PRACTICE EXAM 22: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

Instructions: This simulation exam mirrors the format of the New York State Regents Examination in Life Science: Biology. Questions are organized into stimulus-based clusters. Read each cluster's stimulus completely before answering any questions in that set. Select the one best answer for each question.

Base your answers to questions 1 through 5 on the information below and on your knowledge of biology.

A student investigated how the human body maintains a constant internal body temperature. The student placed a volunteer in a temperature-controlled chamber and measured the diameter of the blood vessels in the volunteer's skin, the rate of sweating, and the volunteer's internal body temperature as the chamber's air temperature was gradually changed. The volunteer's internal body temperature remained close to 37°C across all chamber settings. The other observations are summarized below.

Chamber Temperature (°C)	Skin Blood Vessel Diameter	Rate of Sweating
15	Constricted (narrow)	Very low
22	Normal	Low
30	Dilated (wide)	Moderate
38	Maximally dilated	High

1. What is the main scientific question this experiment is designed to investigate?

A. Whether sweating can occur at temperatures below 0°C inside the chamber B. Whether human body temperature is identical to chamber temperature at all times C. Whether blood vessels can change size when exposed to ultraviolet light alone D. How the body responds to changes in environmental temperature to maintain stable body temperature

2. At a chamber temperature of 15°C, the blood vessels in the skin constricted. This response helps the body to:

A. Increase the loss of body heat to the surrounding cold environment more quickly B. Conserve body heat by reducing blood flow near the skin surface and outward heat loss C. Provide more nutrients to the

skin cells through increased blood circulation in cold D. Cool the body by increasing the amount of blood available for evaporation from the skin

3. At a chamber temperature of 38°C, the body responded by sweating heavily and dilating skin blood vessels. These changes work together to:

A. Release excess body heat into the environment and prevent the body from overheating B. Trap body heat inside the body so internal temperature can continue to rise further C. Increase the production of metabolic heat within the muscles and the liver tissues D. Decrease the amount of water in the bloodstream in order to thicken the blood

4. The maintenance of a stable internal body temperature despite changes in the external environment is an example of:

A. Active transport, in which substances are moved against a concentration gradient B. Osmosis, in which water moves across a selectively permeable membrane C. Homeostasis, in which the body maintains constant internal conditions despite external changes D. Reproduction, in which new individuals are produced from a parent organism

5. The brain region most responsible for monitoring body temperature and triggering the responses observed in this experiment is the:

A. Cerebrum, which controls voluntary movement and conscious thought processes B. Cerebellum, which coordinates balance and fine motor skills throughout the body C. Medulla, which controls heart rate and breathing as well as some involuntary reflexes D. Hypothalamus, which functions as the body's main thermostat and regulator of homeostasis

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

A class investigated the specificity of three different digestive enzymes. Each enzyme was tested with three different types of food molecules to see which substrates it could break down. Students mixed each enzyme with each food type, kept temperature and pH identical across all tubes, and tested for the presence of breakdown products after 30 minutes. A "Yes" indicates that breakdown products were detected; a "No" indicates that no breakdown was observed.

Enzyme	Starch	Lipids	Protein
Amylase	Yes	No	No
Lipase	No	Yes	No
Trypsin	No	No	Yes

6. The data demonstrate that each enzyme is:

A. Specific, meaning it can break down only one type of substrate and no others B. General, meaning it can break down many different types of substrates equally well C. Inactive, meaning it cannot break down any substrates without help from other molecules D. Reversible, meaning it can rebuild the substrates from their breakdown products

7. Each enzyme has a particular three-dimensional shape that determines which substrate it can act upon. This shape is determined by:

A. The temperature of the surrounding solution at the time of the reaction B. The pH of the surrounding solution where the enzyme is currently located C. The specific sequence of amino acids that makes up the enzyme protein D. The amount of substrate present in the surrounding solution at any given time

8. If amylase were placed in a tube containing only protein as a substrate, the most likely result would be:

A. The protein would be broken down rapidly into individual amino acids B. No reaction would occur because protein does not fit the amylase active site C. The amylase would denature instantly upon contact with the protein substrate D. The amylase would convert the protein into a starch molecule for storage

9. In the human digestive system, amylase is produced in the salivary glands and pancreas. The substrate amylase acts on (starch) is best classified as:

A. A lipid, which is broken down into fatty acids and glycerol during digestion B. A protein, which is broken down into amino acids during digestion C. A nucleic acid, which is broken down into individual nucleotides during digestion D. A carbohydrate, which is broken down into simple sugars during digestion

