# PRACTICE EXAM 24: 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. Which sequence represents the levels of biological organization, from smallest to largest?

A. organ → tissue → cell → organism

B. cell → organ system → tissue → organism

C. organism → organ system → tissue → cell

D. cell → tissue → organ → organism

2. The cell membrane is composed primarily of two layers of phospholipid molecules arranged with their

A. hydrophobic tails facing outward toward water

B. hydrophilic heads facing inward away from water

C. hydrophilic heads facing outward toward water

D. hydrophobic tails facing in opposite directions

3. The movement of sodium ions OUT of a cell against their concentration gradient requires

A. ATP energy to power the membrane transport proteins

B. simple diffusion through the lipid bilayer of the membrane

C. osmosis to move sodium with the water flow

D. random molecular motion of sodium ions only

4. Cells that require large amounts of energy, such as muscle cells and neurons, contain many

A. ribosomes that synthesize ATP molecules directly

B. mitochondria that produce ATP through cellular respiration

C. lysosomes that release energy as a chemical product

D. centrioles that organize the energy production

5. Hormones traveling in the bloodstream affect only specific target cells because those cells have

A. higher concentrations of the hormone in their cytoplasm

B. larger nuclei than non-target cells in the body

C. specific receptor proteins that bind to that hormone

D. faster metabolic rates than other body cells in general

6. The enzyme catalase, found in many living cells, breaks down a toxic byproduct of cellular metabolism. This byproduct is

A. glucose, a six-carbon sugar molecule

B. carbon dioxide, released from cellular respiration

C. lactic acid, produced during fermentation

D. hydrogen peroxide, which damages cells

7. During transcription, an RNA molecule is synthesized using

A. an amino acid sequence as the template strand

B. one strand of DNA as the template strand

C. a protein molecule as the template strand

D. both strands of DNA simultaneously as templates

8. If a codon on mRNA is AUG, the corresponding anticodon on the tRNA carrying the amino acid will be

A. UAC, the complementary tRNA anticodon sequence

B. TAC, with thymine bases instead of uracil

C. AUG, with the same sequence as the mRNA codon

D. GUA, the reverse of the original codon sequence

9. Mitosis in multicellular organisms is important for

A. producing gametes for sexual reproduction processes

B. reducing chromosome number from diploid to haploid

C. growth, tissue repair, and asexual reproduction

D. generating genetic variation among offspring through recombination

10. Bacterial cells reproduce asexually by a process in which one parent cell divides into two genetically identical daughter cells. This process is called

A. meiosis, producing four haploid cells

B. binary fission, producing two identical cells

C. budding, with a new cell growing from the parent

D. spore formation, with reproductive cells released

11. In pea plants, the allele for tall (T) is dominant over the allele for short (t). A cross between a homozygous tall plant (TT) and a homozygous short plant (tt) will produce offspring that are

A. all heterozygous (Tt) with the tall phenotype expressed

B. half homozygous tall and half homozygous short plants

C. all homozygous tall (TT) like the tall parent plant

D. all homozygous short (tt) like the short parent plant

12. In four o'clock flowers, crossing a red-flowered plant (RR) with a white-flowered plant (rr) produces offspring with pink flowers. This pattern of inheritance is called

A. codominance, with both alleles fully expressed

B. complete dominance, with one allele masking the other

C. multiple alleles, with three or more alleles involved

D. incomplete dominance, with a blended intermediate phenotype

13. Mendel's law of segregation states that

A. all traits are inherited together as a complete set

B. the two alleles for a trait separate during gamete formation

C. dominant alleles always appear in the offspring

D. alleles for different traits always assort together

14. The bacterial enzyme used to cut DNA at specific recognition sequences during genetic engineering is called

A. a restriction enzyme that recognizes specific sequences

B. DNA polymerase that copies DNA strands

C. DNA ligase that joins DNA fragments together

D. RNA polymerase that builds RNA molecules

15. A flock of sheep produced from a single parent through somatic cell nuclear transfer would best be described as

A. siblings born at the same time naturally

B. parents and offspring related sexually

C. clones with identical genetic information

D. hybrids of two different parent species

16. Charles Darwin proposed that the mechanism driving evolutionary change in populations is

A. inheritance of traits acquired during a parent's lifetime

B. random chance with no selection pressure involved

C. divine guidance toward predetermined outcomes

D. natural selection acting on inherited variation

17. Darwin's finches on the Galápagos Islands, with their many different beak shapes adapted to different food sources, are an example of

A. adaptive radiation from a common ancestral species

B. convergent evolution toward identical features

C. coevolution between predator and prey species

D. geographic isolation without any evolutionary change

18. The forelimbs of humans, whales, bats, and cats all have similar bone structures despite serving very different functions. These limbs are best described as

A. analogous structures with different evolutionary origins

B. homologous structures inherited from a common ancestor

C. vestigial structures no longer used by any of the species

D. convergent structures evolved independently in each species

19. The wings of insects and the wings of birds both allow flight, but they have completely different internal structures and evolved independently. These wings are best described as

A. homologous structures inherited from a common ancestor

B. vestigial structures with no current function or purpose

C. embryonic structures that develop only in young animals

D. analogous structures evolved through convergent evolution

20. A relatively short period of geologic time during which a large percentage of Earth's species disappear is called

A. a population bottleneck affecting one species only

B. a founder effect changing one population's gene pool

C. a mass extinction reducing global biodiversity

D. a coevolution event between many species at once

21. A non-native species that is introduced to a new ecosystem and spreads rapidly, often outcompeting native species, is called

A. an endangered species facing imminent extinction

B. an invasive species disrupting the native ecosystem

C. a keystone species essential to the food web

D. a pioneer species that begins primary succession

22. In a Pacific tidal ecosystem, removing all of one species of starfish caused mussels to take over the rocks and many other species to disappear. The starfish is best described as

A. a keystone species whose impact exceeds its abundance

B. an invasive species harmful to the ecosystem

C. a producer at the base of the food web

D. a decomposer breaking down dead organisms

23. Which of the following is most likely to act as a density-INDEPENDENT limiting factor for a deer population in a forest?

A. the spread of contagious disease through the herd

B. competition for limited food during winter months

C. a sudden severe winter storm with deep snow

D. predation by wolves living in the same forest

24. Excessive fertilizer runoff into a lake causes a massive bloom of algae. When the algae die and decompose, oxygen levels in the water drop sharply, killing fish. This process is called

A. acid rain damaging the lake ecosystem

B. bioaccumulation of fertilizer in fish tissue

C. primary succession of new aquatic life

D. eutrophication leading to oxygen depletion

25. Certain gases in Earth's atmosphere, including carbon dioxide and methane, trap heat near the surface, warming the planet. This process is called

A. the greenhouse effect, which keeps Earth warm

B. ozone depletion, removing protective gas layers

C. acidification, lowering the pH of the atmosphere

D. condensation, removing water from the air

26. Clearing tropical rainforests for agriculture and ranching contributes to climate change primarily because

A. forests release more $CO_2$ than they absorb naturally

B. trees produce greenhouse gases through respiration only

C. fewer trees means less $CO_2$ absorbed by photosynthesis

D. ranching cattle directly cools the global climate

27. The main causes of species becoming endangered or extinct today are

A. natural climate cycles unrelated to human activity

B. habitat destruction, overhunting, pollution, and invasive species

C. random genetic mutations occurring in all species

D. competition between native species in stable habitats

28. Which of the following is a renewable energy source that produces no greenhouse gas emissions during electricity generation?

