

# PRACTICE EXAM 20: LIVING ENVIRONMENT REGENTS SIMULATION

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**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. Which of the following is shared by all living things, regardless of complexity or size?

- A. The ability to fly through the air
- B. The ability to produce their own food
- C. The ability to live without using any energy
- D. The ability to grow, develop, and reproduce

2. A group of similar cells working together to perform a specific function is called

- A. a tissue made of similar cells
- B. an organ made of multiple tissue types
- C. an organ system performing multiple functions
- D. an organism made of all organ systems

3. The cell organelle that modifies, packages, and ships proteins from the endoplasmic reticulum to other parts of the cell is the

- A. ribosome that builds the protein chains
- B. mitochondrion that produces ATP energy
- C. Golgi apparatus that processes and packages
- D. lysosome that breaks down old proteins

4. The process by which a cell engulfs large particles by surrounding them with its membrane to bring them inside is called

- A. exocytosis that releases materials from cells
- B. endocytosis that brings materials into cells
- C. osmosis of water across membranes
- D. diffusion of small molecules across membranes

5. Each enzyme can act on only a specific substrate because of the precise shape of its

- A. active site that binds the substrate
- B. cell membrane around the enzyme
- C. nuclear envelope inside the enzyme
- D. ribosome attached to the enzyme

6. ATP releases its energy when one of its three components is removed. That component is

- A. ribose, the sugar component of ATP
- B. adenine, the nitrogen base of ATP
- C. nitrogen, found inside the adenine ring
- D. a phosphate group, removed to form ADP

7. In photosynthesis, the light-independent reactions (Calvin cycle) take place in the

- A. thylakoid membranes inside the chloroplast
- B. stroma of the chloroplast outside the thylakoids
- C. matrix of the mitochondrion in plant cells
- D. cytoplasm surrounding all of the cell's organelles

8. The first stage of cellular respiration, called glycolysis, occurs in the

- A. nucleus of every eukaryotic cell
- B. inner membrane of the mitochondrion
- C. cytoplasm surrounding the cell's organelles
- D. ribosomes attached to the endoplasmic reticulum

9. The sugar-phosphate backbone of a DNA molecule is formed by

- A. alternating deoxyribose sugars and phosphate groups
- B. alternating nitrogen bases and ribose sugars

C. amino acid residues linked by peptide bonds

D. fatty acid chains connected to glycerol molecules

10. The molecule produced when a gene is transcribed from DNA is

A. a strand of DNA identical to the original

B. a fully assembled protein with all amino acids

C. a tRNA molecule carrying an amino acid

D. an mRNA strand complementary to the DNA gene

11. On a strand of mRNA, the number of bases that code for a single amino acid is

A. one base coding for each amino acid

B. three bases (one codon) coding for each amino acid

C. ten bases coding for each amino acid

D. a hundred bases coding for each amino acid

12. During the S phase of the cell cycle, each chromosome is duplicated into two identical copies called

A. homologous chromosomes from each parent

B. autosomes that determine non-sex traits

C. sister chromatids joined at the centromere

D. spindle fibers attached to chromosomes

13. In sexually reproducing animals, meiosis is essential because it

- A. produces haploid gametes from diploid cells
- B. produces diploid cells from gametes alone
- C. replaces dead skin cells throughout life
- D. heals wounds and damaged body tissues

14. If a heterozygous tall plant with round seeds ( $TtRr$ ) self-pollinates, the phenotypic ratio of offspring will be approximately

- A. 1:1:1:1, with equal numbers of each phenotype
- B. 3:1, the classic monohybrid ratio
- C. 1:2:1, the incomplete dominance ratio
- D. 9:3:3:1, the classic dihybrid ratio

15. A woman who is a carrier for color blindness marries a man with normal vision. The probability that any son they have will be color blind is

- A. 0% chance of being color blind
- B. 25% chance of being color blind
- C. 50% chance of being color blind
- D. 100% chance of being color blind

16. A piece of one chromosome that breaks off and attaches to a non-homologous chromosome has undergone

- A. translocation between different chromosomes
- B. deletion of a chromosome segment
- C. duplication of a chromosome segment
- D. inversion within a single chromosome

17. In a population that is not evolving, allele frequencies remain constant. One of the conditions required for this state is

- A. heavy migration into and out of the population
- B. no mutations occurring within the population
- C. small total population size with random drift
- D. natural selection acting strongly on the population

18. A small group of birds is blown onto a previously uninhabited island. The allele frequencies in the new population are very different from the original population by chance alone. This is an example of

- A. natural selection favoring the strongest birds
- B. coevolution between birds and island plants
- C. directional selection toward one trait extreme
- D. the founder effect, a form of genetic drift

19. Speciation that occurs when a single population is divided by a physical barrier (like a mountain range or river) is called

- A. sympatric speciation in the same area

- B. coevolution between two interacting species
- C. allopatric speciation by geographic isolation
- D. mass extinction of multiple species at once

20. Dolphins (mammals) and sharks (fish) both have streamlined, torpedo-shaped bodies despite belonging to different lineages. This similarity is best explained by

- A. convergent evolution producing similar adaptations
- B. divergent evolution producing different traits
- C. shared ancestry in the recent past
- D. genetic drift in two ocean populations

21. The presence of similar fossils on the coastlines of Africa and South America provides evidence that

- A. modern continents have always been in the same position
- B. fossils can be transported across oceans by water
- C. the two continents were once joined as one landmass
- D. these species evolved independently on both continents

22. The variety of life found within a particular ecosystem, region, or the entire Earth is called

- A. carrying capacity of the ecosystem
- B. biodiversity of life forms
- C. niche overlap between species

D. trophic cascade through food webs

23. The actual physical location where a species lives is called its

A. niche, including all interactions with environment

B. food web of consumers and producers

C. carrying capacity of the local environment

D. habitat, the physical location it occupies

24. In primary succession on bare rock, the first organisms to colonize the area are typically

A. lichens that can break down rock to begin soil formation

B. large trees that need rich soil to grow

C. grasses requiring a developed soil layer

D. mammals that require established food sources

25. At the end of a successional sequence, the stable community that remains and shows little further change over time is called