10. The relationship between an enzyme and its substrate is often compared to:

A. A lock and key, in which only the correct key (substrate) fits the lock (active site) B. A magnet and iron, in which any iron object will be attracted to any magnet at all C. Oil and water, in which the two substances cannot mix together at all D. Sandpaper and wood, in which one substance gradually wears down the other

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

A student investigated how water and nutrients move through a plant. The student placed a freshly cut stem of a white carnation in a vase containing water mixed with blue food coloring. After several hours, the petals of the carnation began to show streaks of blue color. The student then cut a thin cross-section of the stem and examined it under a microscope. The blue dye was concentrated in a ring of tubes near the outside of the stem (xylem) but not in the surrounding tissue (phloem).

11. The blue color appeared in the petals because:

A. The food coloring evaporated from the water and entered the air around the flower B. The food coloring traveled through the air and stained the surface of the petals from outside C. Water containing the dye traveled up through the xylem tissue and into the petals D. The carnation produced new blue pigments in response to being placed in water

12. The xylem tissue of a plant transports primarily:

A. Sugars produced by photosynthesis from the leaves down to the roots and stems B. Water and dissolved minerals from the roots upward to the leaves and flowers C. Genetic information from one generation of plants to the next during reproduction D. Carbon dioxide gas from the surrounding air down into the cells of the plant's roots

13. The other major transport tissue in plants, phloem, transports primarily:

A. Atmospheric nitrogen gas from the air down to the soil bacteria in the roots B. Pure oxygen from the leaves to the rest of the plant body C. Water and dissolved minerals from the leaves down to the roots of the plant D. Sugars produced by photosynthesis from the leaves to other parts of the plant

14. Water rises from the roots to the leaves of a tall tree primarily because of:

A. Transpiration pulling water upward as water vapor exits through pores in the leaves B. The pressure of the soil pushing water upward through the roots into the stem C. The flowers actively pumping water upward against the force of gravity D. The mitochondria of the root cells producing water from cellular respiration

15. If the student had completely blocked the xylem with a clamp on the stem, the most likely result would be that:

A. The carnation petals would turn a deeper blue color than they did without the clamp B. The dye would travel faster up the stem and reach the petals more quickly than before C. Water and the dye would not reach the petals, and the flower would eventually wilt D. The blue dye would change to a green color before reaching the petals above

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

Cellular respiration is the process by which cells extract energy from food molecules to produce ATP. The three main stages of aerobic respiration are glycolysis (in the cytoplasm), the citric acid cycle (in the mitochondrial matrix), and the electron transport chain (along the inner mitochondrial membrane). Together, these stages can produce approximately 36 ATP molecules from a single glucose molecule. By contrast, glycolysis alone — which can occur without oxygen — produces only about 2 ATP molecules per glucose.

16. Which stage of aerobic respiration produces the largest amount of ATP?

A. Glycolysis, which is the only stage of respiration that takes place in the cytoplasm B. The electron transport chain, which generates the majority of ATP during aerobic respiration C. The citric acid cycle, which takes place in the matrix of the mitochondrion D. Fermentation, which takes place when oxygen is unavailable to the cell

17. The difference in ATP yield between aerobic respiration (~36 ATP) and glycolysis alone (~2 ATP) shows that:

A. Aerobic respiration is far more efficient at extracting energy from glucose than anaerobic processes B. Glycolysis is more efficient than aerobic respiration in extracting energy from a glucose molecule C. Aerobic respiration and glycolysis extract equal amounts of energy from each glucose molecule D. Aerobic respiration produces no ATP and relies entirely on the products of fermentation

18. Mitochondria are sometimes called the "powerhouses" of the cell because they:

A. Synthesize the glucose molecules needed for cellular respiration to take place B. Store the genetic information that codes for the enzymes of cellular respiration C. Break down old cellular structures and recycle the components for reuse in the cell D. Carry out most of the reactions that produce ATP during aerobic respiration

19. A cell with very few mitochondria would most likely:

A. Produce more ATP per glucose than a cell with many mitochondria for storage B. Function only when oxygen levels in the surrounding tissues are abnormally high C. Have a lower energy output than a cell with many mitochondria available for ATP production D. Be incapable of performing glycolysis or any other form of energy metabolism

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

Three different types of RNA play essential roles in protein synthesis. Messenger RNA (mRNA) is synthesized in the nucleus from a DNA template and carries the genetic code from DNA to the ribosome. Transfer RNA (tRNA) is a smaller RNA molecule with an anticodon at one end and a specific amino acid attached at the other end; it delivers amino acids to the ribosome during protein synthesis. Ribosomal RNA (rRNA) combines with proteins to form the ribosomes themselves, the cellular structures where proteins are assembled.