A. coal burned in power plants for electricity

B. natural gas burned in modern power plants

C. petroleum refined into transportation fuels

D. wind power harvested by wind turbines

29. Which of the following is the most effective way to reduce the amount of new raw materials extracted from the environment?

A. reducing, reusing, and recycling existing materials

B. burning waste materials to produce electricity

C. burying waste in landfills for long-term storage

D. exporting waste to other regions of the world

30. Sustainable use of natural resources means using them in a way that

A. allows for rapid economic expansion without limits

B. maximizes short-term profits at any environmental cost

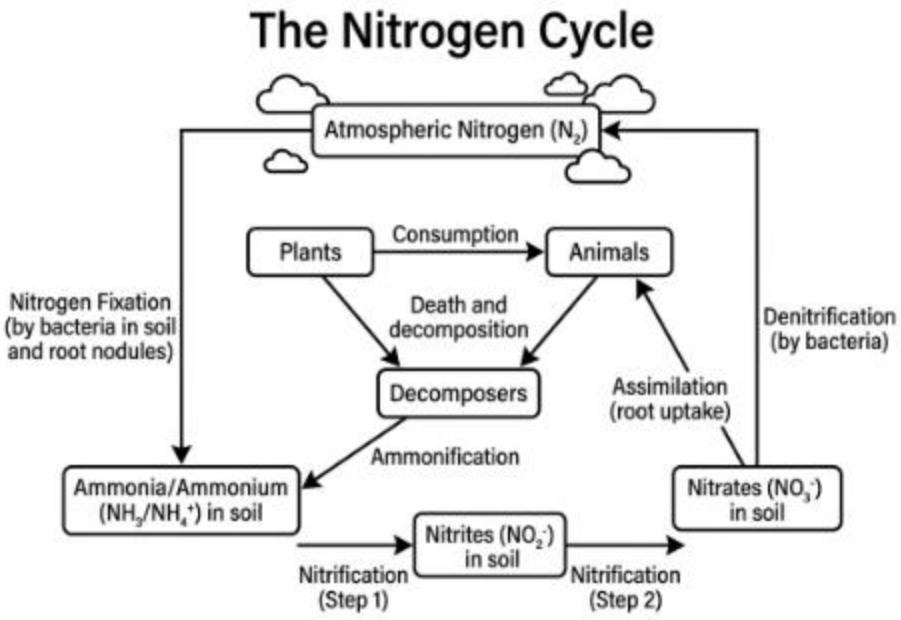
C. meets current needs without compromising future generations

D. eliminates all human use of any natural resources permanently

**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 showing the major processes of the nitrogen cycle.




Based on the diagram, the process by which atmospheric nitrogen ($N_2$) is converted into a form (ammonia/ammonium) that plants can use is called

A. nitrification by certain soil bacteria

B. nitrogen fixation by certain soil bacteria

C. denitrification returning nitrogen to the air

D. ammonification by decomposer organisms

32. Based on the same diagram, nitrogen is essential for organisms because it is a key component of

A. carbohydrates and fats that store cellular energy

B. water molecules used in metabolic reactions

C. proteins and nucleic acids in all living things

D. carbon dioxide and oxygen used in respiration

33. Based on the same diagram, the process that returns nitrogen from soil compounds back to the atmosphere as $N_2$ gas is

A. denitrification carried out by certain bacteria

B. nitrogen fixation by lightning and bacteria

C. ammonification by decomposers in soil

D. assimilation of nitrates by plant roots

34. Based on the same diagram, the decomposers play an essential role in the nitrogen cycle by

A. fixing atmospheric nitrogen directly from the air

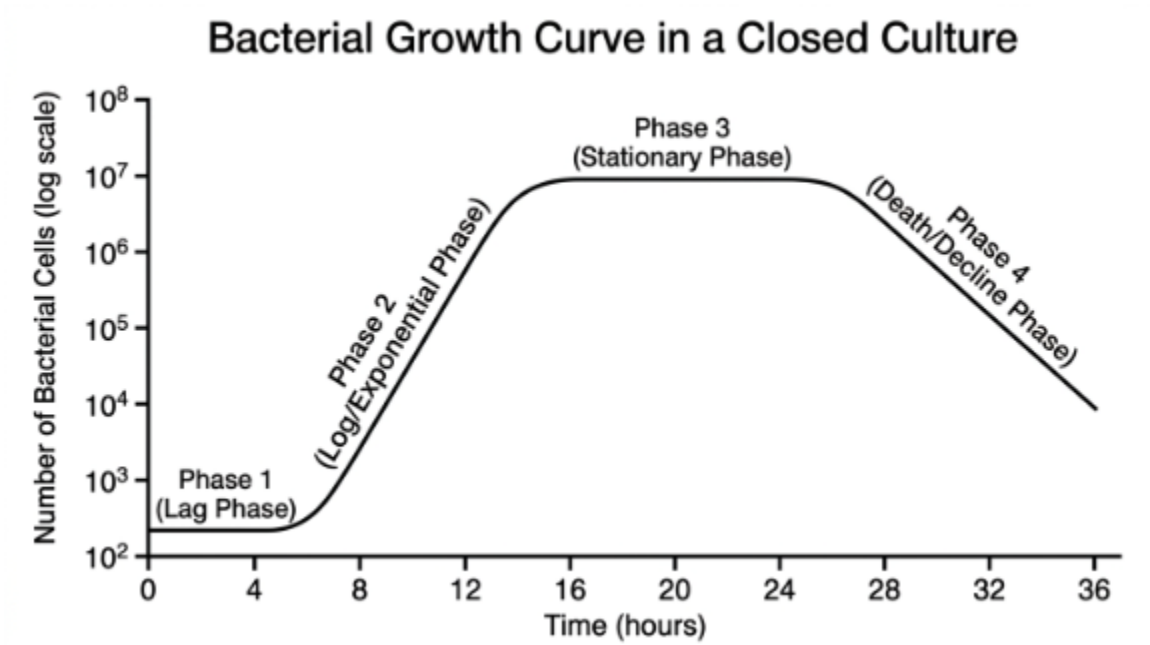
B. converting nitrates back into atmospheric $N_2$ gas

C. providing nitrogen directly to plant roots through symbiosis

D. converting nitrogen in dead organisms back into ammonia

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

35. A student examines a graph showing the growth of a bacterial population over time in a closed culture.




The flat region at the very start of the graph, labeled Phase 1, represents the lag phase, during which the bacteria are

A. adjusting to their new environment before rapid growth

B. dying off rapidly due to lack of food sources

C. growing exponentially at their maximum reproductive rate

D. maintaining a stable population at carrying capacity

36. Based on the same graph, the flat horizontal section labeled Phase 3 (the stationary phase) occurs because

A. the bacteria are actively multiplying at their fastest rate

B. the birth rate equals the death rate as resources become limited

C. the bacteria are still adjusting to their new environment

D. all of the bacteria are dying from accumulated waste products

37. Based on the same graph, the steep upward slope during Phase 2 (the log phase) demonstrates

A. linear growth with a constant number added each hour

B. negative growth with the population decreasing rapidly

C. exponential growth with the population doubling regularly

D. no growth, with the population remaining unchanged

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

38. A student examines a pedigree chart following the inheritance of a genetic disorder through three generations of a family. Affected individuals appear in every generation, both males and females are affected in roughly equal numbers, and every affected individual has at least one affected parent.