A. a pioneer community on freshly exposed surfaces

B. a climax community that is relatively stable

C. a transitional community that is rapidly changing

D. a destroyed community after a major disturbance

26. Acacia trees in Africa have hollow thorns that house ants, and the ants attack other animals that try to eat the tree's leaves. The acacia and the ants both benefit. This relationship is best described as

- A. parasitism harming one of the species
- B. predation between the two species
- C. competition for shared resources
- D. mutualism benefiting both species

27. In an ecological pyramid based on the total mass of organisms (biomass) at each trophic level, the largest mass is typically found at the

- A. producer level at the base of the pyramid
- B. tertiary consumer level at the top of the pyramid
- C. secondary consumer level in the middle of the pyramid
- D. decomposer level off to the side of the pyramid

28. DDT applied to crops becomes more concentrated in the bodies of organisms at higher trophic levels, especially top predators like eagles. This concentration up the food chain is called

- A. acid rain affecting aquatic ecosystems
- B. eutrophication of lake water bodies
- C. biomagnification through the food chain
- D. ozone depletion of the upper atmosphere

29. Which of the following is considered a renewable resource that can be replenished naturally within a human lifetime?

- A. Coal mined from underground reserves
- B. Natural gas extracted from rock formations
- C. Petroleum oil pumped from underground
- D. Solar energy collected by solar panels

30. In the absence of limiting factors, a population can grow at an accelerating rate, doubling and redoubling over time. This type of growth is called

- A. linear growth at a steady, fixed rate
- B. exponential growth that accelerates over time
- C. logistic growth that levels off quickly
- D. negative growth as the population shrinks

**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 Punnett square below and on your knowledge of biology.

31. A student examines a Punnett square showing the cross between two parents heterozygous for ABO blood type.

Figure PQ-1

ABO Blood Type Cross: Type A ( $I^A I^O$ ) × Type B ( $I^B I^O$ )

		Parent 1 (blood type A heterozygous)	
		$I^A$	$I^O$
Parent 2 (blood type B heterozygous)	$I^B$	$I^A I^B$ (blood type AB)	$I^B I^O$ (blood type B)
	$I^O$	$I^A I^O$ (blood type A)	$I^O I^O$ (blood type O)

$I^A$  and  $I^B$  are codominant;  $I^O$  is recessive to both.

Based on the Punnett square shown, the percentage of offspring expected to have blood type AB is

- A. 25% of offspring will have blood type AB
- B. 50% of offspring will have blood type AB
- C. 75% of offspring will have blood type AB
- D. 100% of offspring will have blood type AB

32. Based on the same Punnett square, the percentage of offspring expected to have blood type O is

- A. 75% of offspring will have blood type O
- B. 50% of offspring will have blood type O
- C. 100% of offspring will have blood type O
- D. 25% of offspring will have blood type O

33. Based on the same Punnett square, the inheritance pattern shown by the  $I^A$  and  $I^B$  alleles is best described as

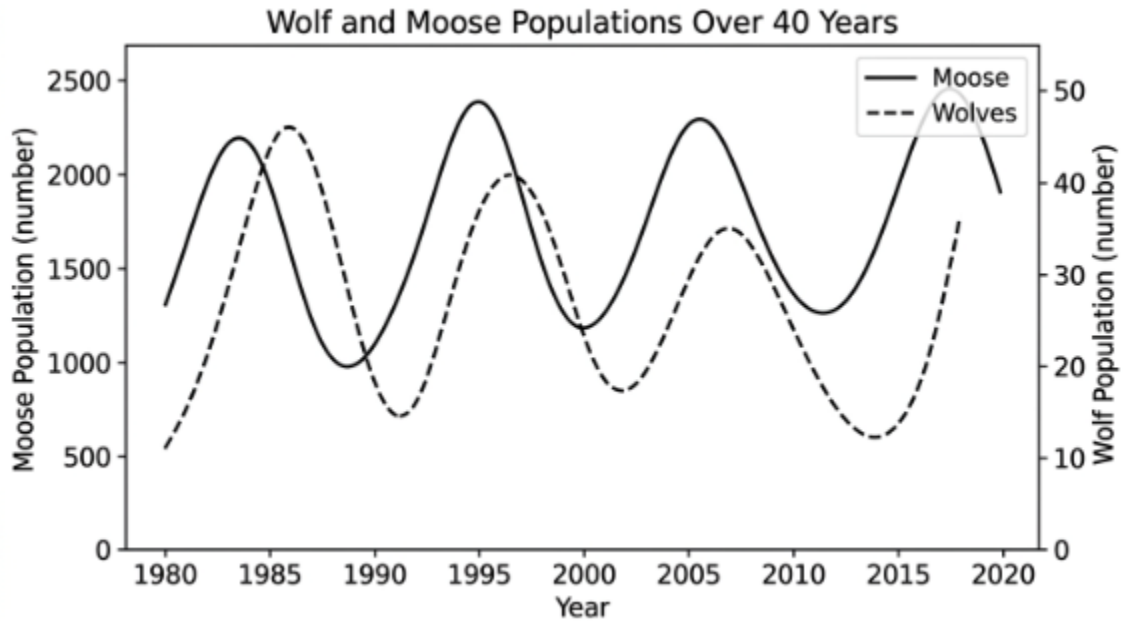
- A. complete dominance, with one allele masking the other
- B. incomplete dominance, with a blended intermediate phenotype
- C. codominance, with both alleles fully expressed together
- D. sex-linked inheritance limited to one parent's sex

34. Based on the same Punnett square, the genotype of an offspring with blood type O is

- A.  $I^A I^B$ , with both A and B alleles present
- B.  $I^O I^O$ , with two copies of the recessive allele
- C.  $I^A I^O$ , with one A and one recessive allele
- D.  $I^B I^O$ , with one B and one recessive allele

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

35. A student examines a graph of the populations of wolves and moose on an isolated island over a 40-year period.



Based on the graph, the relationship between the two populations is best described as

- A. the two populations cycle, with wolves rising after moose populations rise
- B. the two populations are unrelated to each other in any way
- C. wolf populations always lead moose population changes
- D. both populations are steadily declining throughout the period