20. Which type of RNA carries the genetic message from the DNA in the nucleus to the ribosome in the cytoplasm?

A. Messenger RNA (mRNA), which is synthesized from a DNA template in the nucleus B. Transfer RNA (tRNA), which carries a specific amino acid to the ribosome C. Ribosomal RNA (rRNA), which

combines with proteins to form a ribosome D. Double-stranded RNA, which carries genetic information in some viruses only

21. A tRNA molecule with the anticodon 3′-UAC-5′ would pair with which mRNA codon?

A. 5′-UAC-3′, in which the bases are identical to those in the anticodon shown B. 5′-AUG-3′, in which each base is the complement of the corresponding anticodon base C. 5′-TAC-3′, in which thymine is substituted for uracil in the codon sequence D. 5′-CAU-3′, in which the bases are reversed but not complementary

22. rRNA is a major structural component of the ribosome. The ribosome's primary function is to:

A. Replicate the DNA molecules before cell division occurs in the cell nucleus B. Store the genetic information that codes for all the proteins of the cell C. Transport molecules from one location to another within the cell cytoplasm D. Assemble amino acids into proteins according to the mRNA code being read

23. In which cellular structure is mRNA synthesized in a eukaryotic cell?

A. The ribosome, where amino acids are assembled into proteins during translation B. The mitochondrion, which produces ATP for cellular processes through respiration C. The nucleus, which contains the DNA template used to synthesize the mRNA D. The lysosome, which contains digestive enzymes that break down cellular waste

24. A cell that needs to produce large amounts of a particular protein would most likely contain large numbers of:

A. Ribosomes, where the protein is actually assembled from amino acids during translation B. Lysosomes, which break down old proteins after the cell has finished using them C. Chloroplasts, which capture light energy to drive the protein synthesis reactions D. Cell walls, which provide structural support and protect the cell from damage

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

Meiosis is a special type of cell division that produces gametes (sex cells) in sexually reproducing organisms. While mitosis produces two genetically identical diploid daughter cells from one diploid parent cell, meiosis involves two consecutive divisions and produces four haploid daughter cells from one diploid parent cell. Each haploid gamete contains half the number of chromosomes of the parent body cell. When two gametes (one from each parent) combine during fertilization, the resulting offspring has the full diploid chromosome number, with one set of chromosomes contributed by each parent.

25. A human body cell contains 46 chromosomes. The number of chromosomes in a human gamete (egg or sperm) is:

A. 92, which is twice the number of chromosomes found in a body cell of the parent B. 23, which is half the number of chromosomes found in a body cell of the parent C. 46, which is the same number of chromosomes as in a normal body cell D. 12, which is one-quarter the number of chromosomes in the body cell of the parent

26. What is the chromosome number of a human zygote (fertilized egg)?

A. 23, because only one parent contributes chromosomes to the offspring during fertilization B. 92, because the chromosomes double in number immediately after fertilization C. 12, because some chromosomes are lost during the process of fertilization itself D. 46, because each parent contributes one set of 23 chromosomes to the offspring

27. The major difference between mitosis and meiosis is that:

A. Mitosis produces four daughter cells while meiosis produces only two daughter cells B. Mitosis occurs in plants only, while meiosis occurs in both animals and bacteria C. Mitosis produces genetically identical diploid cells; meiosis produces genetically varied haploid cells D. Mitosis requires more time to complete than meiosis does in the cells of an organism

28. Genetic variation among the offspring of sexually reproducing organisms arises in part because:

A. Meiosis randomly assorts maternal and paternal chromosomes into different gametes B. Mitosis produces identical copies of each chromosome before separating them into cells C. The mutation rate during meiosis is one hundred times the rate during mitosis in cells D. Each parent contributes the same identical set of chromosomes to every offspring

29. A pair of chromosomes, one from each parent, that carry genes for the same traits are called:

A. Sister chromatids, which are formed when a single chromosome replicates during S phase B. Homologous chromosomes, which pair up during meiosis and carry genes for the same traits C. Sex chromosomes, which determine whether the offspring will be male or female D. Polyploid chromosomes, which are extra copies that occur in some plants and rare animals

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

Speciation is the process by which one species splits into two or more distinct species. One common pathway begins when a population becomes geographically isolated from the rest of its species — for example, when a group of organisms colonizes an island, or when a river or mountain range divides a population. Over generations, the isolated population is subject to its own local environmental pressures, accumulates its own genetic variations, and may eventually become so different from the original population that the two groups can no longer interbreed even if reunited. At that point, they are considered separate species. Speciation is a major source of Earth's biodiversity.