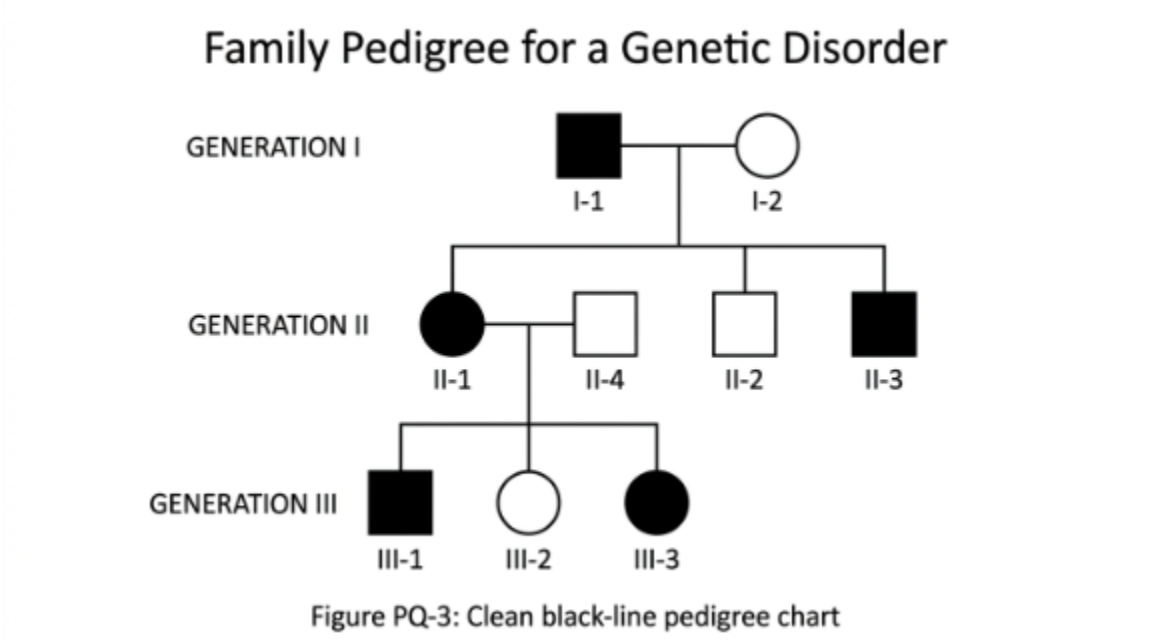



Figure PQ-3: Clean black-line pedigree chart

The pattern of inheritance shown is most consistent with

A. an autosomal recessive disorder skipping generations

B. a sex-linked recessive disorder limited to males

C. a sex-linked dominant disorder passed through females

D. an autosomal dominant disorder appearing every generation

39. Based on the same pedigree, if individual II-1 is heterozygous (Aa) for the disorder and II-4 is unaffected (aa), the probability that any future child of theirs will be affected is

A. 50%, with half of the children expected to be affected

B. 25%, with one quarter of the children expected to be affected

C. 0%, with no children expected to be affected

D. 100%, with all children expected to be affected

40. Based on the same pedigree, the fact that both males and females are affected in roughly equal numbers suggests that the gene for this disorder is located

A. on the Y chromosome inherited only by males

B. on an autosome rather than a sex chromosome

C. only in the mitochondrial DNA of females

D. only on the X chromosome inherited from mothers

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 a temperate deciduous forest ecosystem.

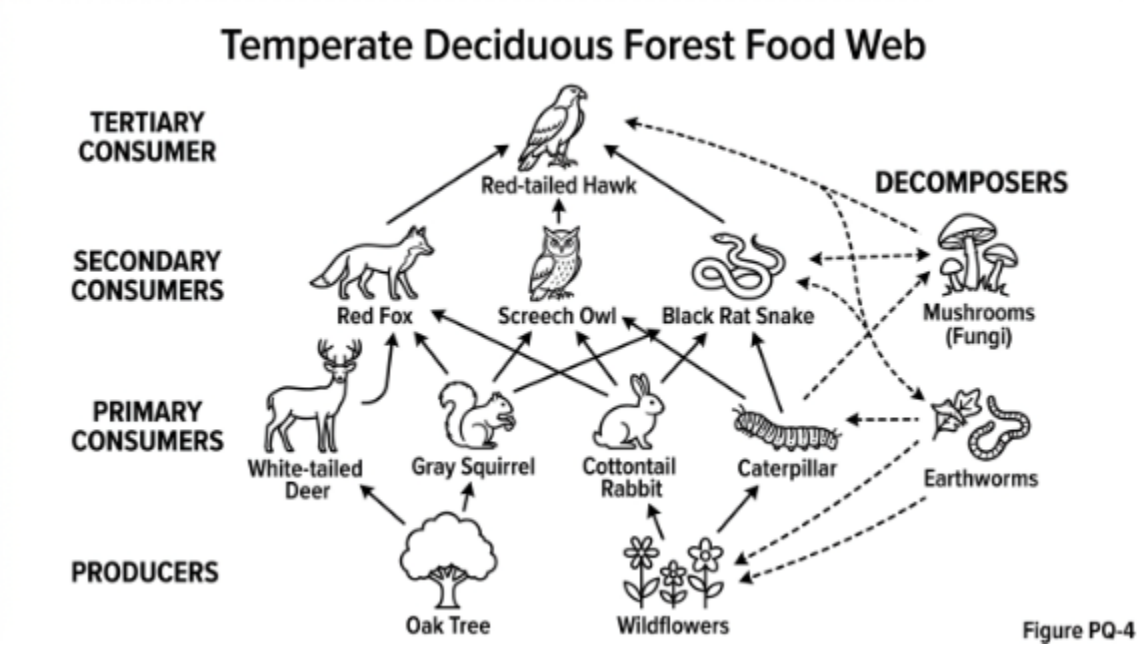



Figure PQ-4

Based on the temperate deciduous forest food web shown, which of the following is a producer that captures the original solar energy entering the food web?

A. the white-tailed deer that browses on tree leaves

B. the red-tailed hawk at the top of the food web

C. the oak tree that performs photosynthesis

D. the mushroom that breaks down dead organic matter

42. Based on the same food web, the red-tailed hawk that eats foxes, owls, and snakes is best classified as

A. a producer at the base of the food web

B. a primary consumer eating only producers directly

C. a decomposer breaking down dead organisms

D. a tertiary consumer at the top of the food web

43. Based on the same food web, if a disease killed off all of the gray squirrels, the population most likely to increase as a direct result would be

A. acorns, since fewer squirrels remain to consume them

B. red foxes that depend exclusively on squirrels for food

C. wildflowers that compete with squirrels for sunlight

D. mushrooms that depend on squirrels for nutrient cycling

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

Answer all questions in this part.

