PRACTICE EXAM 37 — QUESTIONS 1–50

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.

The cell membrane is a selectively permeable barrier composed primarily of a phospholipid bilayer with embedded proteins. Each phospholipid molecule has a hydrophilic ("water-loving") head that faces water on the outside and inside of the cell, and two hydrophobic ("water-fearing") fatty acid tails that point inward and form the membrane's core. Small nonpolar molecules such as oxygen and carbon dioxide pass through the bilayer easily, while large or charged molecules generally require protein channels or carriers to cross. The fluid-mosaic model describes the membrane as a "sea" of phospholipids in which various proteins float and move.

1. The cell membrane is best described as:

A. A phospholipid bilayer with embedded proteins, often modeled as a fluid mosaic
B. A solid layer of protein molecules tightly packed together to block everything
C. A single layer of carbohydrate chains attached to one another in a fixed pattern
D. A nucleic acid film that controls all entry and exit of materials from the cell

2. Phospholipids form a bilayer in water because:

A. Their fatty acid tails are strongly attracted to water on each side of the membrane
B. Their phosphate heads repel each other and create a single layer arrangement instead
C. Their hydrophilic heads face outward toward water while their hydrophobic tails face inward
D. The phospholipid molecules are positively charged and align with negative water molecules

3. Oxygen and carbon dioxide can cross the cell membrane easily because they are:

A. Large polar molecules that fit through specialized water channels in the membrane
B. Small nonpolar molecules that can pass directly through the lipid bilayer of the cell

C. Charged ions that are pulled across the membrane by the electrical attraction of proteins
D. Macromolecules that the cell takes in by bulk transport processes like endocytosis

4. The term "selectively permeable" means that the cell membrane:

A. Allows all substances to pass through with equal ease at all times of the day
B. Blocks all substances from entering or leaving the cell under normal conditions
C. Only allows water molecules to cross while blocking every other type of molecule
D. Allows some substances to cross while restricting or blocking others from passing

5. Large or charged molecules such as glucose and ions usually cross the cell membrane through:

A. The lipid bilayer itself, because all molecules can pass directly through the fatty acid tails
B. Small breaks in the membrane that form temporarily on the membrane's outer surface
C. Membrane proteins that act as channels or carriers for specific molecules
D. The nucleus, which sends every molecule directly into and out of the cell

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

Cells regulate enzyme activity in many ways. One common mechanism is feedback inhibition, in which the final product of a metabolic pathway binds to an earlier enzyme in the pathway and slows its activity. This prevents the cell from wasting resources by making more of a product when enough is already present. For example, in the production of the amino acid isoleucine, the final product (isoleucine itself) binds to the first enzyme in the pathway and reduces its activity. When isoleucine levels drop, the enzyme becomes active again and synthesis resumes. Feedback inhibition is an example of homeostasis at the cellular level.

6. Feedback inhibition occurs when:

A. The final product of a pathway slows the activity of an earlier enzyme in the same pathway
B. The substrate of an enzyme stops binding because the temperature has changed too quickly
C. A foreign chemical permanently destroys all of the enzymes in the metabolic pathway
D. The cell suddenly stops producing all of its enzymes in response to environmental cues

7. Feedback inhibition benefits the cell because it:

A. Forces the cell to produce as much product as possible regardless of the cell's actual need
B. Eliminates the need for enzymes in any of the cell's many metabolic pathways
C. Speeds up reactions even when the product is already present in excess in the cell
D. Conserves resources by preventing overproduction of a substance that is already abundant

8. When isoleucine levels in a cell drop:

A. The enzyme remains permanently inactive because it has been destroyed by binding
B. The enzyme becomes active again and isoleucine synthesis resumes in the cell
C. The cell can no longer produce isoleucine at any rate even if needed for growth
D. The other enzymes in the pathway must replace the first enzyme through new synthesis

9. Feedback inhibition is considered an example of homeostasis because it:

A. Speeds up cellular reactions to maintain growth no matter what conditions exist in the cell
B. Permits the cell to grow indefinitely without responding to its internal conditions at all
C. Helps the cell maintain a stable internal level of a needed product over time
D. Stops the cell from carrying out any further reactions once a product is present