36. Based on the same graph, when the wolf population reaches a peak, the moose population typically

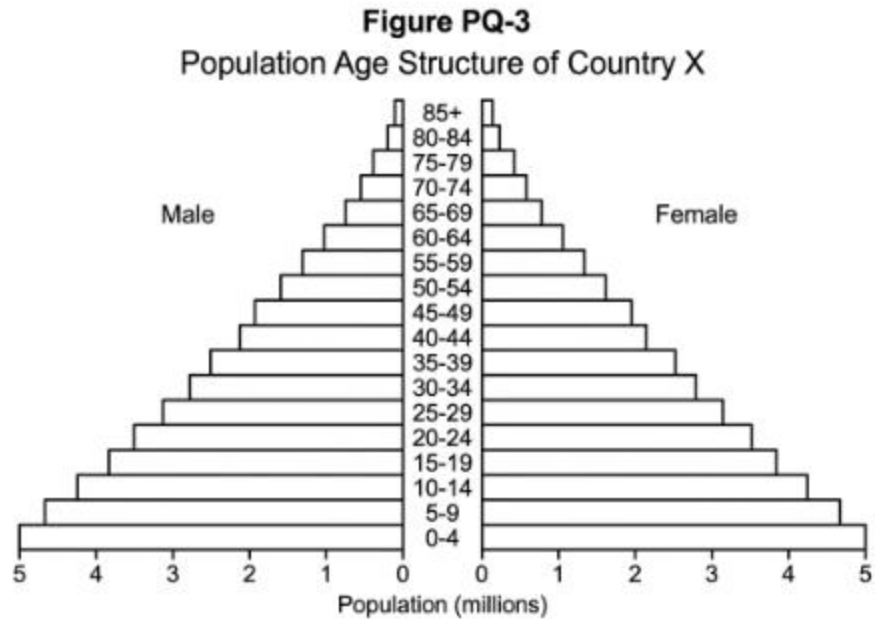
- A. continues to grow at a fast pace
- B. remains exactly the same as before
- C. begins to decrease due to increased predation
- D. completely disappears from the ecosystem

37. Based on the same graph, if a disease eliminated all the wolves from this island, the moose population would most likely

- A. immediately go extinct due to lack of predators
- B. remain at exactly the same population level
- C. decrease over time without their predators
- D. initially grow rapidly until food becomes limited

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

38. A student examines a population age structure diagram representing the population of Country X.



Based on the diagram, the population of Country X is best described as

- A. a population with negative growth, projected to decline

- B. a rapidly growing population, with many young people
- C. a stable population with even age distribution
- D. a population with no children being born currently

39. Based on the same age structure diagram, the population of Country X is likely to

- A. continue growing significantly in the coming decades
- B. immediately decline over the next several years
- C. remain exactly the same size throughout the future
- D. produce no new generations of citizens for decades

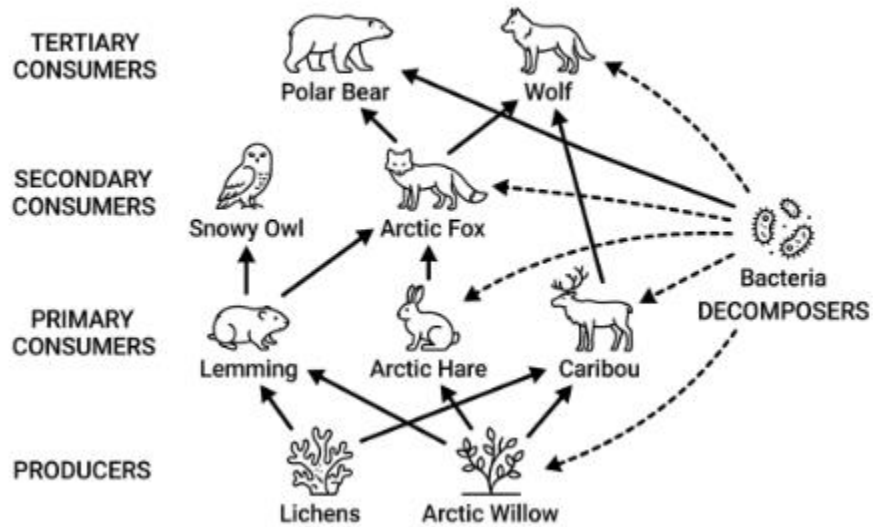
40. Based on the same age structure diagram, Country X is most likely

- A. a country in the post-industrial stage with low birth rates
- B. a country that has experienced a recent mass extinction
- C. a developing country with high birth and death rates
- D. a country where reproduction is no longer occurring

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

41. A student examines a food web of an arctic tundra ecosystem.

## Arctic Tundra Food Web.



Based on the tundra food web shown, which organism is a producer at the base of the food web?

- A. The caribou that eats lichens
- B. The arctic willow that performs photosynthesis
- C. The arctic fox that hunts hares
- D. The polar bear that hunts arctic foxes

42. Based on the same tundra food web, the snowy owl that hunts lemmings occupies which trophic level?

- A. The first trophic level as a producer
- B. The fourth trophic level as a tertiary consumer
- C. The first trophic level as a decomposer
- D. The third trophic level as a secondary consumer

43. Based on the same food web, if climate change caused the arctic willow population to decline sharply, the populations most directly affected would be

- A. lemming, arctic hare, and caribou
- B. polar bear, wolf, and arctic fox
- C. only bacteria and other decomposers
- D. only snowy owl and arctic fox populations

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

Answer all questions in this part.