44. In an experiment testing how light intensity affects the rate of photosynthesis in aquatic plants, the independent variable is

A. the rate of photosynthesis measured by oxygen production

B. the intensity of light shone on the plants in each trial

C. the type of aquatic plant used throughout the experiment

D. the temperature of the water in which plants are grown

45. Which of the following is the best example of a testable scientific hypothesis?

A. If the amount of fertilizer increases, then bean plant growth will increase

B. Bean plants are interesting plants to grow in any garden

C. Bean plants are the most beautiful plants in the world

D. Why do bean plants grow at different rates throughout the year?

46. After collecting experimental data, the next step a scientist should take is to

A. publish the results without further checking the data

B. immediately discard any unexpected data points from the set

C. accept the original hypothesis regardless of the data collected

D. analyze the data to determine what conclusions can be drawn

47. Bile produced by the liver and stored in the gallbladder helps digest fats in the

A. mouth, where chewing begins the digestive process

B. stomach, where strong acid breaks down food

C. small intestine, where most chemical digestion occurs

D. large intestine, where water is reabsorbed

48. In the human lungs, the gas exchange between air and blood takes place in tiny sacs called

A. bronchioles that branch through lung tissue

B. alveoli surrounded by capillary networks

C. trachea connecting the throat to the lungs

D. larynx located at the top of the windpipe

49. The kidneys maintain homeostasis in the body by

A. filtering blood and removing wastes such as urea

B. producing bile for the digestion of fatty foods

C. pumping blood throughout the body's circulatory system

D. taking in oxygen and releasing carbon dioxide gas

50. The organ that produces bile, detoxifies harmful substances absorbed from food, and stores glucose as glycogen is the

A. kidney, which filters blood and produces urine

B. pancreas, which produces insulin and digestive enzymes

C. spleen, which filters blood and removes old cells

D. liver, the largest internal organ in the body

51. The liquid portion of blood that carries dissolved nutrients, hormones, and wastes throughout the body is called

A. plasma, the watery yellowish fluid in blood

B. red blood cells carrying oxygen to tissues

C. white blood cells fighting against infections

D. platelets involved in blood clotting processes

52. When a person cuts their skin, small cell fragments in the blood help form clots that stop the bleeding. These cell fragments are called

A. red blood cells transporting oxygen molecules

B. white blood cells destroying invading pathogens

C. platelets, fragments that aid in blood clotting

D. plasma proteins dissolved in the blood liquid

53. In females, the development of an egg in the ovary each month is regulated by hormones secreted by the

A. adrenal glands above the kidneys

B. pituitary gland and the ovaries themselves

C. thyroid gland in the neck region

D. pancreas, behind the stomach in the abdomen

54. In humans, fertilization of an egg by a sperm cell typically occurs in the

A. uterus, where the fetus develops during pregnancy

B. ovary, where the egg is produced and released

C. vagina, the birth canal during childbirth

D. fallopian tube, as the egg moves toward the uterus

55. When a person touches a hot stove and pulls their hand away before consciously feeling the heat, the rapid response is controlled by a

A. reflex arc involving the spinal cord, not the brain

B. conscious decision made by the cerebrum first

C. hormonal signal sent through the bloodstream

D. learned behavior practiced many times before

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

Answer all questions in this part.

56. The endosymbiotic theory proposes that mitochondria evolved from

A. ancient viruses that infected early cells

B. invaginations of the early cell membrane

C. ancient free-living bacteria taken in by early cells

D. molecules of RNA that gained membranes over time

57. In a plant leaf, the cellular structure where photosynthesis occurs is the

A. mitochondrion that produces ATP molecules

B. nucleus that contains the genetic material

C. ribosome that synthesizes proteins for the plant

D. chloroplast containing the green pigment chlorophyll

58. Chlorophyll in plant cells is important for photosynthesis because it

A. uses ATP to drive chemical reactions in cells

B. absorbs light energy used to power photosynthesis

C. releases oxygen as a waste product of respiration

D. breaks down glucose to release stored energy

59. Scientists can compare DNA samples from different individuals by cutting the DNA with restriction enzymes and separating the fragments by size using

A. gel electrophoresis, in which fragments move in an electric field

B. polymerase chain reaction, copying DNA millions of times

C. translation, converting mRNA into protein products

D. ribosomes producing DNA from amino acid chains

60. The specific three-dimensional shape of a protein determines its function. If the protein is heated to a high temperature, it loses its shape — a process called

A. transcription of the gene encoding the protein

B. replication of the protein's amino acid sequence

C. denaturation, with loss of three-dimensional shape

D. translation of the protein into its functional form

61. Insulin produced by the pancreas affects liver cells and muscle cells but not brain cells. This selectivity is because

A. insulin diffuses only through certain tissues

B. brain cells produce their own insulin in greater amounts

C. insulin travels in the blood to specific organ locations

D. liver and muscle cells have insulin receptors that brain cells lack

62. When a person has not eaten for many hours and blood sugar levels drop, the pancreas releases the hormone glucagon, which causes the liver to release stored glucose. This response is best described as

A. negative feedback restoring normal blood glucose levels

B. positive feedback amplifying the original drop in glucose

C. an allergic response to the lack of food in the digestive tract

D. a learned behavior to maintain blood sugar levels

63. The lymphatic system contributes to homeostasis by

A. pumping blood throughout the body's tissues

B. returning excess tissue fluid to the bloodstream

C. producing bile for digestion of fatty foods

D. exchanging oxygen and carbon dioxide in the lungs

64. White blood cells contribute to homeostasis primarily by

A. carrying oxygen to all the body's tissues

B. clotting blood at the site of wounds

C. defending against bacteria, viruses, and other pathogens

D. producing the digestive enzymes that break down food

65. When a person breathes in airborne flu virus particles, the body's first line of defense includes

A. mucus and cilia in the respiratory passages

B. specific antibodies that target the virus instantly

C. memory cells from a previous flu infection

D. enlarged lymph nodes throughout the body

66. A vaccine works by exposing the immune system to a harmless form of a pathogen, causing the body to

A. break out in a serious illness as treatment begins

B. immediately become resistant to all other diseases

C. produce more red blood cells to fight the pathogen

D. produce memory cells that respond rapidly to future infections

67. In rheumatoid arthritis, the body's own immune system mistakenly attacks the joints. This is best classified as

A. an infectious disease caused by an outside pathogen

B. an autoimmune disorder where the immune system attacks self-tissue

C. a genetic disorder present from birth in all cases

D. a nutritional disorder caused by lack of vitamins

68. Sperm cells are produced by meiosis in the male's

A. prostate gland, which surrounds the urethra

B. seminal vesicles, which produce seminal fluid

C. testes, located in the scrotum outside the body

D. epididymis, where sperm are stored after production

69. During pregnancy in mammals, the structure that allows the exchange of nutrients, oxygen, and wastes between the mother and the developing embryo is the

A. amniotic sac that surrounds the developing embryo

B. umbilical cord connecting embryo to the placenta

C. yolk sac in the embryo containing stored nutrients

D. placenta with capillaries from both mother and embryo

70. Embryonic stem cells are valuable for medical research because they

A. can differentiate into any type of cell in the body

B. produce hormones needed for normal cell function

C. can survive without any source of nutrients

D. are easier to grow than other types of cells

71. Antibiotics such as penicillin work against bacterial infections but have no effect on viral infections because

A. viruses reproduce more slowly than bacteria

B. antibiotics target bacterial structures that viruses lack

C. viruses are larger than bacteria and harder to kill

D. antibiotics are not strong enough to kill viruses

72. The widespread overuse of antibiotics in humans and livestock has led to the rapid evolution of antibiotic-resistant bacteria because

A. antibiotics cause mutations directly in bacterial DNA

B. bacteria learn to resist antibiotics during their lifetimes

C. antibiotics provide strong selection favoring resistant bacteria

D. resistant bacteria appear randomly with no selection involved

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

Answer all questions in this part.

