirely

65. Compared to arteries, the walls of capillaries are very thin to allow

- A. blood to be pumped under very high pressure
- B. the storage of oxygen for emergency use
- C. rapid clotting of blood when a vessel breaks
- D. exchange of gases and nutrients with tissues

66. The pH of blood in a healthy person is maintained close to 7.4 by buffers in the blood plasma. This regulation is essential because

- A. proteins in the blood are unable to function above pH 7.0
- B. high blood pH would cause the heart to stop beating
- C. enzymes in the body work only within a narrow pH range
- D. carbon dioxide is unable to dissolve at any other pH

67. The hormone glucagon raises blood glucose by signaling the liver to break down

- A. glycogen stored in the liver cells
- B. fatty acids stored in adipose tissue
- C. proteins broken down into amino acids
- D. cellulose taken in through the diet

68. A reflex arc allows the body to respond rapidly to a stimulus without needing the brain because the response is processed in the

- A. cerebrum, the seat of conscious thought
- B. spinal cord, the relay between body and brain
- C. cerebellum, the coordinator of body movement
- D. brainstem, the control center for breathing

69. An autoimmune disease such as rheumatoid arthritis or type 1 diabetes results from

- A. the immune system failing to respond to any pathogens
- B. an inability of the bone marrow to produce blood cells
- C. a complete shutdown of the body's nervous system
- D. the immune system attacking the body's own tissues

70. Vaccination protects against disease because it causes the body to

- A. produce more red blood cells to fight infections
- B. release more digestive enzymes to break down toxins
- C. produce memory cells specific to the pathogen
- D. lower its body temperature to halt pathogen growth

71. Plant hormones called auxins cause plant stems to bend toward a light source. This response is best described as a

- A. positive phototropism toward the light source
- B. negative phototropism away from the light source
- C. positive gravitropism toward the center of Earth
- D. negative gravitropism away from the center of Earth

72. In flowering plants, the structure that develops from a fertilized ovule and contains an embryo is called

- A. a flower that attracts pollinators to the plant
- B. a seed that may grow into a new plant
- C. a leaf that performs photosynthesis for energy
- D. a root that absorbs water from the soil

PART D — LABORATORY PRACTICAL (13 Questions, 13 Points)

Answer all questions in this part.

73. In the Beaks of Finches laboratory, students using a tweezer "beak" may find it efficient at picking up small grains but inefficient at picking up large kidney beans. This observation supports the idea that

- A. all animal beaks function the same regardless of food type
- B. tools become less effective the longer they are used
- C. specific traits provide advantages in specific environments
- D. all populations remain genetically identical over time

74. The Relationships and Biodiversity laboratory uses several techniques to compare species, including chromatography, indicator tests for molecules, and

- A. measurement of average lifespan of each species
- B. observation of social behavior in groups of animals
- C. counting of leaves on each plant in the sample
- D. simulated gel electrophoresis of DNA samples

75. The Diffusion Through a Membrane laboratory typically uses a glucose indicator (Benedict's solution) that requires

- A. heating in a hot water bath before checking for color change
- B. cooling on ice for several minutes before mixing
- C. adding a few drops of acid to react with glucose
- D. the addition of iodine to enhance the reaction

76. In the Making Connections laboratory, students measure pulse rate before, during, and after exercise. To improve the validity of the data, the student should

- A. measure only one student's pulse rate during the lab
- B. compare data only with the original hypothesis stated
- C. take multiple readings and calculate an average
- D. measure only one heartbeat at a time during the test

77. When using a metric ruler to measure the diameter of a circular field of view in a microscope at low power, the diameter is typically

- A. 1.5 micrometers (μm) across the field of view
- B. 1.5 millimeters (mm) across the field of view
- C. 1.5 centimeters (cm) across the field of view
- D. 1.5 meters (m) across the field of view

78. In a biology laboratory, students should always tie back long hair and avoid loose clothing primarily to

- A. make it easier to take notes during the experiment
- B. comply with optional school dress code policies
- C. avoid contaminating the experimental samples with skin oils
- D. prevent hair or clothing from being caught in equipment or flames