44. A student tests how light intensity affects plant growth using only one plant in each light condition. The main problem with this experimental design is that

- A. it tests too many variables at once
- B. the student has too many control groups
- C. the small sample size makes results unreliable
- D. the experiment cannot include any control group

45. In an experiment investigating the effect of fertilizer concentration on tomato plant growth, the dependent variable is

- A. the height or mass of the tomato plants
- B. the concentration of fertilizer applied to plants

- C. the species of plants being tested
- D. the type of soil used in all the pots

46. A scientist measures the temperature of a chemical reaction every minute for one hour. The most appropriate type of graph to show how temperature changed over time is

- A. a circle graph showing parts of a whole
- B. a bar graph comparing different categories
- C. a histogram showing frequency distributions
- D. a line graph showing change over time

47. In paper chromatography of plant pigments, the pigment that travels the farthest up the paper is the one that is

- A. heaviest and least soluble in the solvent
- B. most soluble in the solvent being used
- C. the most abundant in the original mixture
- D. the darkest color of all the pigments

48. Proteins embedded in the cell membrane serve many functions, including

- A. providing the energy for active transport reactions
- B. storing genetic information for the cell's nucleus
- C. acting as channels and pumps for moving substances

D. catalyzing all the chemical reactions inside the cell

49. Specialized immune cells can identify foreign substances inside the body because the foreign substances have unique surface molecules called

A. enzymes that catalyze chemical reactions

B. antigens that the immune system can recognize

C. antibodies produced by the host's body

D. hormones that signal between body organs

50. Modern corn was developed from a wild grass called teosinte over thousands of years of selective breeding. This example demonstrates

A. artificial selection by humans choosing the parent plants

B. natural selection by environmental pressures alone

C. genetic engineering through direct DNA modification

D. coevolution between two interacting species

51. Human insulin used to treat diabetes is now produced by bacteria that have been given a copy of the human insulin gene. The bacteria can produce human insulin because

A. bacteria naturally produce human insulin without modification

B. all bacteria contain the same genetic code as humans do

C. the bacteria evolved the ability to produce insulin

D. the genetic code is universal among all living organisms

52. When a person becomes dehydrated, the brain triggers the sensation of thirst, prompting the person to drink water. This response is an example of

- A. positive feedback amplifying the dehydration
- B. acquired behavior learned during early childhood
- C. negative feedback maintaining water balance
- D. permanent adaptation to dry environments

53. A population of bacteria in a small petri dish reaches very high density. As density increases, the population growth rate begins to decrease due to

- A. density-dependent limiting factors like nutrient depletion
- B. density-independent factors such as random temperature swings
- C. immediate genetic mutations preventing reproduction
- D. all bacteria simultaneously dying for unrelated reasons

54. In a complex food web with many interconnected species, the ecosystem is generally more stable than one with a simple food chain because

- A. complex food webs have fewer species available
- B. lost species can often be replaced by alternative food sources
- C. complex food webs experience no environmental change
- D. all species in complex food webs share identical niches

55. When two species in the same ecosystem use very similar resources in similar ways, they may experience

- A. mutualism that benefits both species equally
- B. parasitism in which one species harms the other
- C. competition that may reduce both populations
- D. predation between the two species at all times

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

Answer all questions in this part.

56. The Krebs cycle (also called the citric acid cycle) of cellular respiration takes place in the

- A. cytoplasm outside any organelle membranes
- B. nucleus alongside the cellular DNA
- C. thylakoid membranes of the chloroplast
- D. matrix of the mitochondrion inside the inner membrane

57. In cellular respiration, the largest amount of ATP is produced during the

- A. electron transport chain in the mitochondrion
- B. glycolysis step in the cytoplasm
- C. Krebs cycle in the mitochondrial matrix

D. fermentation pathway without oxygen present

58. Both the chloroplast and the mitochondrion contain their own DNA, ribosomes, and inner membrane systems. These shared features support the idea that

- A. chloroplasts are derived from mitochondria directly
- B. both organelles evolved from ancient bacteria living inside other cells
- C. mitochondria are derived from chloroplasts directly
- D. both organelles are still alive as bacteria today

59. The hypothesis that mitochondria and chloroplasts originated when ancient cells engulfed bacteria but did not digest them is called

- A. cell theory describing the cell as the unit of life
- B. natural selection by environmental pressures alone
- C. germ theory of how diseases are caused
- D. endosymbiotic theory of organelle origins

60. In a plant, water absorbed by the roots travels upward to the leaves through specialized tubes called

- A. phloem that transports sugars throughout the plant
- B. stomata located on the leaf surface for gas exchange
- C. xylem that transports water from roots to leaves
- D. chloroplasts inside the green cells of leaves

61. In a plant, the sugars produced by photosynthesis are transported throughout the plant body in tubes called

- A. xylem that transports water from roots upward
- B. phloem that transports sugars from leaves to other parts
- C. stomata located on the underside of the leaves
- D. chloroplasts inside the cells of green leaves

62. The small openings on the underside of plant leaves through which gas exchange and transpiration occur are called

- A. roots absorbing water from the soil
- B. xylem tubes carrying water upward
- C. phloem tubes carrying sugars throughout
- D. stomata regulating gas exchange

63. Flowering plants reproduce sexually when pollen grains transfer male gametes to the female reproductive structure for fertilization. The plant structure that contains the female gametes is the

- A. stamen with anther and filament
- B. petal that attracts pollinators
- C. carpel (pistil) with stigma, style, and ovary
- D. sepal that protects the developing flower

64. Compared to a bacterium, a virus

- A. cannot reproduce or carry out life processes without a host cell
- B. is much larger than typical bacterial cells
- C. contains all the cellular organelles of a bacterium
- D. always lives independently in the environment

65. A typical virus consists of a protein coat called a capsid surrounding

- A. a complete bacterial cell with all its organelles
- B. ribosomes and mitochondria for energy production
- C. a nucleus surrounded by a nuclear envelope
- D. genetic material such as DNA or RNA

66. Antibodies produced by the immune system are specifically designed to bind to

- A. healthy cells of the body's own tissues
- B. antigens on the surface of pathogens
- C. red blood cells carrying oxygen throughout the body
- D. neurotransmitters released at the synapses

67. Specialized white blood cells that directly attack and destroy virus-infected body cells are called

- A. red blood cells carrying oxygen throughout
- B. platelets involved in blood clotting

- C. cytotoxic T cells of the immune system
- D. skin cells forming a physical outer barrier

68. When a person receives a vaccine and later develops protection against a disease, the protection is the result of

- A. active immunity from the body's own antibody production
- B. passive immunity from antibodies in the vaccine
- C. innate immunity present from birth onward
- D. acquired antibiotic resistance from the vaccine