73. In the Diffusion Through a Membrane laboratory, students place dialysis tubing containing starch and glucose into a beaker of water with Lugol's iodine. After 30 minutes, Lugol's iodine inside the tubing turns blue-black. This shows that

A. starch diffused out of the tubing into the water

B. glucose diffused out of the tubing into the water

C. neither molecule diffused across the membrane

D. iodine diffused from the beaker into the tubing

74. In the Beaks of Finches simulation, after several rounds, the surviving students were predominantly those using tools that were efficient at picking up the food provided. This outcome illustrates

A. natural selection favoring beneficial inherited traits

B. random changes occurring without any selection

C. learned behaviors developed during the simulation

D. the inheritance of traits acquired during the simulation

75. In the Making Connections laboratory, students measure their pulse rate before and after squeezing a clothespin for one minute. The independent variable in this experiment is

A. the time spent measuring the pulse rate after squeezing

B. whether or not the student squeezes the clothespin (activity level)

C. the pulse rate measured at the wrist or neck of the student

D. the type of clothespin used during the experiment

76. In the Relationships and Biodiversity laboratory, students compare a hypothetical valuable species (Botana curus) to several related species using molecular, chemical, and structural tests. The purpose of using multiple different tests rather than just one is to

A. take more time to complete the laboratory exercise

B. make the laboratory more interesting for the students

C. allow students to practice many different techniques

D. provide more reliable evidence about evolutionary relatedness

77. When preparing a wet-mount slide of an onion cell, students should lower the cover slip slowly at an angle. This prevents

A. the cells from being crushed by the cover slip

B. the cells from being stained by chemicals on the slip

C. air bubbles from being trapped under the cover slip

D. water from evaporating during the observation

78. A compound microscope has an ocular lens with 10× magnification. If a student switches to the objective lens with 40× magnification, the total magnification of the specimen is

A. 40 times its actual size, the objective lens alone

B. 400 times its actual size, the lenses multiplied

C. 50 times its actual size, the lenses added together

D. 10 times its actual size, the ocular lens alone

79. Using a compound microscope under low power, a student observes that a single onion cell stretches across about one-tenth of the field of view. If the field of view is 1,500 micrometers wide, the approximate length of the cell is

A. 1,500 micrometers, equal to the field of view

B. 15,000 micrometers, ten times the field of view

C. 1,500,000 micrometers, much larger than the field

D. 150 micrometers, one-tenth of the field of view

80. In a biology laboratory, Benedict's solution is used to test for the presence of

A. simple sugars such as glucose in a sample

B. starch in a sample of food material

C. proteins in a sample of biological material

D. lipids or fats in a sample of food material

81. Bromothymol blue is an indicator that changes color in the presence of

A. starch dissolved in a water solution

B. simple sugars produced from starch digestion

C. carbon dioxide producing an acidic environment

D. proteins broken down by digestive enzymes

82. When using a compound microscope, a student should focus first using

A. only the fine adjustment knob throughout the procedure

B. the low-power objective and the coarse adjustment knob

C. the high-power objective and the coarse adjustment knob

D. only the high-power objective without any adjustment

83. If a chemical is spilled on a student's skin during a laboratory exercise, the student should

A. wipe the chemical off with a paper towel quickly

B. ignore the spill and continue with the experiment

C. apply ice immediately to the affected skin area

D. flush the area with water and notify the teacher

84. Before beginning a laboratory exercise that involves heating chemicals over an open flame, a student should

A. wear sandals and short sleeves for comfort

B. tie back long hair and put on safety goggles

C. apply hand lotion to protect against burns

D. drink water to stay hydrated during the experiment

85. A student accidentally breaks a glass beaker during a laboratory exercise. The appropriate response is to

A. pick up the pieces by hand and dispose of them in the regular trash

B. leave the broken glass on the floor and continue with the experiment

C. notify the teacher and use a broom and dustpan to collect the pieces

D. cover the broken glass with paper towels and step around it carefully

## Practice Exam 24 — Answer Key and Explanations

**1. D** — Cell → tissue → organ → organism is the correct hierarchy from smallest to largest. Similar cells form tissues, tissues form organs, and organs work together as organ systems within an organism. This bottom-up organization is fundamental to understanding how complex multicellular life is built from simpler units.

**2. C** — Phospholipids are amphipathic, with hydrophilic (water-loving) phosphate heads and hydrophobic (water-fearing) fatty acid tails. In the membrane, the heads face outward toward the watery extracellular and cytoplasmic environments, while the tails hide inward away from water. This arrangement creates a selectively permeable barrier essential for cell function.

**3. A** — Active transport moves substances against their concentration gradient and therefore requires ATP energy. The sodium-potassium pump is a classic example: it uses ATP hydrolysis to power membrane proteins that move $Na^+$ out and $K^+$ in, maintaining the gradients essential for nerve signaling and other cellular processes.

**4. B** — Mitochondria are the cellular powerhouses, producing ATP through aerobic cellular respiration. Cells with high energy demands — muscle, neurons, liver — contain hundreds or thousands of

mitochondria, while less metabolically active cells contain far fewer. The number of mitochondria correlates directly with a cell's energy requirements.

**5. C** — Hormones travel through the bloodstream to every cell in the body, but they affect only target cells that have specific receptor proteins matching the hormone's shape. The receptor-hormone binding is like a lock-and-key fit; cells without the matching receptor simply do not respond. This specificity is how the endocrine system targets particular tissues.

**6. D** — Hydrogen peroxide ($H_2O_2$) is a toxic byproduct of normal cellular metabolism that damages cells if it accumulates. Catalase, found in peroxisomes, breaks $H_2O_2$ down into harmless water and oxygen, protecting cellular components from oxidative damage. This is one reason peroxisomes are abundant in liver cells, which detoxify many compounds.

**7. B** — During transcription, RNA polymerase uses one strand of DNA (the template strand) to build a complementary RNA molecule. The other DNA strand carries the same sequence as the RNA (with T instead of U) and is not directly read by the polymerase. The resulting mRNA carries the genetic message from the nucleus to the ribosome.

**8. A** — Base pairing rules between RNA molecules pair A with U and G with C. An mRNA codon of AUG is matched by a tRNA anticodon of UAC, the complementary sequence read in the opposite direction. AUG is the start codon, so this particular tRNA delivers methionine to begin every protein chain.

**9. C** — Mitosis produces two genetically identical diploid daughter cells from one parent cell. In multicellular organisms, this drives growth, replaces worn-out or damaged cells (tissue repair), and underlies asexual reproduction in many simple animals and plants. Meiosis, by contrast, makes gametes and reduces chromosome number.