79. In the Beaks of Finches laboratory, the "environment" that the simulated finches must adapt to is represented by

- A. the type of "seeds" provided to the students each round
- B. the temperature of the air in the room during the lab
- C. the gender of the students performing the simulation
- D. the time of day when the laboratory is being conducted

80. A student wants to compare the relative concentration of solutes inside a cell with the solution outside the cell. The student observes that water moves out of the cell and the cell shrinks. The outside solution must be

- A. hypotonic, with less solute than inside the cell
- B. isotonic, with equal solute on both sides of the membrane
- C. an unrelated chemical that doesn't affect water movement
- D. hypertonic, with more solute than inside the cell

81. After completing a graph based on experimental data, a student notices a single data point that is very far from the rest of the data. This point is best described as

- A. evidence of the relationship under careful study
- B. an outlier that may have resulted from an error
- C. the most important data point in the entire study
- D. proof that the original hypothesis was correct

82. When dissecting a flower in the laboratory, scalpels and razor blades should be

- A. shared freely among students to save time during lab
- B. cleaned at the end of the lab without other steps
- C. discarded into the regular trash can at end of lab

D. handled carefully and covered or stored safely when not in use

83. A student writes a procedure for an experiment but discovers that the results vary widely each time the experiment is performed. The most likely improvement to make is

A. to repeat the experiment more times to identify and reduce sources of error

B. to use only the data points that match the original hypothesis

C. to change the conclusion to match the variable results obtained

D. to abandon the experiment as unworkable in the lab

84. When writing a conclusion for a laboratory experiment, a student should

A. ignore data that does not support the original hypothesis

B. repeat the original hypothesis word-for-word as the conclusion

C. state whether the data support or do not support the hypothesis

D. avoid mentioning any sources of error in the experiment

85. In the Diffusion Through a Membrane laboratory, the dialysis tubing models which type of cell structure?

A. the nucleus where DNA is stored within the cell

B. the cell membrane that selectively allows substances through

C. the cytoplasm where many chemical reactions occur

D. the ribosome that assembles proteins from amino acids

ANSWER KEY WITH EXPLANATIONS — Practice Exam 9

1. D — Cell theory states that all cells come from preexisting cells, all living things are made of cells, and the cell is the basic unit of life. Natural selection, central dogma, and germ theory are separate biological theories that do not address cell origin. This principle, established by Schleiden, Schwann, and Virchow, is foundational to all of cell biology.

2. B — The cell wall, made of cellulose, provides rigid structural support and protection to plant cells. The cell membrane is selectively permeable but flexible, the vacuole stores water, and the nucleus directs cellular activities — only the cell wall provides rigid shape and protection. This is one of the key differences between plant and animal cells.

3. A — Active transport moves substances against their concentration gradient using ATP-supplied energy and protein pumps. Diffusion, osmosis, and facilitated diffusion all rely on concentration gradients to move substances passively without energy input. Active transport allows cells to accumulate nutrients and maintain ion concentrations critical for function.

4. C — Denaturation is the disruption of an enzyme's three-dimensional shape by extreme heat, pH, or chemicals, leaving the active site unable to bind substrate. This is why high fevers are dangerous — enzymes denature above about 40°C and stop functioning, halting essential metabolic reactions.

5. A — Breaking the terminal phosphate bond of ATP releases energy that the cell uses for work such as muscle contraction, active transport, and biosynthesis. The reaction produces ADP and an inorganic phosphate. ATP is the cell's main energy currency precisely because this bond is easily broken to release usable energy.

6. D — The light reactions of photosynthesis occur in the thylakoid membranes of chloroplasts, where chlorophyll captures light energy and uses it to split water and generate ATP and NADPH. The dark reactions (Calvin cycle) take place in the surrounding stroma. The thylakoid arrangement maximizes membrane surface for light capture.

7. B — The electron transport chain in the inner mitochondrial membrane produces about 32–34 ATP per glucose molecule, far more than glycolysis (2 ATP) or the Krebs cycle (2 ATP). Oxygen serves as the final electron acceptor here, which is why aerobic respiration is so much more efficient than fermentation.

8. C — Adenine pairs with thymine through two hydrogen bonds, and cytosine pairs with guanine through three hydrogen bonds (Chargaff's rules). The pairing is complementary because the geometry and bonding pattern of each base matches only its specific partner. This precision allows accurate DNA replication and transcription.