30. When a population is split into two groups by a mountain range or a river, the two groups can no longer exchange genes. This separation is called:

A. Sexual selection, in which mate choice drives changes in physical traits over generations B. Genetic engineering, in which scientists deliberately modify the genome of a species C. Geographic isolation, in which two groups of a species are separated by a physical barrier D. Convergent evolution, in which two unrelated species develop similar physical traits

31. If two geographically isolated populations evolve to the point that they can no longer interbreed and produce fertile offspring, they are considered to be:

A. The same species with two slightly different sets of physical characteristics overall B. A single hybrid population that combines the features of both original groups together C. Two subspecies of the same overall species, with only minor genetic differences between them D. Two separate species, because the ability to interbreed is a defining feature of one species

32. The Galápagos finches studied by Charles Darwin are different species on different islands of the same archipelago. The most likely explanation for this pattern is:

A. The finches' common ancestor colonized different islands, and the isolated populations evolved separately B. Each island was colonized independently by completely unrelated bird species from different continents C. Sailors on Darwin's voyage moved finches from island to island, creating new species each time D. The finches change their physical appearance during their own lifetimes to match each island

33. Which factor would most likely lead to the formation of two species from one ancestral population?

A. The two populations occasionally interbreed and produce healthy fertile offspring together B. The two populations live in the same habitat and share the same food resources fully C. The two populations are physically separated and subject to different selective pressures D. The two populations remain genetically identical to each other over many generations

34. The accumulation of small genetic differences between two isolated populations over time is best explained by:

A. The deliberate effort of individual organisms to become different from members of the other group B. Random mutations and natural selection acting independently in each separated population C. Genetic engineering performed by scientists studying the populations over many generations D. The two populations simultaneously inventing new traits in response to a shared environmental cue

35. The wide variety of life forms on Earth (biodiversity) is largely the result of:

A. A small number of original species being maintained without significant change since life began B. New species periodically appearing from non-living material through spontaneous generation C. Each species permanently retaining all of its original traits since the dawn of life on Earth D. Speciation occurring repeatedly over billions of years, branching one species into many

36. The fossil record provides strong evidence of speciation by:

A. Showing transitional forms with features intermediate between earlier and later species B. Showing identical species existing unchanged from the earliest fossils to the present day C. Showing that all species on Earth appeared simultaneously at the same point in history D. Showing that fossils are exactly the same as the modern descendants of those organisms

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

A keystone species is a species that has a disproportionately large effect on its ecosystem relative to its abundance. The removal of a keystone species can cause dramatic changes throughout the ecosystem, often leading to a decline in biodiversity. A classic example is the sea otter on the Pacific coast of North America. Sea otters feed on sea urchins, which graze on kelp. When sea otter populations were reduced by hunting in the 1800s, sea urchin populations exploded, and the urchins overgrazed the kelp, transforming productive kelp forests into barren "urchin barrens." When sea otters were later protected and recovered, kelp forests returned, and many other species that depended on the kelp recovered as well.

37. The sea otter is described as a keystone species because:

A. Sea otters are the most numerous species in the kelp forest ecosystem B. Sea otters have a much greater effect on the ecosystem than their numbers alone would suggest C. Sea otters are the largest species in the kelp forest community by body size D. Sea otters depend on kelp directly for food in the marine ecosystem

38. Removing sea otters from the ecosystem led to:

A. An increase in kelp forest density and species diversity within those kelp forests B. A decrease in the sea urchin population due to a lack of available food C. An explosion of sea urchin populations and the destruction of kelp forests D. An increase in the overall biodiversity of the entire coastal marine ecosystem

39. The relationship between sea otters and sea urchins in this ecosystem is best described as:

A. Mutualism, in which both species benefit equally from the close interaction B. Commensalism, in which one species benefits while the other is unaffected C. Competition, in which both species fight for the same limited resources D. Predation, in which the sea otters consume sea urchins as their prey