**10. B** — Binary fission is the prokaryotic form of asexual cell division in which a bacterium replicates its single circular DNA, then splits into two identical daughter cells. The process is fast — under ideal conditions, some bacteria divide every 20 minutes — which is why bacterial populations can grow rapidly when conditions are favorable.

**11. A** — In a Punnett square cross of TT × tt, every offspring receives one T allele from the homozygous tall parent and one t allele from the homozygous short parent. All offspring (the $F_1$ generation) are therefore heterozygous (Tt) and tall in phenotype, because T is dominant over t. This is Mendel's classic $F_1$ uniformity result.

**12. D** — Incomplete dominance occurs when the heterozygous phenotype is an intermediate blend of the two homozygous phenotypes. Red × white yielding pink shows that neither allele fully dominates, so the heterozygote (Rr) appears as a mix. This differs from codominance, in which both phenotypes appear simultaneously rather than blending into one.

**13. B** — Mendel's law of segregation states that during gamete formation, the two alleles for each trait separate so that each gamete carries only one allele. When gametes fuse at fertilization, the offspring

receives one allele from each parent. This law is mechanistically realized by the separation of homologous chromosomes during meiosis I.

**14. A** — Restriction enzymes are bacterial proteins that recognize specific short DNA sequences (such as GAATTC for EcoRI) and cut DNA at those sites. In genetic engineering, they are used to cut both donor and recipient DNA at predictable locations so that genes can be inserted reliably. DNA ligase then seals the new fragment into place.

**15. C** — Clones are organisms with identical genetic information, produced asexually from a single parent. Somatic cell nuclear transfer — the technique used to produce Dolly the sheep — inserts a body-cell nucleus into an enucleated egg, generating offspring genetically identical to the nuclear donor. Such offspring are clones, not siblings or hybrids.

**16. D** — Darwin proposed that organisms vary, more offspring are produced than can survive, and individuals with traits better suited to the environment survive and reproduce more — passing those heritable traits to the next generation. This mechanism is natural selection, the central engine of evolutionary change in his theory of descent with modification.

**17. A** — Adaptive radiation is the rapid evolution of a single ancestral species into many descendant species adapted to different ecological niches. On the Galápagos, an ancestral finch radiated into multiple species with beaks specialized for seeds, insects, cactus flowers, and other foods. The available unfilled niches drove this diversification.

**18. B** — Homologous structures share a common evolutionary origin and basic anatomical plan even when their functions differ. The forelimbs of mammals all have the same one-bone, two-bone, wrist-bones, fingers pattern because they descend from a common ancestor with that limb plan. Their similarities reveal shared ancestry despite later modifications.

**19. D** — Analogous structures look similar and serve similar functions but evolved independently in different lineages, often through convergent evolution under similar selective pressures. Insect wings (made of cuticle supported by veins) and bird wings (modified vertebrate forelimbs) both fly, but their underlying anatomy reveals no common ancestry.

**20. C** — A mass extinction is a relatively short geological interval during which a large fraction of Earth's species go extinct. The Cretaceous-Paleogene event 66 million years ago killed the non-avian dinosaurs and roughly 75% of all species; five major mass extinctions punctuate the fossil record, each reshaping global biodiversity.

**21. B** — An invasive species is a non-native organism that establishes itself in a new ecosystem and spreads aggressively, often without the predators or competitors that controlled it in its native range. Zebra mussels, kudzu, and brown tree snakes are textbook examples that disrupt native food webs and cause major economic and ecological damage.

**22. A** — A keystone species has a disproportionately large effect on its ecosystem relative to its abundance — its removal triggers cascading changes. Robert Paine's classic Pisaster starfish removal study showed exactly this pattern: without starfish predation, mussels dominated and tidal biodiversity collapsed.

**23. C** — Density-independent factors affect populations regardless of how dense they are; weather events and natural disasters are the classic examples. A severe winter storm kills deer whether the population is small or large. Disease, food competition, and predation, in contrast, intensify as density rises and are therefore density-dependent factors.

**24. D** — Eutrophication occurs when excess nutrients (especially nitrogen and phosphorus from fertilizer runoff) trigger algal blooms; when the algae die, decomposers consume them and deplete dissolved oxygen. The resulting hypoxic "dead zones" suffocate fish and other aerobic aquatic life. This is a major problem in many lakes and coastal waters worldwide.

**25. A** — Greenhouse gases — $CO_2$, methane, water vapor, nitrous oxide — absorb outgoing infrared radiation from Earth's surface and re-emit some of it downward, trapping heat in the lower atmosphere. This natural greenhouse effect keeps Earth habitable; human-driven increases in these gases intensify the effect and drive global warming.

**26. C** — Trees absorb $CO_2$ from the atmosphere during photosynthesis and store carbon in their wood and leaves. When forests are cleared, this carbon sink shrinks, so less atmospheric $CO_2$ is removed — and burning the cut wood adds even more $CO_2$ to the air. Deforestation thus contributes to rising atmospheric $CO_2$ and climate change.

**27. B** — Modern extinction risk is driven primarily by human activities: habitat destruction (the single biggest cause), overexploitation through hunting and fishing, pollution, and introduced invasive species. These pressures often combine and reinforce each other, making the current extinction rate hundreds to thousands of times the natural background rate.

**28. D** — Wind power generates electricity from the kinetic energy of moving air using turbines; the resource is essentially limitless on human timescales (renewable), and operation produces no direct greenhouse gases. Coal, natural gas, and petroleum are fossil fuels that release stored carbon as $CO_2$ when burned, driving climate change.

**29. A** — Reducing consumption first, then reusing what we already have, and recycling materials at end of life — the "three Rs" hierarchy — minimizes new resource extraction. Burning, burying, or exporting waste still depletes source materials and shifts the problem rather than solving it. Source reduction is the most effective conservation strategy.

**30. C** — Sustainability means meeting present human needs without compromising the ability of future generations to meet their own — the definition from the 1987 Brundtland Report. This balances economic activity, social well-being, and environmental protection so resources remain available indefinitely rather than being depleted in a single generation.

## PART B-1 — DATA-BASED MULTIPLE CHOICE (Questions 31–43)

**31. B** — Nitrogen fixation converts atmospheric $N_2$ — a stable, inert molecule that most organisms cannot use — into ammonia ($NH_3$) or ammonium ($NH_4^+$) that plants can absorb. The diagram shows this step

performed by specialized soil bacteria, including symbiotic Rhizobium in legume root nodules, which break the strong N≡N triple bond.

**32. C** — Nitrogen is a key element in amino acids (which build proteins) and in nucleotides (which build DNA and RNA). Without a reliable source of usable nitrogen, organisms cannot synthesize these essential macromolecules. This is why nitrogen is often the limiting nutrient in many ecosystems and why farmers add nitrogen fertilizer to crops.

**33. A** — Denitrification is performed by anaerobic bacteria that convert nitrate ($NO_3^-$) back into atmospheric $N_2$ gas, completing the nitrogen cycle. The diagram shows this step returning fixed nitrogen to the atmosphere. Without denitrification, nitrogen would steadily accumulate in soils and water rather than recycling.