10. A mutation in the first enzyme that prevents isoleucine from binding to it would most likely cause:

A. Overproduction of isoleucine, because feedback control of the pathway is lost
B. A complete halt in the production of isoleucine in the cell at all times
C. An immediate increase in the body's protein synthesis rate to match isoleucine levels
D. No change in isoleucine production because feedback inhibition is not really important

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

Transpiration is the loss of water vapor from plant leaves, mainly through small pores called stomata. Although it is sometimes seen as a "cost" because water is lost, transpiration plays several useful roles: it pulls water up the plant from the roots through the xylem (the "transpirational pull"), it cools the leaves by evaporation, and it delivers dissolved minerals from the soil to the leaves where they are used. The amount of transpiration depends on environmental conditions such as temperature, humidity, wind, and light intensity. Plants in dry environments often have adaptations such as a thick waxy cuticle, fewer stomata, or stomata located in sunken pits, all of which reduce water loss.

11. Transpiration is best defined as:

A. The uptake of water from the soil by the root hairs of a plant by osmosis
B. The transport of sugars from the leaves to other parts of the plant in the phloem
C. The breakdown of glucose to release energy in the cells of a plant's leaves and stems
D. The loss of water vapor from a plant, mainly through stomata in the leaves

12. Water moves upward through a plant primarily because:

A. The plant's stomata actively pump water upward against the pull of gravity at all times
B. The evaporation of water from the leaves creates a pull that draws water up the xylem
C. The roots push water upward by using ATP to actively transport water molecules
D. Water moves upward by random diffusion regardless of the conditions surrounding the plant

13. Which environmental condition would most increase the rate of transpiration?

A. A hot, dry, windy day with bright sunlight and low humidity in the surrounding air
B. A cool, humid, still day with overcast skies and a very high humidity level
C. A cold, snowy day with the plant covered in a thick layer of snow and ice
D. A warm, humid, still night with no wind and a very high humidity reading

14. A thick waxy cuticle on the leaves of a desert plant is an adaptation that:

A. Increases the rate of photosynthesis on hot sunny days in the desert biome
B. Allows the plant to absorb more water through the upper surfaces of its leaves
C. Reduces the loss of water through evaporation from the leaf surface
D. Helps the plant attract more pollinating insects to its flowers in the dry desert

15. In addition to water, transpiration helps move which other substance up the plant?

A. Sugars produced by photosynthesis traveling from the roots up to the leaves of the plant
B. Dissolved minerals absorbed from the soil traveling from the roots up to the leaves
C. Oxygen produced during respiration in the roots moving from the roots up to the leaves
D. Carbon dioxide absorbed at the roots traveling up to the leaves for photosynthesis

Base your answers to questions 16 through 20 on the information below and on your knowledge of biology.

Cellular respiration is the process by which cells break down glucose to release usable energy in the form of ATP. The overall equation for aerobic cellular respiration is:

$$\mathbf{C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + ATP\ (energy)}$$

In this reaction, glucose is combined with oxygen, and carbon dioxide, water, and ATP are produced. Cellular respiration occurs in three main stages: glycolysis (in the cytoplasm), the Krebs cycle (in the mitochondrial matrix), and the electron transport chain (across the inner mitochondrial membrane). Aerobic respiration is far more efficient than anaerobic respiration: it produces about 36 ATP per glucose molecule, compared to only 2 ATP from anaerobic respiration.