69. In males, the primary male sex hormone responsible for development of sperm and male secondary sex characteristics is

- A. insulin produced by the pancreas
- B. testosterone produced primarily in the testes
- C. estrogen produced primarily in the ovaries
- D. adrenaline produced by the adrenal glands

70. A hormone produced by the pituitary gland that stimulates growth in bones and tissues throughout the body is

- A. insulin from the islets of Langerhans
- B. thyroxine from the thyroid gland in the neck
- C. growth hormone from the anterior pituitary

D. adrenaline from the adrenal medulla glands

71. When the body becomes dehydrated, the pituitary gland releases antidiuretic hormone (ADH), which causes the kidneys to

- A. reabsorb more water back into the bloodstream
- B. release more water as urine for elimination
- C. produce more red blood cells in the bone marrow
- D. release more glucose into the bloodstream rapidly

72. The liver helps in the digestion of fats by producing

- A. insulin to regulate blood glucose levels
- B. pepsin to break down proteins in the stomach
- C. amylase to break down starches in the mouth
- D. bile to emulsify fats in the small intestine

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

Answer all questions in this part.

73. In a paper chromatography experiment, a pigment travels 6 cm up the paper while the solvent travels 10 cm. The R<sub>f</sub> value (ratio of pigment distance to solvent distance) is

- A. 4.0 as the calculated Rf value
- B. 16 as the calculated Rf value
- C. 0.6 as the calculated Rf value
- D. 1.6 as the calculated Rf value

74. In the Beaks of Finches simulation, students model how natural selection works on populations. When students with successful "beak" tools survive to the next round and those with unsuccessful tools are eliminated, this models

- A. genetic engineering through tool modification
- B. natural selection eliminating poorly adapted individuals
- C. random sampling errors in the data collection
- D. migration of finches to new island habitats

75. In the Diffusion Through a Membrane laboratory, students dissolve glucose in water inside dialysis tubing and place the tubing in plain water. After 30 minutes, a glucose test shows that glucose has moved from inside the tubing to the outside water. This result occurs because

- A. starch molecules also passed through the tubing
- B. water cannot pass through dialysis tubing pores
- C. glucose was actively transported against its gradient
- D. glucose molecules are small enough to diffuse through the tubing

76. In the Making Connections laboratory, students record pulse rate before and after squeezing a clothespin repeatedly. The hypothesis being tested in this lab is best stated as

- A. If muscle activity increases, then pulse rate will increase
- B. If pulse rate decreases, then muscle activity will increase
- C. If the room is cold, then plants will grow more slowly
- D. If a population increases, then food will become scarce

77. In the Relationships and Biodiversity laboratory, students compare a hypothetical valuable species (Botana curus) to three related species using several different tests. The use of multiple tests rather than a single test provides

- A. exactly the same evidence as a single test would
- B. a way to make the experiment take less time overall
- C. stronger evidence by examining multiple lines of comparison
- D. evidence that one of the species is not actually related

78. A student observes a slide under a compound microscope at low power and sees a cell at the right edge of the field of view. To center the cell before switching to high power, the student should move the slide

- A. up away from the body of the microscope
- B. to the right, in the same direction as the cell
- C. straight down toward the body of the microscope
- D. in the opposite direction from where the cell appears

79. When preparing a wet-mount slide, a cover slip should be placed over the specimen at an angle and lowered slowly to

- A. apply more pressure to the specimen on the slide
- B. allow heat to escape from the specimen layer
- C. block light from reaching the specimen during observation
- D. prevent air bubbles from being trapped under the cover slip

80. Methylene blue stain is often added to a wet-mount slide of cheek cells because the stain

- A. provides nutrients to keep the cells alive longer
- B. dissolves the cell membrane to expose the organelles
- C. binds to cell structures and makes the nucleus and other parts visible
- D. raises the temperature of the cells to enhance activity

81. To estimate the size of a fish population in a small lake, ecologists capture, tag, and release 100 fish. A week later, they capture 80 fish and find that 20 of them have tags. Using the formula  $(\text{total tagged}) \times (\text{second sample size}) / (\text{tagged in second sample})$ , the estimated total fish population is

- A. 400 fish in the lake
- B. 200 fish in the lake
- C. 800 fish in the lake
- D. 1,200 fish in the lake

82. A student wants to test an unknown solution for the presence of starch. The most appropriate indicator to use is

- A. Benedict's solution that detects glucose sugar

- B. Lugol's (iodine) solution that detects starch
- C. bromothymol blue that detects carbon dioxide
- D. methylene blue stain that colors cell nuclei

83. To estimate the number of dandelions in a large lawn, a student places several square frames randomly on the lawn and counts the dandelions inside each frame. This sampling method assumes that

- A. the dandelions are clustered in one area of the lawn
- B. dandelions are present everywhere on the lawn equally
- C. the random sample is representative of the whole lawn
- D. all the dandelions in the lawn must be counted individually

84. A student measures the length of an insect as 2.7 cm using a metric ruler. Another student measures the same insect with a more precise instrument as 27.3 mm. The two measurements differ because

- A. one of the students made a serious measurement error
- B. the insect changed length between the two measurements
- C. metric units cannot be converted between each other
- D. the more precise instrument provides more decimal places

85. After an experiment, a student notices that the experimental data does not support the original hypothesis. The most appropriate scientific response is to

- A. change the data to make it support the hypothesis
- B. report the data accurately and reconsider the hypothesis

- C. repeat the experiment until the desired results appear
- D. ignore the data and keep the original hypothesis anyway