**34. D** — Decomposers — bacteria and fungi — break down dead plants, animals, and waste, releasing the organic nitrogen as ammonia ($NH_3$) and ammonium ($NH_4^+$) in a process called ammonification. This returns nitrogen to the soil in a form plants can re-absorb after nitrification. Without decomposers, nitrogen would remain locked in dead organic matter.

**35. A** — The lag phase represents the time bacteria spend adjusting to a new environment — synthesizing enzymes, repairing any damage, and preparing the cellular machinery for division. The flat curve at low cell count reflects this metabolic preparation before active reproduction begins. Once ready, the bacteria enter the log phase of rapid growth.

**36. B** — In the stationary phase, the population stops growing because resources (nutrients, space) become limiting and waste products accumulate. Birth rate falls and death rate rises until they balance, producing the flat plateau. This represents the population's carrying capacity in that closed culture.

**37. C** — The log (exponential) phase shows steep upward growth because each division doubles the population: $1 \rightarrow 2 \rightarrow 4 \rightarrow 8 \rightarrow 16$, and so on. Plotted on a log scale, this regular doubling produces a straight upward line — the signature of exponential growth in a resource-rich environment with no limiting factors.

**38. D** — Autosomal dominant disorders appear in every generation (no skipping), affect males and females roughly equally, and require only one copy of the mutant allele to express the phenotype. Every affected individual must have at least one affected parent. The pedigree matches all three criteria perfectly — the inheritance pattern of disorders like Huntington's disease.

**39. A** — A heterozygous parent (Aa) crossed with an unaffected parent (aa) gives equal numbers of Aa (affected) and aa (unaffected) offspring in a 1:1 ratio. The probability that any single child is affected is therefore 50%. This high recurrence risk is characteristic of autosomal dominant disorders.

**40. B** — When a disorder affects males and females in roughly equal numbers, the responsible gene almost certainly sits on an autosome rather than a sex chromosome. Sex-linked traits, especially X-linked ones, show clear differences in expression between males and females. Roughly equal numbers across sexes points to autosomal inheritance.

**41. C** — Producers are autotrophs that capture solar energy through photosynthesis to make their own organic compounds. Oak trees are green plants that perform photosynthesis, placing them at the base of the food web as producers along with the wildflowers. Consumers and decomposers depend on this original energy capture.

**42. D** — A tertiary consumer feeds on secondary consumers (other predators), typically occupying the top of the food web. The red-tailed hawk eats foxes, owls, and snakes — all of which are themselves carnivores eating other consumers — placing the hawk at the highest trophic level shown in this food web.

**43. A** — Gray squirrels eat acorns; removing them releases that food source from heavy consumption, so acorns accumulate on the trees and the ground. Red foxes have multiple prey species and would not increase from squirrel loss. Wildflowers and mushrooms have no direct dependence on squirrels in this food web.

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

**44. B** — The independent variable is the factor the experimenter intentionally changes to test its effect. Here, light intensity is being manipulated across trials, while photosynthesis rate (the response being measured) is the dependent variable. Plant type and temperature should be held constant as controlled variables.

**45. A** — A scientific hypothesis is a testable, falsifiable prediction, typically stated in if-then form linking an independent variable to a dependent variable. The fertilizer-and-growth statement specifies what should happen if a change is made, making it experimentally testable. Aesthetic opinions and open-ended questions are not testable hypotheses.

**46. D** — Once data are collected, the scientist analyzes them — calculating averages, looking for patterns, testing statistical significance — to determine whether the results support the hypothesis. Publishing without analysis, discarding inconvenient data, or accepting a hypothesis without evidence all violate basic scientific practice.

**47. C** — The small intestine is the primary site of chemical digestion, including fat digestion. Bile from the liver and gallbladder emulsifies fats into small droplets here, dramatically increasing the surface area available for pancreatic lipase to break the fats down into fatty acids and glycerol.

**48. B** — Alveoli are tiny grape-like air sacs at the ends of the bronchioles, surrounded by dense capillary networks. Their thin walls and enormous combined surface area (about 70 $m^2$ in adults) make them ideal for rapid gas exchange — oxygen diffuses into the blood while carbon dioxide diffuses out to be exhaled.

**49. A** — The kidneys filter the blood, removing nitrogenous wastes such as urea (from protein breakdown), excess water, salts, and toxins, while reabsorbing useful substances such as glucose and amino acids. The resulting urine maintains the body's water, salt, and pH balance — central to homeostasis.

**50. D** — The liver is the body's largest internal organ and serves many homeostatic roles: producing bile for fat digestion, detoxifying drugs and metabolic poisons, storing glucose as glycogen, synthesizing

plasma proteins, and processing fats and amino acids. No other single organ performs all of these functions.

**51. A** — Plasma is the pale yellow liquid portion of blood (about 55% of blood volume) that consists mostly of water with dissolved proteins, hormones, nutrients, electrolytes, gases, and wastes. It carries these substances throughout the body, suspending the red cells, white cells, and platelets that handle other functions.

**52. C** — Platelets are small cell fragments produced by megakaryocytes in the bone marrow that play a central role in blood clotting. At an injury site, platelets adhere to the damaged vessel wall, release clotting factors, and form a plug that stops bleeding. Disorders of platelet number or function lead to abnormal bleeding or clotting.

**53. B** — Egg development is regulated by the hypothalamic-pituitary-gonadal axis: the pituitary gland releases FSH and LH, which act on the ovaries to drive follicle growth and ovulation. The ovaries themselves also produce estrogen and progesterone, which feed back to coordinate the menstrual cycle. The adrenal, thyroid, and pancreas play different roles.

**54. D** — Fertilization typically occurs in the upper third of the fallopian tube (oviduct), where the egg meets sperm shortly after ovulation. The fertilized zygote then travels down the tube over several days, dividing as it goes, before implanting in the uterine wall as a blastocyst. Fertilization in the uterus or vagina is rare and abnormal.

**55. A** — A reflex arc is a rapid neural pathway in which a sensory signal travels to the spinal cord, where an interneuron directly relays it to a motor neuron that triggers the response. This bypass of the brain allows withdrawal from harmful stimuli in milliseconds, well before the conscious sensation of heat reaches the cortex.

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

**56. C** — The endosymbiotic theory, championed by Lynn Margulis, proposes that mitochondria descended from aerobic bacteria that were engulfed by — but not digested by — early eukaryotic cells. The bacterium gained protection and a stable nutrient supply; the host gained efficient ATP production. Mitochondrial circular DNA, ribosomes, and double membranes all support this origin.

**57. D** — Chloroplasts are the plant organelles that carry out photosynthesis, using chlorophyll to absorb light and convert $CO_2$ and water into glucose and oxygen. They are found in green plant tissues, especially leaves, and (like mitochondria) contain their own DNA — evidence of their own ancient endosymbiotic origin from cyanobacteria.

**58. B** — Chlorophyll molecules in the chloroplast thylakoid membranes absorb light energy, primarily in the red and blue wavelengths, and reflect green (which is why plants look green). This absorbed light energy excites electrons that power the light-dependent reactions, ultimately producing the ATP and NADPH used to fix $CO_2$ into sugar.

**59. A** — Gel electrophoresis separates DNA fragments by size by applying an electric field across a gel; smaller fragments migrate faster through the gel matrix and travel farther than larger ones. The resulting pattern of bands is a DNA fingerprint that can identify individuals, diagnose genetic disorders, or compare related sequences.