9. D — Transcription is the process that occurs in the nucleus and produces an mRNA strand using a DNA template. Translation occurs at ribosomes to make proteins, replication copies DNA, and mutations alter DNA. Only transcription generates a complementary mRNA from a DNA gene sequence.

10. A — A codon is a sequence of three mRNA bases that specifies one amino acid in a polypeptide chain. The genetic code uses 64 codons to specify the 20 amino acids plus start/stop signals. Triplet coding is necessary because any code shorter than three bases could not generate enough combinations for all 20 amino acids.

11. C — A $TT \times tt$ cross produces 100% Tt heterozygous offspring, and because T is dominant, all offspring show the tall phenotype. This is the classic monohybrid cross result when one parent is homozygous dominant and the other homozygous recessive. All F_1 offspring inherit one of each allele.

12. B — By traditional pedigree convention, squares represent males and circles represent females. A filled symbol indicates an affected individual, while half-filled symbols often indicate carriers. These conventions allow geneticists to trace inheritance patterns across multiple generations consistently.

13. A — Males have the genotype XY, so they pass their X chromosome only to daughters and their Y chromosome only to sons. A hemophiliac man ($X^h Y$) therefore passes the X^h allele to every daughter (who becomes a carrier) and never to any son. This is a defining pattern of X-linked inheritance from affected fathers.

14. D — A translocation is a chromosomal mutation in which a piece of one chromosome breaks off and attaches to a non-homologous chromosome. Point mutations affect single bases, deletions remove DNA, and duplications add extra DNA — translocations specifically involve transfer of genetic material between different chromosomes. Translocations cause some forms of leukemia.

15. B — During metaphase, chromosomes line up along the cell's equator (metaphase plate) with their centromeres attached to spindle fibers from opposite poles. This alignment ensures that when anaphase begins, sister chromatids will be pulled apart correctly to opposite poles. Mistakes here can lead to nondisjunction and abnormal chromosome numbers.

16. C — Crossing over is the exchange of corresponding segments between homologous chromosomes during prophase I of meiosis. This process creates new combinations of alleles on each chromosome, dramatically increasing genetic variation among gametes. It is one of the main sources of variation that fuels evolution.

17. A — Natural selection favors individuals whose inherited traits give them an advantage in survival and reproduction in their specific environment. These better-adapted individuals leave more offspring, passing on their favorable alleles. Over generations, this increases the frequency of advantageous traits in the population.

18. D — Vestigial structures are reduced or non-functional remnants of organs that were important in ancestral species. The human appendix and the pelvic bones of whales both reflect their evolutionary descent from ancestors in which these structures had functional roles. They provide strong evidence for common descent and evolution.

19. C — Divergent evolution is the process by which a single ancestral species gives rise to two or more distinct species over many generations. Convergent evolution involves unrelated species developing similar traits, and adaptation refers to a single trait change. Divergence is the engine of speciation and biodiversity.

20. B — Exponential growth occurs when reproduction is not limited by resources or environmental constraints, producing a J-shaped curve with no upper boundary. Logistic growth, by contrast, slows and levels off at carrying capacity. Real populations rarely sustain exponential growth for long because limiting factors eventually intervene.

21. A — Producers — mostly plants, algae, and photosynthetic bacteria — capture solar energy and convert it to chemical energy (glucose) through photosynthesis. They form the base of nearly all food

chains because all other trophic levels depend ultimately on this captured energy. Without producers, ecosystems collapse.

22. D — Decomposers, including bacteria and fungi, break down dead organisms and waste products, releasing inorganic nutrients back into the soil for reuse by producers. This recycling is essential because nutrients are limited, and without decomposition they would remain locked in dead matter and ecosystems would run out of usable material.

23. C — Competition occurs when two or more species require the same limited resource, such as food. The two bird species competing for the same insects are in direct interspecific competition, which can lead to reduced populations or shifts in feeding behavior. Competition is a major force shaping community structure.

24. B — When prey populations grow, predator populations typically increase because food is more abundant, supporting greater predator reproduction and survival. This linked oscillation between predator and prey populations is a fundamental pattern in ecology, classically illustrated by lynx and hare cycles.