40. When sea otters returned to the ecosystem, kelp forests recovered. This shows that:

A. Removing the urchin grazing pressure allowed kelp to grow and regenerate the forest B. Sea otters directly fertilize the kelp with nutrients from their digestive waste C. Kelp only grows when sea otters

are physically present in the surrounding water D. Sea urchin populations naturally decline whenever kelp forests begin to expand

41. Many species besides kelp depend on a healthy kelp forest ecosystem. The loss of sea otters can therefore lead to:

A. An overall increase in biodiversity as new species adapt to take the place of lost species B. A decline in many species in the ecosystem, even those that do not eat sea otters or urchins C. A perfectly stable ecosystem because non-keystone species fill the same niche role D. Improved fishing yields for human communities along the coast in the affected areas

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

Burning fossil fuels — such as coal, oil, and natural gas — releases sulfur dioxide (SO2) and nitrogen oxides (NOx) into the atmosphere. These gases react with water vapor and oxygen in the atmosphere to form sulfuric acid and nitric acid, which fall to Earth as acid rain (rain with a lower-than-normal pH). Acid rain can damage forests by harming tree leaves and altering soil chemistry, acidify lakes and streams enough to kill fish and other aquatic organisms, and corrode buildings and statues made of certain types of stone. Acid rain has been a significant environmental issue in industrialized regions of the world since the mid-1900s.

42. The pH of normal rainwater is slightly acidic (around pH 5.6) because of dissolved carbon dioxide. The pH of acid rain is:

A. Equal to normal rainwater because all rainwater has the same pH everywhere B. Higher than normal rainwater, making it more basic than ordinary rain C. Lower than normal rainwater, making it more acidic than ordinary rain D. Equal to pure distilled water at exactly pH 7.0 in all conditions

43. The primary source of the gases that produce acid rain is:

A. The combustion of fossil fuels in power plants, vehicles, and industrial factories B. The photosynthesis carried out by green plants on land and in the oceans C. The respiration of decomposer bacteria in the soils of large forests around the world D. The natural release of oxygen from volcanic eruptions in various regions of the world

44. One of the major effects of acid rain on a lake ecosystem is:

A. An immediate increase in the diversity of fish and amphibian species in the lake B. A complete elimination of all photosynthetic organisms within just a few days C. Improved water quality due to the neutralization of harmful basic substances in the lake D. A decline in fish populations as the acidity damages eggs and young aquatic organisms

45. Reducing acid rain in industrialized regions has required:

A. Increasing the use of coal-burning power plants in every community of the region B. Reducing emissions of sulfur dioxide and nitrogen oxides through pollution-control technology C. Building taller smokestacks that release the pollutants higher into the atmosphere D. Allowing acid rain to fall without any restrictions on industrial emissions whatsoever

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

Human reproduction begins when a sperm cell from a male fertilizes an egg cell (ovum) from a female. The resulting fertilized egg, called a zygote, divides repeatedly by mitosis as it travels down the fallopian tube and implants in the lining of the uterus. The developing organism is called an embryo during the first eight weeks of pregnancy, and then a fetus from the ninth week until birth. The placenta, formed during pregnancy, allows the exchange of nutrients, oxygen, and waste between the mother's blood and the developing fetus, without the two bloodstreams actually mixing.

46. A human zygote forms when:

A. A sperm cell divides repeatedly inside the male reproductive tract before being released B. An egg cell divides repeatedly by mitosis in the absence of any fertilization at all C. A sperm cell fertilizes an egg cell, combining the genetic material of both parents D. Two egg cells fuse together inside the female reproductive tract during ovulation

47. The zygote develops into an embryo through repeated rounds of:

A. Mitosis, which produces genetically identical cells through standard cell division B. Meiosis, which produces gametes with half the chromosome number of the parent C. Binary fission, which is a form of cell division found primarily in bacterial cells D. Sexual reproduction, which produces new individuals through the fusion of gametes

48. The placenta serves several essential functions during pregnancy, including:

A. Providing the fetus with the light it needs to develop its eyes properly before birth B. Generating the heat required to keep the developing fetus warm inside the uterus C. Producing the fetus's first cells and tissues during the early weeks of pregnancy D. Exchanging nutrients, oxygen, and wastes between the mother's blood and the fetus

49. The placenta is unique in that:

A. The blood of the mother and the fetus mix freely throughout the entire pregnancy B. The mother's blood directly enters the fetal blood vessels and circulates back again C. Nutrients and gases are exchanged across membranes without the two bloodstreams mixing D. The mother and fetus share a single common heart that pumps blood for both of their bodies