## Practice Exam 20 – Answer Key and Explanations

- 1. D** — Growth, development, and reproduction are universal characteristics of all life, regardless of complexity. Flying, autotrophic feeding, and energy-free living are limited to specific groups or are impossible — only the universal traits define life as a category.
- 2. A** — A tissue is a group of similar cells working together for a specific function — muscle tissue for contraction, epithelial tissue for protection, and so on. Tissues sit between individual cells and organs in the biological hierarchy: cells → tissues → organs → organ systems → organism.
- 3. C** — The Golgi apparatus receives proteins from the rough ER, modifies them (often by adding sugars or lipids), packages them into vesicles, and directs them to their final destinations. It functions as the cell's processing, packaging, and shipping center.
- 4. B** — Endocytosis is the active process by which a cell engulfs material by folding its membrane inward to form a vesicle that brings the material inside. This is how cells take in large particles such as bacteria (phagocytosis) or dissolved substances (pinocytosis).
- 5. A** — Each enzyme has a specifically shaped active site that binds only its matching substrate, much like a lock fits only its key. This shape specificity is what gives enzymes their selectivity and is destroyed when extreme heat or pH denatures the enzyme.
- 6. D** — ATP releases energy when its third (terminal) phosphate group is removed, converting it to ADP plus a free phosphate. The energy stored in that high-energy phosphate bond powers nearly every active process in the cell.
- 7. B** — The Calvin cycle (light-independent reactions) occurs in the stroma — the fluid-filled space inside the chloroplast surrounding the thylakoids. Light-dependent reactions take place in the thylakoid membranes, and their products (ATP and NADPH) diffuse into the stroma to power the Calvin cycle.
- 8. C** — Glycolysis is the first stage of cellular respiration and takes place in the cytoplasm of the cell. Because it occurs outside the mitochondrion, glycolysis can proceed even when oxygen is absent — making it the universal first step shared by aerobic and anaerobic pathways.
- 9. A** — The DNA backbone consists of alternating deoxyribose sugars and phosphate groups linked by phosphodiester bonds. The nitrogen bases project inward from this backbone and pair across the two strands to hold the double helix together.

- 10. D** — Transcription copies a section of DNA into an mRNA strand that is complementary to the DNA template (with U replacing T). This mRNA then leaves the nucleus and serves as the template for translation at the ribosome.
- 11. B** — The genetic code is a triplet code in which three consecutive bases (a codon) specify one amino acid. With 4 bases possible at each of 3 positions, there are  $4^3 = 64$  possible codons, more than enough to code for all 20 amino acids plus start/stop signals.
- 12. C** — During S phase, each chromosome is replicated to produce two identical copies called sister chromatids, joined together at a region called the centromere. The sister chromatids separate later in mitosis (anaphase), delivering one copy of each chromosome to each daughter cell.
- 13. A** — Meiosis is the specialized cell division that reduces chromosome number from diploid ( $2n$ ) to haploid ( $n$ ), producing gametes. This halving is essential so that fertilization can restore the diploid number without doubling it generation after generation.
- 14. D** — A dihybrid cross between two heterozygotes ( $TtRr \times TtRr$ ) produces the classic 9:3:3:1 phenotypic ratio: 9 dominant for both traits, 3 dominant for one and recessive for the other, 3 the reverse, and 1 recessive for both. Mendel's pea experiments with two independently segregating traits established this pattern.
- 15. C** — A carrier mother ( $X^B X^b$ ) and a normal father ( $X^B Y$ ) produce sons who inherit Y from the father and either  $X^B$  or  $X^b$  from the mother. Each son therefore has a 50% chance of inheriting the color-blind  $X^b$  — and because males have no second X to mask it, expressing color blindness.
- 16. A** — A translocation occurs when a segment of one chromosome breaks off and attaches to a non-homologous chromosome (a chromosome from a different pair). This is one of the major categories of chromosomal mutation, alongside deletions, duplications, and inversions.
- 17. B** — Hardy-Weinberg equilibrium requires five conditions: no mutation, no migration, large population size, random mating, and no natural selection. If all five conditions are met, allele frequencies remain stable from generation to generation — the population is not evolving.
- 18. D** — The founder effect is a special case of genetic drift in which a small group establishes a new population, carrying only a subset of the original genetic variation. The new population's allele frequencies can differ dramatically from the source population purely by chance.
- 19. C** — Allopatric speciation ("other homeland") occurs when a physical barrier divides a population into geographically isolated groups that evolve independently. With gene flow blocked, mutations and selection drive the populations apart until they can no longer interbreed.
- 20. A** — Convergent evolution produces similar adaptations in unrelated lineages facing similar environmental pressures. Streamlined body shapes evolved independently in dolphins, sharks, and ichthyosaurs because all three lineages had to move efficiently through water.

- 21. C** — Matching fossils on now-separated continents make sense only if those landmasses were once joined. This pattern was central evidence supporting Alfred Wegener's continental drift hypothesis, later confirmed by plate tectonics.
- 22. B** — Biodiversity refers to the total variety of life — number of species, genetic variation within them, and the diversity of ecosystems they form. Higher biodiversity generally correlates with greater ecosystem resilience and stability.
- 23. D** — Habitat refers strictly to the physical place where a species lives. Niche, by contrast, includes the species' habitat plus its role and all its interactions — a broader concept that habitat is part of.
- 24. A** — Lichens are pioneer species in primary succession because they can colonize bare rock without any preexisting soil. They secrete acids that slowly break down rock, contributing organic matter that gradually builds the soil needed for later colonizers.
- 25. B** — A climax community is the relatively stable, self-sustaining endpoint of ecological succession in a given climate. It persists until disturbed by fire, storm, or other major event, at which point secondary succession begins.
- 26. D** — Mutualism is a symbiotic relationship in which both species benefit, with each providing something the other needs. The acacia–ant relationship is a textbook example: ants get shelter and food (nectar), while the tree gets defense against herbivores and competing plants.
- 27. A** — Because only about 10% of energy and biomass transfers from one trophic level to the next, producers at the base of the pyramid contain the greatest total biomass. The pyramid narrows progressively at each higher level.
- 28. C** — Biomagnification is the progressive increase in concentration of persistent pollutants (DDT, mercury, PCBs) as they move up the food chain. Top predators accumulate these toxins to dangerous levels because each prey item already concentrated the toxin from its own food.
- 29. D** — Solar energy is renewable because the sun continuously delivers it on a human timescale. Coal, oil, and natural gas are fossil fuels — formed over hundreds of millions of years and consumed far faster than they form, making them nonrenewable.
- 30. B** — Exponential growth occurs when a population reproduces without limiting factors, so growth accelerates and produces the characteristic J-shaped curve. The growth rate compounds because more individuals means more reproduction, doubling and redoubling the population over equal time intervals.
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## PART B-1 — DATA-BASED MULTIPLE CHOICE (Questions 31-43)