25. A — Lichens are pioneer species that colonize bare rock and slowly secrete acids that break down the rock surface. Over time, the rock fragments combine with the organic matter from lichen decomposition to form the first thin layer of soil. This process initiates primary succession and is essential for further plant colonization.

26. C — Condensation is the change of water vapor into liquid water droplets, which form clouds when warm humid air rises and cools. Evaporation is the reverse process, precipitation is rainfall, and transpiration is water loss from plants. Condensation is the cloud-forming step of the water cycle.

27. D — Nitrogen-fixing bacteria, such as *Rhizobium* in legume root nodules, convert atmospheric N_2 into ammonia (NH_3) and nitrates that plants can absorb and use. Without this conversion, plants could not access the abundant atmospheric nitrogen. Nitrogen fixation is the critical entry point of nitrogen into the biological nitrogen cycle.

28. B — Insulin signals body cells (especially muscle and liver) to take up glucose from the blood, lowering blood sugar back to homeostatic levels after a meal. The liver also stores excess glucose as glycogen in response to insulin. This is why insulin is essential for the treatment of type 1 diabetes.

29. A — The left ventricle pumps oxygenated blood to the entire body through the aorta, requiring much higher pressure than the right ventricle (which pumps only to the nearby lungs). The thick muscular wall generates this force. This is why heart failure of the left side has such serious systemic consequences.

30. C — When the diaphragm contracts downward and the rib muscles lift the ribs outward, the chest cavity expands and lung pressure drops below atmospheric pressure. Air then flows into the lungs to equalize the pressure. This negative-pressure breathing is how mammals draw air in passively.

31. B — Chloroplasts contain chlorophyll, which absorbs light energy and uses it to drive the conversion of water and carbon dioxide into glucose. The nucleus stores DNA, mitochondria produce ATP, and the

central vacuole stores fluids. Only chloroplasts perform photosynthesis, the energy-capturing process unique to plants and algae.

32. D — The cell wall, composed of rigid cellulose, surrounds plant cells outside the cell membrane and provides structural support, shape, and protection. Animal cells have no cell wall — they rely on the cytoskeleton and intercellular matrix for support. The cell wall is also key for resisting the high turgor pressure inside plant cells.

33. A — The large central vacuole stores water, ions, nutrients, and wastes, and its hydrostatic pressure (turgor) presses against the cell wall to maintain rigidity and shape. When water is lost, the vacuole shrinks and the plant wilts. The vacuole is therefore essential for both plant structure and water balance.

34. C — Rough endoplasmic reticulum is studded with ribosomes that synthesize proteins, which are then modified within the ER before being passed to the Golgi apparatus. The vacuole, chloroplast, and cell wall do not produce proteins — protein synthesis specifically occurs on ribosomes attached to the rough ER and on free ribosomes.

35. D — The graph plateaus at a reaction rate of about 26 $\mu\text{mol}/\text{min}$, which represents the maximum velocity (V_{max}) at which the enzyme can convert substrate to product. Beyond this point, adding more substrate does not increase the rate because all enzyme active sites are already occupied. V_{max} reflects enzyme saturation.

36. B — At high substrate concentrations, every available enzyme active site is filled with substrate at any given moment, so the reaction rate is limited by how quickly enzymes can release products and bind new substrate. This is called enzyme saturation. Adding more substrate cannot speed the reaction further unless more enzyme is added.

37. A — At low substrate concentration, reaction rate is approximately proportional to substrate level because most enzyme active sites are unoccupied. Doubling substrate roughly doubles the rate. This linear relationship breaks down only as the enzyme begins to approach saturation at higher substrate concentrations.

38. C — Carrier females are heterozygous ($X^H X^h$): they carry one normal and one recessive allele but do not show the disorder because the dominant normal allele provides sufficient function. The half-filled symbol in the pedigree indicates this carrier status. Daughters of affected fathers are always carriers if the mother is unaffected.

39. B — A carrier mother ($X^H X^h$) produces 50% X^H eggs and 50% X^h eggs. An unaffected father ($X^H Y$) produces 50% X^H sperm and 50% Y sperm. Sons receive only the Y from the father, so each son has a 50% chance of receiving X^h from the mother and being affected.