16. In aerobic cellular respiration, glucose is combined with which molecule?

A. Carbon dioxide, which is broken down to release the energy stored in its bonds
B. Nitrogen gas, which the cell uses to release energy when respiration begins
C. Water, which breaks the bonds of glucose to release the stored chemical energy
D. Oxygen, which is required for the complete breakdown of glucose into CO_2 and H_2O

17. The products of aerobic cellular respiration are:

A. Carbon dioxide, water, and ATP (the energy used by the cell for many processes)
B. Glucose, oxygen, and water (the same materials used as inputs at the start)
C. Nitrogen, hydrogen, and ATP (the elements making up amino acids in the cell)
D. Chlorophyll, glucose, and oxygen (the materials made during photosynthesis)

18. Aerobic cellular respiration produces approximately how many ATP molecules per glucose molecule?

A. Two ATP, the same number produced by anaerobic respiration in muscle cells
B. Six ATP, one for each carbon atom of the original glucose molecule
C. Thirty-six ATP, much more than the two produced by anaerobic respiration alone
D. Three hundred ATP, far more than is needed for normal cell function each day

19. The Krebs cycle and the electron transport chain occur in the:

A. Cytoplasm of the cell, outside the mitochondria, where glycolysis also occurs
B. Mitochondria, which are sometimes called the "powerhouses" of the cell
C. Nucleus of the cell, alongside DNA replication and the regulation of genes
D. Ribosomes, which are also responsible for the synthesis of cellular proteins

20. Why is aerobic respiration more important than anaerobic respiration for most large multicellular organisms?

A. Anaerobic respiration releases harmful chemicals that damage the surrounding tissues quickly
B. Anaerobic respiration uses oxygen, which is in short supply in the bodies of large animals
C. Aerobic respiration produces glucose, which large multicellular organisms need to grow well
D. Aerobic respiration yields far more ATP per glucose, meeting the high energy demands of large bodies

Base your answers to questions 21 through 25 on the information below and on your knowledge of biology.

Protein synthesis begins with transcription, the process in which the information in a gene is copied from DNA into a molecule of messenger RNA (mRNA). Transcription occurs in the nucleus of a eukaryotic cell. The enzyme RNA polymerase reads one strand of DNA and assembles a complementary RNA strand by adding RNA nucleotides one at a time. In RNA, the base uracil (U) pairs with adenine instead of thymine, while the other base pairings are the same as in DNA. Once the mRNA is complete, it leaves the nucleus through a nuclear pore and travels to a ribosome in the cytoplasm, where its message is translated into a protein.

21. Transcription is the process of:

A. Copying the information in a gene from DNA into a molecule of messenger RNA
B. Translating the information from a molecule of mRNA into a chain of amino acids
C. Duplicating the entire DNA molecule before the cell divides into two daughter cells
D. Breaking down old proteins into amino acids so they can be recycled by the cell

22. In a eukaryotic cell, transcription occurs in the:

A. Cytoplasm, the fluid part of the cell where ribosomes carry out other functions
B. Mitochondrion, where energy is produced for the cell's various metabolic processes
C. Nucleus, which is the membrane-bound organelle that contains the cell's DNA
D. Ribosome, which is the small organelle responsible for the synthesis of all proteins

23. In RNA, the base that pairs with adenine is:

A. Thymine, the same base that pairs with adenine in molecules of DNA
B. Uracil, which replaces thymine and pairs with adenine in molecules of RNA
C. Guanine, which pairs with cytosine in both DNA and RNA molecules of all kinds
D. Cytosine, which pairs with guanine in both DNA and RNA molecules of all kinds

24. After transcription is complete, the mRNA molecule:

A. Remains permanently in the nucleus where it was first produced by transcription
B. Is broken down immediately back into individual nucleotides before any use is made of it
C. Joins with two strands of DNA to form a triple-stranded molecule in the nucleus of the cell
D. Travels out through a nuclear pore and moves to a ribosome in the cytoplasm

25. The enzyme responsible for assembling mRNA during transcription is:

A. RNA polymerase, which reads the DNA template and adds RNA nucleotides one at a time
B. DNA polymerase, which copies entire DNA molecules during the process of replication
C. Helicase, which breaks down ribosomes after the process of translation is complete
D. Lipase, which breaks down fats in the digestive system rather than working on RNA molecules

Base your answers to questions 26 through 30 on the information below and on your knowledge of biology.