50. The developing organism is considered a fetus rather than an embryo beginning:

A. At the moment of fertilization when the sperm and egg cells first combine in the tube B. After approximately eight weeks of pregnancy, when major organ systems have begun to form C. At the moment of birth, when the baby is delivered from the mother's body D. At the moment of implantation in the uterine wall during the first week of development

PRACTICE EXAM 22 – EXPLAINED ANSWER KEY (Q1–Q50)

1. D — The experiment measures the body's physiological responses (vasoconstriction/dilation, sweating) across a range of chamber temperatures while internal body temperature stays nearly constant. This setup is designed to reveal how the body actively regulates its internal temperature against external changes. Understanding this regulatory question is the central purpose of the investigation.

2. B — Constricting blood vessels near the skin reduces blood flow to the surface, decreasing the amount of heat carried from the warm core to the cool exterior. Less heat is then transferred to the environment, conserving body warmth. Vasoconstriction is one of the body's first responses to cold and helps prevent dangerous drops in core temperature.

3. A — Dilation of skin blood vessels increases blood flow near the surface, allowing heat to radiate away from the body, while sweating evaporates from the skin and carries additional heat with it. Together these responses dump excess heat into the environment. They are essential for preventing dangerous overheating.

4. C — Homeostasis is the maintenance of stable internal conditions despite changes in the external environment. A constant body temperature inside a changing chamber is a textbook example. Many other physiological variables — pH, blood glucose, blood pressure — are regulated by similar homeostatic mechanisms.

5. D — The hypothalamus contains specialized neurons that monitor blood temperature and coordinate the body's heating and cooling responses, including sweating, shivering, and changes in skin blood-vessel diameter. It serves as the body's central thermostat. Damage to the hypothalamus can severely impair temperature regulation.

6. A — Each enzyme broke down only one specific substrate and did nothing to the others, demonstrating substrate specificity. Each enzyme's active site has a shape that fits only its particular substrate. This specificity is what allows cells to control thousands of different chemical reactions independently.

7. C — A protein's three-dimensional shape — including the shape of an enzyme's active site — is determined by the linear sequence of amino acids encoded by its gene. Temperature, pH, and substrate concentration affect how an enzyme works, but they do not determine its underlying shape. This is why mutations that change amino acid sequence can disable an enzyme.

8. B — Amylase's active site is shaped to fit starch, not protein, so a protein substrate cannot bind. With no enzyme–substrate complex forming, no breakdown occurs. This is why each digestive enzyme works on only one class of food molecule.

9. D — Starch is a polysaccharide made of long chains of glucose units, placing it in the carbohydrate category. Amylase hydrolyzes the bonds between glucose units, producing simple sugars that can be absorbed in the small intestine. Recognizing the major macromolecule classes is foundational to understanding digestion.

10. A — The "lock and key" analogy captures the idea that the substrate must fit precisely into the enzyme's active site, just as only the correct key fits a specific lock. Other substrates do not fit and cannot be acted upon. This model — later refined by the "induced fit" model — remains the standard introduction to enzyme specificity.

11. C — Water moves up through the xylem tissue of the stem, carrying the dissolved blue dye along with it. When the water reaches the petals and evaporates, the dye is left behind, producing visible blue streaks. This experiment is a classic demonstration of xylem transport in flowering plants.

12. B — Xylem consists of dead, hollow, tube-like cells that transport water and dissolved minerals upward from the roots to the rest of the plant. Movement is driven mainly by transpiration pulling water through the plant. Without xylem, tall plants could not deliver water to their leaves.

13. D — Phloem consists of living cells that move dissolved sugars (made in the leaves by photosynthesis) to the roots, fruits, and other parts of the plant that need energy or growth. This movement can occur in either direction depending on where the sugars are needed. Phloem and xylem together form the plant's vascular system.

14. A — Water evaporates from leaves through tiny pores called stomata, creating a "pull" that draws a continuous column of water upward through the xylem from the roots. This process, called transpiration, is what raises water tens of meters up in tall trees. Cohesion between water molecules keeps the water column intact during this rise.

15. C — Blocking the xylem prevents water from moving up the stem to the leaves and petals. Without a water supply, cells lose turgor pressure, and the flower wilts. This demonstrates that xylem is the route by which water and dissolved substances reach the upper parts of the plant.

16. B — The electron transport chain, located on the inner mitochondrial membrane, produces roughly 32–34 of the approximately 36 ATP generated per glucose during aerobic respiration. Oxygen serves as the final electron acceptor, allowing the chain to continue operating. This is why cells require oxygen for full aerobic energy production.