40. A — In X-linked inheritance, sons inherit their single X chromosome from their mother. An affected hemophiliac male ($X^h Y$) must have received his X^h allele from his mother, who is either a carrier or affected herself. Fathers contribute the Y chromosome to sons, not the X, so the disease allele cannot come from the father.

- 41. C** — Nitrogen fixation, performed mainly by bacteria living in legume root nodules and in soil, converts atmospheric N_2 into ammonia (NH_3) — a form plants can use. Other steps of the cycle modify nitrogen already in the soil or return it to the atmosphere, but only fixation brings nitrogen into the biological system from the air.
- 42. D** — Denitrification, performed by certain soil bacteria, converts nitrates (NO_3^-) back into atmospheric N_2 gas, completing the nitrogen cycle. This step balances nitrogen fixation by returning nitrogen to the atmosphere. Without denitrification, nitrogen would steadily accumulate in soil over geological time.
- 43. B** — Decomposers break down nitrogen-containing molecules (proteins, nucleic acids) in dead organisms and waste, releasing ammonia (NH_3) into the soil. This process, called ammonification, makes the nitrogen available for further conversion to nitrates by nitrifying bacteria. Decomposers are therefore essential to nitrogen recycling.
- 44. A** — A hypothesis is a tentative, testable explanation for an observed phenomenon, based on existing knowledge and intended to be tested by experiment. Hypotheses are not yet facts, controls, or conclusions — they are starting points for scientific investigation. A useful hypothesis must be falsifiable.
- 45. D** — A controlled experiment tests only one variable at a time while keeping all other factors constant, which allows the researcher to attribute observed effects specifically to the variable changed. Field observation, photo study, and opinion polls cannot establish causal relationships. Controlled experiments are the gold standard of scientific testing.
- 46. C** — In an $Aa \times Aa$ cross, the offspring genotype ratio is 1 AA : 2 Aa : 1 aa , giving 3 with at least one dominant allele to 1 homozygous recessive. The 3 out of 4 with a dominant allele show the dominant phenotype, so 75% of offspring are expected to show the dominant trait.
- 47. B** — PCR (polymerase chain reaction) uses repeated cycles of heating, cooling, and DNA polymerase activity to make millions of copies of a specific DNA segment from a small starting sample. This amplification is essential for forensic analysis, disease diagnosis, and many other DNA-based applications where small samples must be analyzed.
- 48. A** — By Chargaff's rules, G pairs with C (both 30%) and A pairs with T in equal amounts. If $G + C = 60\%$, then $A + T = 40\%$, and since $A = T$, each must be 20%. This base-pairing arithmetic is a frequent calculation on the Regents exam.
- 49. D** — Hardy-Weinberg equilibrium holds only when no evolutionary forces are acting: no mutation, no migration, no natural selection, no genetic drift, and random mating. Any of these forces will shift allele frequencies and cause evolution. The principle therefore provides a baseline against which evolution can be detected and measured.
- 50. C** — HIV (human immunodeficiency virus) specifically targets and destroys helper T cells (CD4 cells), which coordinate the immune response. As CD4 counts fall, the immune system loses its ability to defend against infections, eventually leading to AIDS. This targeting is what makes HIV so devastating to the immune system.

51. B — Invasive species often lack natural predators or competitors in their new environment, allowing them to outcompete native species for food, space, and other resources. This frequently disrupts ecosystems and reduces native biodiversity. Examples include zebra mussels, kudzu, and Burmese pythons in the United States.

52. A — The taiga (boreal forest) is found across northern latitudes and is characterized by long cold winters, short cool summers, and dominance by needle-leaved evergreen trees such as spruce, fir, and pine. These conifers are well adapted to cold, with needle leaves that resist freezing and shed snow.

53. D — A keystone predator helps maintain biodiversity by limiting the population of a dominant competitor species, preventing it from monopolizing resources and crowding out other species. The classic example is the starfish *Pisaster*, which controls mussel populations and preserves intertidal diversity. Removing a keystone predator can collapse entire communities.