Some genetic disorders are carried on the X chromosome and follow a pattern of inheritance called "X-linked recessive." An example is Duchenne muscular dystrophy (DMD), which causes progressive muscle weakness. Because males have only one X chromosome (XY), a single copy of the recessive allele on their X chromosome is enough to cause the disorder. Females have two X chromosomes (XX), so they typically need two copies of the recessive allele to show the disorder; a female with one copy is a "carrier" who usually does not show symptoms but can pass the allele to her children. Let X^N represent the dominant normal allele and X^d represent the recessive Duchenne allele.

26. A male's possible genotypes for the Duchenne gene are:

A. X^N X^N (normal female) or X^N X^d (carrier female), but never a male genotype
B. X^N X^d (carrier) or X^d X^d (affected) — males come in two genotype categories only
C. X^N Y (normal male) or X^d Y (affected male) — only one X allele is present in males
D. Y Y (homozygous male) or X X (homozygous female) — there are no other possibilities

27. A female who is a carrier of Duchenne has the genotype:

A. X^N X^N, with two dominant normal alleles for the Duchenne gene in her cells
B. X^N X^d, with one dominant normal allele and one recessive Duchenne allele
C. X^d X^d, with two recessive Duchenne alleles which always show the disorder
D. X^d Y, with a single recessive Duchenne allele on her one X chromosome

28. A carrier mother (X^N X^d) has children with a normal father (X^N Y). The probability that any one of their sons will be affected with Duchenne is:

A. 50%, because each son inherits one of the mother's two X chromosomes with equal odds
B. 25%, the same probability seen for an autosomal recessive disorder with carrier parents
C. 75%, because three of the four genotype combinations result in the affected phenotype
D. 100%, because every son in this cross will inherit the recessive Duchenne allele from his mother

29. In the same cross (X^N X^d mother × X^N Y father), what is the probability that any one of their daughters will be affected with Duchenne?

A. 100%, because every daughter will inherit two recessive Duchenne alleles in this cross
B. 75%, because three of the four daughter genotypes are homozygous recessive in the cross
C. 50%, the same probability that applies to the sons in this particular cross
D. 0%, because the father contributes a normal X^N allele to every one of his daughters

30. X-linked recessive disorders such as Duchenne muscular dystrophy are more common in males than in females because:

A. Males have a stronger immune response that weakens the recessive Duchenne allele
B. Females cannot inherit the X-linked allele due to their two X chromosomes preventing it

C. Males have only one X chromosome, so a single recessive allele is enough to cause the disorder
D. Females always inherit the allele from their fathers but never from their mothers

Base your answers to questions 31 through 35 on the information below and on your knowledge of biology.

Evolutionary biologists draw on many independent lines of evidence to reconstruct the history of life and to demonstrate that species share common ancestors. These lines include the fossil record, comparative anatomy (homologous structures and vestigial structures), comparative embryology (early embryos of related species look strikingly similar), biogeography (the geographic distribution of species), and molecular evidence (comparisons of DNA and protein sequences). Of these, molecular evidence has become especially powerful: species that are more closely related share more similar DNA and protein sequences than species that are more distantly related.

31. Two species that share a more recent common ancestor would be expected to have:

A. Completely identical DNA sequences in every gene of their respective genomes
B. More similar DNA and protein sequences than species sharing only a distant common ancestor
C. Completely different DNA sequences with no shared nucleotides at any position in the genome
D. Identical fossil records and identical patterns of geographic distribution on the planet

32. The early embryos of many vertebrate species (such as fish, chickens, and humans) look strikingly similar to each other. This similarity is best explained by:

A. Coincidence, since the species have no actual evolutionary relationship to each other at all
B. Convergent evolution from completely different ancestors in independent lines of descent
C. The fact that all vertebrate species evolved within the past few thousand years on Earth
D. Descent from a common ancestor whose embryonic development is reflected in each lineage

33. Homologous structures, such as the forelimbs of humans, whales, and bats, are:

A. Structures with similar underlying bone arrangement, inherited from a common ancestor
B. Structures with completely unrelated functions and completely unrelated underlying anatomy
C. Structures found only in vertebrates that swim through the water as part of their life
D. Identical structures with no differences between any of the species that possess them