- 31. A** — The cross  $I^A I^O \times I^B I^O$  produces four equally likely genotypes:  $I^A I^B$ ,  $I^B I^O$ ,  $I^A I^O$ , and  $I^O I^O$  — one in each cell of the Punnett square. The single  $I^A I^B$  cell represents 1 of 4 = 25% of offspring expected to have blood type AB.
- 32. D** — Of the four cells in the Punnett square, only  $I^O I^O$  (bottom right) produces blood type O. This single outcome represents 1 of 4 = 25% of offspring.
- 33. C** — Codominance occurs when both alleles in a heterozygote are fully and independently expressed in the phenotype. In type AB blood, both A and B antigens appear on red cells simultaneously, with neither masking the other.
- 34. B** — Blood type O requires the homozygous recessive genotype  $I^O I^O$ , with no A or B antigen produced. Without either dominant allele expressed, the red blood cells display neither A nor B antigens on their surface.
- 35. A** — Predator and prey populations oscillate together in a coupled cycle, with the predator population peaks following slightly behind the prey population peaks. The graph shows this classic time-lagged cycling between wolves and moose.
- 36. C** — When the wolf population is high, predation pressure on moose is greatest, so the moose population declines. The reduced moose population then leads to wolf starvation and a delayed decline in wolves, completing the cycle.
- 37. D** — Without their main predator, the moose population would initially grow rapidly because more individuals survive and reproduce. This unchecked growth continues until limiting factors such as food shortage, disease, or habitat capacity slow it down.
- 38. B** — A wide-based, narrow-topped pyramid indicates a population with many young individuals and proportionally few elderly — the classic shape of a rapidly growing population. The wide base means many people of reproductive age are coming up.
- 39. A** — A population with a wide-based age pyramid will continue to grow as the large young cohort moves into reproductive ages. Even if birth rates decline, this "demographic momentum" produces continued growth for decades.
- 40. C** — Pyramid-shaped age structures with very wide bases are characteristic of developing countries with high birth rates and high death rates. As countries industrialize and birth rates fall, the pyramid shape narrows at the bottom and becomes more column-shaped.
- 41. B** — Producers are autotrophs that perform photosynthesis to capture energy at the base of the food web. The arctic willow is a green plant that photosynthesizes, making it a producer; lichens are also producers in this web.

**42. D** — A snowy owl that eats lemmings (primary consumers) is itself a secondary consumer, occupying the third trophic level. Energy flow goes: producers (level 1) → primary consumers (level 2) → secondary consumers (level 3).

**43. A** — Lemmings, arctic hares, and caribou all feed directly on arctic willow and would lose their primary food source first. Higher-level predators would feel the effects only after the herbivore base collapsed.

## **PART B-2 – MIXED FORMAT (Questions 44-55)**

**44. C** — A sample size of one provides no way to distinguish real effects from random variation between individuals. Reliable scientific conclusions require multiple replicates so that average values can be calculated and chance variation accounted for.

**45. A** — The dependent variable is what the experimenter measures to detect the effect of the independent variable. Here the student is varying fertilizer concentration and measuring plant height (or mass) in response, making the height the dependent variable.

**46. D** — Line graphs are the standard choice for displaying continuous data that change over time, such as temperature recorded once per minute. The line shows trends and rates of change at a glance.

**47. B** — In chromatography, more soluble pigments dissolve readily in the moving solvent and travel farther up the paper, while less soluble pigments lag behind. The ratio of pigment distance to solvent distance ( $R_f$  value) is a useful identifying property.

**48. C** — Membrane proteins serve many functions but are especially important as channels, carriers, and pumps that move specific substances across the otherwise impermeable phospholipid bilayer. This selective transport is essential for nutrient uptake, waste removal, and signaling.

**49. B** — Antigens are unique surface molecules (often proteins or polysaccharides) on the outside of pathogens that the immune system recognizes as foreign. Each antigen triggers production of a specific matching antibody that binds to it.

**50. A** — Artificial selection occurs when humans choose which individuals reproduce based on desired traits, gradually transforming wild species into domesticated varieties. Teosinte's transformation into modern corn over thousands of years is one of the most dramatic examples on record.

**51. D** — The genetic code is universal — the same triplets specify the same amino acids in bacteria, plants, and humans. This universality allows a human gene inserted into bacterial DNA to be read and translated into the correct human protein, the basis of recombinant insulin production.

**52. C** — Thirst-driven drinking corrects low body water and returns conditions toward the normal set point, opposing the original change. This opposing response is the defining feature of negative feedback, the dominant mechanism for maintaining homeostasis.

**53. A** — Density-dependent factors — competition for nutrients, accumulation of wastes, disease transmission — become more severe as population density rises. These factors slow growth as the population approaches its carrying capacity, distinguishing them from density-independent factors like weather.

**54. B** — In a complex food web, predators often have multiple prey species available, so the loss of one species can be partially compensated by switching to alternatives. This functional redundancy gives complex webs much greater stability than simple linear food chains.

**55. C** — When two species use similar resources in similar ways, their niches overlap and they compete. Competition reduces resource availability for both, often slowing population growth, and may eventually lead to competitive exclusion of the less-efficient species.

## **PART C – EXTENDED CONSTRUCTED RESPONSE (Questions 56–72)**

**56. D** — The Krebs cycle takes place in the matrix — the fluid-filled interior space of the mitochondrion, inside the inner membrane. The enzymes that drive each step of the cycle are located here, where pyruvate from glycolysis is fully broken down.

**57. A** — The electron transport chain in the inner mitochondrial membrane produces about 32–34 ATP per glucose, far more than glycolysis (2 ATP) or the Krebs cycle (2 ATP directly). Together with chemiosmosis, the ETC accounts for the vast majority of ATP yield in aerobic respiration.

**58. B** — Mitochondria and chloroplasts both have their own circular DNA, ribosomes, and double membranes that resemble those of bacteria. These features support the endosymbiotic theory: both organelles descend from ancient free-living bacteria engulfed by an early eukaryotic cell.