54. C — Deforestation to make way for agriculture eliminates the habitat that native species depend on, often forcing them to migrate or die out. This is the most direct ecological consequence and a leading cause of biodiversity loss worldwide. Restoration of cleared land takes decades to centuries, if it occurs at all.

55. B — Burning fossil fuels (coal, oil, natural gas) releases vast amounts of carbon dioxide and other greenhouse gases that were stored in geologic deposits for millions of years. This represents the largest human contribution to atmospheric greenhouse gas levels. Volcanic and biological sources also release CO₂ but at much smaller scales globally.

56. A — During the S (synthesis) phase of the cell cycle, DNA is replicated so that each chromosome consists of two identical sister chromatids before mitosis begins. This ensures that both daughter cells will inherit a complete copy of the genome. The S phase falls within interphase, between G1 and G2.

57. D — Meiosis II separates sister chromatids without further reducing chromosome number, so each of the four daughter cells contains 23 chromosomes (the haploid number for humans). This is essential for sexual reproduction, because gametes fusing at fertilization must restore the diploid number of 46 chromosomes.

58. C — Genes located close together on the same chromosome tend to be inherited as a unit because they are unlikely to be separated by crossing over. This is called genetic linkage and is an exception to Mendel's law of independent assortment. The closer two genes are, the more tightly they are linked.

59. A — Directional selection favors one extreme of a trait, shifting the population's average phenotype in that direction over time. As pollution darkens tree bark, dark moths blend in better and survive predation more often, increasing their frequency. This is the classic peppered moth example of evolution by natural selection.

60. B — Recombinant DNA technology inserts a human insulin gene into bacterial DNA, allowing the bacteria to produce insulin protein at industrial scales. This is a textbook example of genetic engineering. The technique made human insulin widely available for treating diabetes, replacing the older animal-derived sources.

61. D — Predator population size depends directly on the available food supply, which is determined by the prey population. When prey are abundant, predators reproduce successfully; when prey decline, predators starve or reproduce less. This linked cycling between predator and prey populations is a fundamental ecological pattern.

62. C — Competitive exclusion is the principle that two species cannot occupy the same niche indefinitely — the more successful competitor eventually drives the other to extinction or to a different niche. The classic experiments by Gause with *Paramecium* demonstrated this principle clearly. It is a major force shaping community structure.

63. A — The kidneys, located on either side of the lower back, filter blood through millions of nephrons to remove urea, excess water, salts, and other wastes, producing urine. The liver detoxifies and stores nutrients, the pancreas produces digestive enzymes and insulin, and the spleen filters blood cells — none produces urine.

64. B — Greenhouse gases such as carbon dioxide, methane, and water vapor absorb infrared radiation (heat) emitted from Earth's surface and re-radiate some of it back downward, warming the atmosphere. This natural process keeps Earth habitable, but rising greenhouse gas levels are intensifying it and driving global warming.

65. D — Capillaries are only one cell thick to allow rapid diffusion of oxygen, nutrients, carbon dioxide, and waste products between blood and tissue cells. Their thinness — and their vast total surface area — make them ideal for gas and nutrient exchange. Arteries have thick walls because they must withstand higher pressure.

66. C — Enzymes have narrow optimal pH ranges and denature outside them, losing their three-dimensional shape and function. Most human enzymes function best near pH 7.4, the normal blood pH. Disruption of blood pH (acidosis or alkalosis) interferes with enzyme activity throughout the body and can be life-threatening.

67. A — Glucagon signals the liver to break down glycogen, releasing glucose into the bloodstream and raising blood sugar. This action opposes insulin and helps prevent dangerously low blood glucose between meals. Together, insulin and glucagon form the negative feedback system that maintains blood glucose homeostasis.

68. B — A reflex arc routes the sensory signal directly through the spinal cord to a motor neuron, producing a response before the signal reaches the brain. This shortcut allows extremely rapid reactions to dangerous stimuli, such as pulling a hand from a hot surface. The brain becomes aware of the event only afterward.

69. D — In autoimmune diseases, the immune system mistakenly identifies normal body tissues as foreign and attacks them. In rheumatoid arthritis the targets are joint tissues; in type 1 diabetes the targets are pancreatic beta cells. The cause of this mistaken targeting is not fully understood but involves both genetic and environmental factors.