17. A — Aerobic respiration extracts about 18 times more ATP from each glucose molecule than glycolysis alone (~36 vs. ~2). This far greater efficiency is the main reason oxygen-using organisms can support large, complex bodies. Anaerobic energy production is much less efficient and is generally used only when oxygen is unavailable.

18. D — Mitochondria carry out the citric acid cycle and the electron transport chain, generating the bulk of the cell's ATP supply. They are abundant in cells with high energy demands, such as muscle and nerve cells. This central role in ATP production is why they are called the cell's "powerhouses."

19. C — Most of a cell's ATP comes from the mitochondria, so fewer mitochondria means less ATP production overall. Cells with many mitochondria — muscle, heart, neurons — have correspondingly higher energy outputs. Glycolysis would still occur in the cytoplasm, but on its own it cannot meet the energy needs of most cells.

20. A — Messenger RNA is transcribed in the nucleus from a DNA template and then carries the genetic instructions to the ribosome in the cytoplasm. The other RNA types (tRNA and rRNA) play different supporting roles in translation. mRNA is essentially the working "copy" of a gene that the cell uses to build a protein.

21. B — Codons and anticodons pair in antiparallel orientation, with A pairing to U and G pairing to C. Reading the anticodon 3′-UAC-5′ from 3′ to 5′ gives the complementary codon 5′-AUG-3′. AUG is also the universal start codon, signaling the ribosome to begin protein synthesis.

22. D — The ribosome reads each mRNA codon and matches it with the appropriate tRNA, then catalyzes the peptide bond that links amino acids into a growing protein chain. Without ribosomes, no protein could be synthesized. Ribosomes are present in all known living cells.

23. C — Transcription — the synthesis of mRNA from a DNA template — takes place in the nucleus of a eukaryotic cell, where the DNA resides. The mRNA then moves out to the cytoplasm to be translated. This compartmentalization is a defining feature of eukaryotic cells.

24. A — Ribosomes are the cellular machines that actually build proteins from mRNA instructions. Cells that produce large amounts of protein — such as plasma cells producing antibodies or pancreatic cells producing digestive enzymes — contain unusually large numbers of ribosomes. Other organelles do not perform protein assembly.

25. B — Meiosis halves the chromosome number when producing gametes, so a human gamete contains 23 chromosomes — half of the 46 found in body cells. This haploid number is essential so that fertilization restores the full diploid number rather than doubling it each generation. Errors in this halving can cause chromosomal disorders such as Down syndrome.

26. D — Fertilization combines 23 chromosomes from the egg with 23 chromosomes from the sperm, restoring the diploid number of 46 in the zygote. Each parent contributes one full set, so the offspring is genetically a mixture of both. This 23 + 23 = 46 arithmetic underlies all human inheritance.

27. C — Mitosis produces two genetically identical diploid daughter cells used for growth and repair, while meiosis produces four genetically varied haploid daughter cells used for sexual reproduction. The differences in outcome reflect their different biological roles. This distinction is foundational to genetics.

28. A — During meiosis, homologous chromosomes line up and are randomly distributed into the resulting gametes — a process called independent assortment. Combined with crossing-over and the random pairing of gametes at fertilization, this generates enormous genetic variation among offspring. Sexual reproduction therefore produces highly varied progeny from the same two parents.

29. B — Homologous chromosomes are paired chromosomes — one inherited from each parent — that carry genes for the same traits at the same positions. They pair up during meiosis and exchange segments via crossing-over. Sister chromatids, by contrast, are the two identical copies produced when a single chromosome replicates.

30. C — Geographic isolation is the separation of populations by a physical barrier such as a river, mountain range, or stretch of ocean, preventing gene flow between them. It is the most common starting condition for speciation. Without barriers to gene flow, populations tend to remain a single interbreeding species.

31. D — The biological species concept defines a species as a group of populations whose members can interbreed and produce fertile offspring. When two populations have diverged enough that interbreeding is no longer possible, they have become two species. This is the standard criterion used by biologists to identify species boundaries.

32. A — A founding population of finches reached the Galápagos and then dispersed to various islands, where each isolated subpopulation adapted to local conditions. Over time, the populations diverged enough to form distinct species — a process known as adaptive radiation. Darwin's finches are the classic textbook example of this kind of speciation.