**59. D** — The endosymbiotic theory, developed by Lynn Margulis, proposes that mitochondria originated from aerobic bacteria and chloroplasts from photosynthetic bacteria taken up by host cells. The host cells gained energy production while the bacteria gained protection — a long-term mutualism that became permanent.

**60. C** — Xylem is the vascular tissue that transports water and dissolved minerals upward from roots to leaves through hollow tubes formed by dead, lignified cells. Transpiration at the leaves and root pressure together drive this one-way upward flow.

**61. B** — Phloem is the vascular tissue that transports sugars (mainly sucrose) and other organic compounds from photosynthetic leaves to roots, fruits, and growing tissues. Unlike xylem, phloem transport (translocation) occurs through living sieve tube cells.

**62. D** — Stomata are tiny pores on the underside of leaves, each bordered by two guard cells that open and close to regulate gas exchange. They allow CO<sub>2</sub> in for photosynthesis and let O<sub>2</sub> and water vapor (transpiration) escape.

**63. C** — The carpel (also called the pistil) is the female reproductive structure of a flower, consisting of the stigma (catches pollen), style (a tube), and ovary (contains ovules with female gametes). The stamen with anther and filament is the male structure.

**64. A** — Viruses are obligate intracellular parasites that cannot reproduce, metabolize, or grow on their own. They must hijack a host cell's machinery to replicate, which is why they are not considered fully alive.

**65. D** — A virus consists of nucleic acid (DNA or RNA) enclosed in a protein coat called a capsid; some also have a lipid envelope. The genetic material carries the instructions for hijacking host cells and producing new virus particles.

**66. B** — Antibodies are Y-shaped proteins that bind with high specificity to particular antigens on the surface of pathogens. This binding marks the pathogen for destruction by other immune cells or neutralizes it directly.

**67. C** — Cytotoxic (killer) T cells of the adaptive immune system recognize body cells infected by viruses and destroy them by inducing apoptosis. This eliminates virus factories from the body and is essential for clearing intracellular infections.

**68. A** — Vaccines work by training the immune system to make its own antibodies and memory cells against a specific pathogen, providing active immunity. This is long-lasting protection because memory cells survive and respond rapidly to future exposures.

**69. B** — Testosterone is produced primarily by the Leydig cells of the testes, where it drives sperm production and male secondary sex characteristics such as deeper voice, facial hair, and muscle development. Smaller amounts are also produced by the adrenal glands.

**70. C** — Growth hormone (also called somatotropin) is secreted by the anterior pituitary gland and stimulates growth of bone, cartilage, and other tissues throughout childhood and adolescence. Deficiency causes dwarfism; excess causes gigantism or acromegaly.

**71. A** — ADH (also called vasopressin) acts on the collecting ducts of the kidney's nephrons to increase water reabsorption from urine back into the bloodstream. This concentrates the urine and corrects dehydration — a classic negative feedback loop.

**72. D** — The liver produces bile, which is stored in the gallbladder and released into the small intestine to emulsify dietary fats. Emulsification breaks large fat droplets into smaller ones, dramatically increasing surface area for pancreatic lipase to digest.

## **PART D — LABORATORY PRACTICAL (Questions 73–85)**

**73. C** —  $R_f$  (retention factor) = distance pigment traveled  $\div$  distance solvent traveled =  $6 \div 10 = 0.6$ .  $R_f$  values always fall between 0 and 1 and serve as identifying "fingerprints" for individual pigments.

**74. B** — Removing students with unsuccessful tools and allowing successful students to continue to the next round models differential survival and reproduction — the core mechanism of natural selection. Over generations, the population's "beak" composition shifts toward more effective forms.

**75. D** — Glucose is a small molecule that fits through the microscopic pores in dialysis tubing, so it diffuses out from the higher-concentration solution inside to the lower-concentration water outside. Larger molecules like starch cannot pass through and would remain trapped inside.

**76. A** — The Making Connections lab tests the relationship between muscle activity (squeezing the clothespin) and cardiovascular response (pulse rate). The "if-then" hypothesis captures this expected causal relationship between the independent and dependent variables.

**77. C** — Using multiple independent tests (DNA, protein, pigment, indicator chemicals) provides several lines of evidence that can converge on the same conclusion. Agreement across multiple tests is much stronger evidence than a single test, which could be misleading due to chance or experimental error.

**78. B** — Because the compound microscope inverts the image, an object on the slide and its image in the eyepiece appear to move in opposite directions relative to each other. To bring an image at the right edge toward the center, the student moves the slide in the same direction the image appears — to the right.

**79. D** — Lowering the cover slip at an angle allows trapped air to escape from one side as the slip touches down, preventing air bubbles that would distort the view. A flat, even seal produces the clearest microscope image.

**80. C** — Methylene blue binds selectively to negatively charged structures such as nuclei and certain cytoplasmic components, making them visible against the transparent background. Without staining, cell structures appear nearly colorless under the light microscope.

**81. A** — Mark-recapture estimates population size as  $(\text{total tagged}) \times (\text{second sample size}) \div (\text{tagged in second sample}) = (100 \times 80) \div 20 = 8,000 \div 20 = 400$  fish. The method assumes tagged individuals mix randomly with the population between captures.

**82. B** — Lugol's solution (iodine) turns blue-black in the presence of starch, the standard test for this carbohydrate. Benedict's solution tests for reducing sugars like glucose; bromothymol blue detects CO<sub>2</sub>; methylene blue is a cell stain — none detects starch.

**83. C** — Random sampling works only if the sample fairly represents the larger area being studied. By placing frames randomly and averaging across many of them, the student reduces bias and produces an estimate that can be scaled up to the whole lawn.

**84. D** — Different instruments have different precisions, and more precise instruments report measurements with more decimal places (or smaller increments). 2.7 cm and 27.3 mm describe the same length; the second instrument simply detects an additional decimal place of detail.

**85. B** — Honest scientific practice requires reporting data accurately, regardless of whether they support the original hypothesis. A failed prediction is informative — it suggests the hypothesis needs revision or rejection, which is how science self-corrects and advances.