34. Vestigial structures, such as the hip bones of whales, provide evidence of evolution because they:

A. Are completely useless and unrelated to the structure of any ancestral species at all
B. Show that whales were created exactly as they are today without any ancestral history
C. Reflect structures that were functional in ancestral species but have been reduced over time
D. Demonstrate that whales are most closely related to fish among modern vertebrates today

35. Comparing the DNA sequences of two species is a useful method for determining their evolutionary relatedness because:

A. Two unrelated species are guaranteed to have identical DNA sequences at every position
B. DNA changes randomly at exactly the same rate in every species regardless of their lineage
C. DNA sequences are completely unrelated to the inherited evolutionary history of species
D. Closely related species share more similar DNA sequences than do distantly related species

Base your answers to questions 36 through 40 on the information below and on your knowledge of biology.

A population's growth is shaped by its environment. The maximum population size that a particular environment can support over time is called its carrying capacity (often denoted K). Factors that limit population growth fall into two main categories. Density-dependent factors (such as food availability, disease, and competition) have stronger effects as the population becomes larger and more crowded. Density-independent factors (such as floods, fires, droughts, and severe storms) affect populations regardless of their size. When a population approaches carrying capacity, growth slows; if it exceeds K, the population typically declines back toward K.

36. The carrying capacity of an environment is best described as:

A. The maximum number of all species combined that can live anywhere on the planet
B. The maximum population size of a particular species that an environment can support over time
C. The exact number of individuals of a species living in an environment at the present moment
D. The smallest population size of a species that can still avoid eventual extinction

37. Which of the following is a density-dependent limiting factor?

A. Competition for food among members of the population that grows worse as the population grows
B. A severe winter storm that kills many members of the population regardless of size
C. A flood that destroys an entire forest including all of the species that live within it
D. A volcanic eruption that wipes out populations of many species over a large area

38. Which of the following is a density-independent limiting factor?

A. The spread of an infectious disease, which becomes faster as the population becomes more crowded
B. Competition for nesting sites, which intensifies as the population approaches carrying capacity
C. Predation, which often increases as prey populations become larger and easier to find
D. A drought, which reduces water availability whether the population is large or small

39. When a population's size exceeds the carrying capacity of its environment, the population:

A. Continues to grow rapidly because plenty of resources remain available for all individuals
B. Stabilizes at the new larger size and remains at that level indefinitely afterward
C. Typically declines back toward the carrying capacity as resources become insufficient
D. Doubles within a single generation due to the abundant resources of the larger habitat

40. Density-dependent factors typically have stronger effects as a population grows because:

A. Crowding makes individuals stronger and less affected by environmental conditions
B. Crowded conditions make competition, disease spread, and similar effects more intense
C. Larger populations always have access to more resources than smaller populations do
D. Larger populations are always immune to the effects of any environmental factor

Base your answers to questions 41 through 45 on the information below and on your knowledge of biology.

Tropical rainforests, especially the Amazon rainforest in South America, contain some of the highest biodiversity on Earth. They are also the site of substantial deforestation, the clearing of forest for agriculture, ranching, logging, and development. Deforestation reduces biodiversity by destroying habitat, contributes to climate change by releasing stored carbon as CO_2 (and by removing trees that would otherwise absorb CO_2), and disrupts the local water cycle because forests recycle large amounts of water through transpiration. Globally, deforestation is considered one of the most serious environmental problems facing humanity today.

41. The clearing of forests for agriculture, ranching, or development is called:

A. Deforestation, the removal of forest cover from a region by human activity
B. Reforestation, the planting of new trees to replace forest that has been cleared
C. Afforestation, the planting of forests in places where there were none before
D. Photosynthesis, the process by which forests capture energy from sunlight to grow

42. Deforestation contributes to climate change in part by:

A. Increasing the rate of photosynthesis worldwide, raising oxygen levels in the air
B. Cooling the planet by removing trees that would otherwise absorb sunlight as it falls
C. Removing carbon dioxide from the atmosphere at a much faster rate than before
D. Releasing stored carbon as CO_2 and removing trees that would absorb additional CO_2