70. C — Vaccines expose the immune system to weakened or inactivated pathogen components, stimulating production of memory B and T cells specific to that pathogen. If the real pathogen later enters the body, memory cells trigger a rapid, strong response that often prevents illness entirely. This is the basis of long-lasting vaccine protection.

71. A — Phototropism is the growth response of plants to light. Auxins migrate to the shaded side of a stem, where they stimulate elongation that bends the stem toward the light source — a positive phototropism. This adaptation maximizes light capture for photosynthesis and is especially important for seedlings.

72. B — After fertilization, the ovule develops into a seed containing the plant embryo, stored food (endosperm or cotyledons), and a protective seed coat. The seed is the structure that disperses the new plant individual. The ovary surrounding the ovule typically develops into the fruit that protects and disperses the seeds.

73. C — The Beaks of Finches simulation shows that beak tools (representing inherited traits) work well for some foods and poorly for others, depending on the environment. This models how natural selection favors specific traits in specific conditions, with no single trait being best in all environments. It directly illustrates adaptive radiation.

74. D — The Relationships and Biodiversity lab uses simulated gel electrophoresis to compare DNA samples, along with chromatography for pigments and indicator tests for proteins and starches. The multiple molecular comparisons allow students to determine which species are most closely related, simulating modern taxonomic methods.

75. A — Benedict's solution requires heating in a hot water bath to react with reducing sugars like glucose. A positive test produces colors ranging from green (low glucose) to brick-red (high glucose). Without heating, the color-changing reaction does not occur, so this step is essential for the test to work.

76. C — Taking multiple readings and averaging them reduces the influence of random errors and produces more reliable data. A single reading may not be representative, but the average of many measurements tends to approximate the true value more closely. This is a fundamental principle of experimental design.

77. B — The diameter of the field of view at low power on a typical compound microscope is about 1.5 millimeters (1500 micrometers). This unit is appropriate because the field of view spans larger objects than individual cells. Knowing this dimension allows estimation of specimen size by comparing it to the field width.

78. D — Loose hair and clothing can be caught in moving equipment, dipped into chemicals, or catch fire over flames such as Bunsen burners. Tying back hair and avoiding loose sleeves are basic laboratory safety practices that prevent serious accidents. These rules are standard in all science lab settings.

79. A — In the Beaks of Finches simulation, the "seeds" provided each round represent the food resources of the simulated environment. Changing the seed type models environmental change and tests how well

each beak tool performs under new conditions. This simulates how environmental changes drive natural selection of advantageous traits.

80. D — A hypertonic solution has a higher solute concentration outside the cell than inside, so water moves out of the cell by osmosis, causing it to shrink (crenate). Hypotonic solutions cause swelling, and isotonic solutions cause no net movement. This principle explains why salt-cured foods preserve so well — salt creates a hypertonic environment that kills microbes.

81. B — An outlier is a data point that lies far from the rest of the data and may indicate a measurement error, equipment malfunction, or unusual sample. While outliers should not simply be deleted, they should be examined for possible causes. Identifying outliers is an important part of analyzing experimental results.

82. D — Sharp instruments such as scalpels and razor blades must always be handled with care, kept covered when not in use, and stored safely to prevent accidental cuts. They should never be passed open or left exposed on a lab bench. Lab safety rules for sharps protect both the user and other students nearby.

83. A — When experimental results vary widely, the best course is to repeat the procedure many times to identify sources of error and improve the experimental design. Repetition increases statistical reliability and helps distinguish true patterns from random noise. Selecting only confirming data or changing the conclusion would violate scientific integrity.

84. C — A laboratory conclusion must state clearly whether the experimental data support or refute the original hypothesis, based on what was actually observed. Even data that contradict the hypothesis are valid and important — they may suggest a new hypothesis or experimental refinement. Sound conclusions follow the data, not the experimenter's expectations.

85. B — The dialysis tubing in this lab is selectively permeable: small molecules such as water, glucose, and iodine pass through its pores, while large molecules such as starch do not. This selective permeability models the behavior of a real cell membrane, which similarly controls what enters and leaves the cell.