33. C — Speciation requires both isolation (so gene flow is blocked) and different selection pressures (so the populations evolve differently). Together, these conditions drive the populations apart over generations. The other options either keep the populations connected or eliminate the genetic differences needed for divergence.

34. B — In each isolated population, random mutations introduce new variations, and natural selection favors those that suit local conditions. Because the conditions differ between populations, the accumulated changes also differ. Over many generations, these independent processes produce two genetically distinct lineages.

35. D — Today's biodiversity is the product of about 3.5 billion years of speciation events building a vast branching tree of life. Each speciation event adds a new branch, while extinction prunes others. This long history is what accounts for the millions of species alive today.

36. A — The fossil record contains many examples of transitional forms — fossils with mixed features connecting earlier and later groups (such as *Tiktaalik* between fish and tetrapods, or *Archaeopteryx* between reptiles and birds). These intermediates are direct evidence that one form gave rise to another. Such fossils are exactly what evolutionary theory predicts.

37. B — A keystone species' importance to ecosystem structure is out of proportion to its biomass or population size. The collapse of kelp forests when sea otters were removed showed that this one predator's role was disproportionately large. The keystone concept helps conservation managers identify which species most deserve protection.

38. C — Without sea otters to control them, sea urchin numbers grew sharply, and the urchins overgrazed the kelp. The kelp forest collapsed into a depleted "urchin barren," dramatically reducing habitat for many other species. This top-down cascade is a textbook example of how predators shape ecosystems.

39. D — Predation is a relationship in which one organism (the predator) consumes another (the prey). Sea otters eat sea urchins, fitting this definition exactly. Predators often play disproportionately large roles in shaping community structure, as the otter–urchin–kelp system demonstrates.

40. A — Returning sea otters reduced urchin numbers, releasing the kelp from heavy grazing. Without that pressure, kelp could grow back and rebuild the forest structure. The same predator–prey logic that caused the collapse also drove the recovery.

41. B — A healthy kelp forest provides food, shelter, and nursery habitat for many species, from fish and crabs to seabirds. Losing kelp through the otter–urchin cascade therefore reduces populations across the community, including species with no direct connection to otters or urchins. This is why protecting keystone species often protects whole ecosystems.

42. C — Acid rain has a pH below 5.6, the slightly acidic baseline of normal rainwater. Lower pH means greater acidity. Acid rain values in heavily polluted regions have been recorded as low as pH 4 or even lower.

43. A — Sulfur dioxide and nitrogen oxides released when fossil fuels burn are the main precursors of acid rain. In the atmosphere they react with water and oxygen to form sulfuric and nitric acid, which fall as acidic precipitation. Power plants, vehicles, and industrial facilities are the primary sources.

44. D — As lake water becomes more acidic, fish eggs and young fish are damaged or killed, and other aquatic organisms (such as some invertebrates) also decline. Acidification can ultimately render entire lakes nearly lifeless. This effect has devastated lakes in regions like the Adirondacks and parts of Scandinavia.

45. B — Reducing emissions of SO2 and NOx — through scrubbers in power plants, catalytic converters in cars, and other pollution-control technologies — is the only effective way to limit acid rain. Taller smokestacks merely shift the problem downwind, while continued unrestricted emissions worsen it. Such regulations have substantially reduced acid rain in North America and Europe since the 1990s.

46. C — A zygote is formed when a sperm cell fuses with an egg cell during fertilization. The resulting single cell contains a complete diploid set of chromosomes, half from each parent. This is the first cell of the new individual.

47. A — Following fertilization, the zygote undergoes repeated rounds of mitosis, producing genetically identical daughter cells that go on to form all tissues of the body. Meiosis occurs only in the formation of gametes, not in the growth of an embryo. This is why all of an individual's body cells share the same DNA.

48. D — The placenta is a temporary organ where fetal blood (in capillaries) flows close to maternal blood (in pools), separated by a thin barrier. Across this barrier, oxygen and nutrients pass from mother to fetus,

while CO2 and other wastes pass back. Without the placenta, fetal life inside the uterus would be impossible.

49. C — Maternal and fetal blood do not actually mix; instead, they exchange materials by diffusion across thin placental membranes. Keeping the two circulations separate prevents immediate mismatches (such as blood-type incompatibility) from harming the fetus. The placenta is therefore both a barrier and a bridge.

50. B — By convention, the developing organism is called an embryo through the first eight weeks of pregnancy, during which the basic tissues and organ systems form. From the ninth week until birth, it is called a fetus, a period of growth and maturation. This terminology is standard in medicine and developmental biology.