**60. C** — Denaturation is the loss of a protein's three-dimensional shape (and therefore its function) without breaking the peptide bonds in its primary sequence. High temperatures disrupt the hydrogen bonds and other weak interactions that hold the protein folded. Cooking an egg — denaturing its proteins — is an everyday example of the process.

**61. D** — Hormones reach essentially every cell, but only target cells with matching receptors can respond. Liver and muscle cells express insulin receptors, so insulin triggers glucose uptake in them; brain cells lack these specific receptors and use a different transport system instead. Receptor distribution determines which tissues a hormone affects.

**62. A** — Negative feedback opposes the original change to restore the set point. When blood glucose drops, glucagon raises it by releasing stored glucose from the liver — countering the initial decrease. This opposing response is the hallmark of negative feedback and the dominant mechanism for maintaining homeostasis in the body.

**63. B** — The lymphatic system collects excess interstitial fluid that leaks out of capillaries into tissues and returns it to the bloodstream through the lymphatic vessels. Without this return route, tissues would swell with fluid (edema). The system also transports immune cells and absorbs dietary fats from the intestines.

**64. C** — White blood cells (leukocytes) are the immune system's effector cells, defending the body against pathogens through phagocytosis (neutrophils, macrophages), antibody production (B cells), and direct cell killing (cytotoxic T cells). They do not carry oxygen, clot blood, or produce digestive enzymes — those functions belong to other cell types.

**65. A** — The first line of defense is nonspecific innate immunity, which keeps pathogens out before specific responses can mount. In the airways, mucus traps inhaled particles and cilia sweep them upward to be swallowed or expelled, blocking viruses and bacteria from reaching the lungs. Specific antibodies and memory cells take days to mobilize.

**66. D** — Vaccines expose the immune system to harmless versions or pieces of a pathogen, triggering antibody production and — crucially — memory B and T cell formation without causing disease. Memory cells persist for years, allowing the immune system to mount a rapid, strong response if the real pathogen later invades the body.

**67. B** — Autoimmune disorders occur when the immune system fails to distinguish self from non-self and attacks the body's own tissues. In rheumatoid arthritis, immune cells attack the synovial membranes of joints, causing inflammation, pain, and joint destruction. Type 1 diabetes and lupus are other examples of autoimmune disease.

**68. C** — Spermatogenesis takes place in the seminiferous tubules of the testes, where diploid germ cells undergo meiosis to produce haploid sperm. The testes sit in the scrotum outside the body cavity because sperm production requires temperatures slightly below core body temperature.

**69. D** — The placenta is the temporary organ formed during pregnancy that allows exchange of nutrients, oxygen, hormones, and wastes between the mother's blood and the embryo's blood without direct mixing. Both maternal and embryonic capillaries lie in close contact within the placenta, enabling diffusion across the thin barrier.

**70. A** — Embryonic stem cells are pluripotent — capable of differentiating into any of the more than 200 cell types in the body. This property makes them valuable for potential regenerative therapies, disease modeling, and basic research into how cells specialize. Adult stem cells are typically more restricted (multipotent) in what they can become.

**71. B** — Antibiotics target structures unique to bacterial cells: the peptidoglycan cell wall, bacterial ribosomes, and bacterial DNA replication enzymes. Viruses lack all of these features — they are essentially genetic material in a protein coat that uses host cellular machinery. With no bacterial targets to attack, antibiotics cannot kill viruses.

**72. C** — Antibiotics act as a strong selective pressure: susceptible bacteria die, while any with pre-existing resistance mutations survive and multiply, passing resistance to their offspring. Overuse magnifies this selection across many bacterial populations, accelerating the spread of resistance and producing today's "superbugs."

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

**73. D** — Lugol's iodine was initially outside the tubing in the beaker; finding it turned blue-black inside the tubing means it diffused through the membrane and encountered the starch inside. Starch molecules are too large to cross the dialysis tubing pores, but small iodine molecules can — demonstrating the selective permeability of the membrane.

**74. A** — In the Beaks of Finches simulation, students with tools (beak shapes) efficient for the available food gathered more, "survived," and "reproduced," while inefficient tools were eliminated. Over rounds, the population shifted toward effective beak shapes — exactly the mechanism of natural selection acting on inherited variation.

**75. B** — The independent variable is the factor manipulated by the experimenter — the activity level (whether or not the student squeezes the clothespin). Pulse rate, the variable being measured in response, is the dependent variable. Controlled variables include measurement technique, type of clothespin, and resting conditions.

**76. D** — Closely related species share more recent common ancestors and therefore more similar molecular, chemical, and structural traits. Performing multiple independent tests and seeking consistent agreement across them strengthens conclusions about relatedness; a single test could mislead due to coincidence, error, or convergent evolution.

**77. C** — Lowering the cover slip slowly at an angle allows trapped air to escape ahead of the descending slip, preventing bubbles that would distort or obscure the specimen. Air bubbles look like dark-edged circles under the microscope and can ruin an otherwise good preparation.

**78. B** — Total magnification of a compound microscope equals the product of ocular magnification and objective magnification: 10× × 40× = 400×. The specimen therefore appears 400 times larger than its actual size. Adding the lens powers, rather than multiplying, would give an incorrect result.

**79. D** — If the cell spans one-tenth of a field of view that is 1,500 µm wide, the cell length is approximately 1/10 × 1,500 = 150 micrometers. This proportional reasoning is the standard method for estimating sizes under a microscope when the field-of-view diameter is known.

**80. A** — Benedict's solution is a chemical test for reducing sugars such as glucose, fructose, and maltose. When heated with a reducing sugar, the blue Benedict's reagent changes color through green, yellow, orange, and brick red depending on sugar concentration. It does not react with starch, proteins, or lipids.

**81. C** — Bromothymol blue is a pH indicator that turns yellow in acidic solutions and remains blue in neutral or basic solutions. When $CO_2$ dissolves in water, it forms carbonic acid, lowering the pH and turning bromothymol blue yellow. The test is commonly used to detect $CO_2$ produced during cellular respiration.

**82. B** — Focusing should always begin with the lowest-power objective and the coarse adjustment knob, which provides the widest field of view and largest depth of focus. Once the specimen is centered and roughly focused, switching to higher power and using the fine adjustment refines the image. Using coarse adjustment on high power risks crashing the objective into the slide.

**83. D** — Immediate, thorough flushing with large amounts of water dilutes and removes the chemical from the skin, minimizing tissue damage. Notifying the teacher ensures proper documentation and additional first-aid measures. Wiping with a paper towel may spread the chemical, ice is rarely appropriate, and ignoring the spill is dangerous.

**84. B** — Before any heating activity, students should tie back long hair to prevent it from catching fire and put on safety goggles to protect their eyes from splashes, sparks, or hot fumes. Sandals expose feet to spilled chemicals, and hand lotion and hydration do not address the actual hazards posed by open flames and hot chemicals.

**85. C** — Broken glass should never be picked up by hand, as cuts and infection risk are likely. Notifying the teacher ensures proper documentation and adult supervision, and using a broom and dustpan allows safe collection of all fragments. The pieces should then be placed in a designated broken-glass container, not the regular trash.