43. The Amazon rainforest is often described as a biodiversity "hotspot" because it:

A. Has very few species, all of which are restricted to small geographic ranges in the forest
B. Has high temperatures that prevent most organisms from living in the forest at all

C. Contains an extraordinarily high number of species, many of which are found nowhere else
D. Has been completely studied so that every species in the forest is already well known

44. Deforestation can disrupt the local water cycle because:

A. Trees prevent rainfall from occurring in any region where forests are still present
B. Forests release large amounts of water vapor through transpiration, contributing to local rainfall
C. Trees increase the salinity of fresh water in nearby streams and rivers each year
D. Forests reflect sunlight back into space and prevent water from evaporating to form clouds

45. The main reason deforestation reduces biodiversity is that it:

A. Destroys the habitat of many species, leaving them no place to live and reproduce
B. Introduces too many new species into the forest at one time for the ecosystem to handle
C. Removes too many predators, allowing prey populations to grow uncontrollably in the forest
D. Improves living conditions for most rainforest species by opening up new space

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

The human digestive system breaks down food into small molecules that can be absorbed into the bloodstream and used by cells. Mechanical digestion (chewing, churning) physically breaks food into smaller pieces; chemical digestion uses enzymes to break the chemical bonds of food molecules. Different parts of the digestive tract have specialized roles. The mouth begins both mechanical and chemical digestion (with the enzyme amylase breaking down starch). The stomach uses acid and the enzyme pepsin to begin protein digestion. The small intestine, with help from the pancreas and liver, completes most chemical digestion and absorbs the resulting nutrients into the bloodstream. The large intestine absorbs water and forms feces from the remaining waste.

46. Chemical digestion in the mouth begins with the enzyme:

A. Pepsin, which breaks down proteins in the strongly acidic environment of the stomach
B. Lipase, which breaks down fats in the upper portion of the small intestine of the body
C. Amylase, which is found in saliva and begins the breakdown of starch into sugars
D. Cellulase, an enzyme that humans do not produce, which would break down cellulose

47. The function of the stomach is mainly to:

A. Absorb most of the nutrients from food into the bloodstream of the body
B. Produce bile, which helps to emulsify fats in the small intestine for digestion
C. Absorb water from the remaining waste before the feces are eliminated by the body
D. Begin the chemical digestion of proteins using stomach acid and the enzyme pepsin

48. Most chemical digestion and most nutrient absorption take place in the:

A. Mouth, where chewing breaks food into smaller pieces before it is swallowed
B. Small intestine, which receives digestive secretions from the pancreas and liver
C. Stomach, where strongly acidic conditions break apart all of the food molecules
D. Large intestine, which receives partly digested food from the small intestine for further work

49. The large intestine's main function is to:

A. Absorb water from the remaining waste and form feces for elimination from the body
B. Produce most of the digestive enzymes the body uses to break down nutrients in food
C. Begin the chemical digestion of proteins using pepsin and stomach acid in the body
D. Absorb most of the nutrients (sugars, amino acids, and fatty acids) into the bloodstream

50. Bile, which helps in the digestion of fats, is produced by the:

A. Pancreas, which also produces several enzymes that break down food in the small intestine
B. Stomach, the muscular organ where protein digestion first begins in the body
C. Liver, the large organ that produces bile which is then stored in the gallbladder
D. Small intestine, the long tube where most chemical digestion is completed in the body

PRACTICE EXAM 37 — EXPLAINED ANSWER KEY (Q1–Q50)

1. A — The fluid-mosaic model describes the cell membrane as a phospholipid bilayer with embedded proteins that can move laterally within the bilayer. Proteins act as channels, pumps, and receptors, while the lipid bilayer provides the basic barrier. This combined structure is what enables selective permeability.

2. C — Phospholipids are amphipathic: the phosphate "head" is hydrophilic and the fatty-acid tails are hydrophobic. In water, this drives the heads to face the watery environment on either side while the tails point inward, forming the bilayer's nonpolar interior. The arrangement is energetically the most stable configuration.

3. B — Small, uncharged, nonpolar molecules such as O_2 and CO_2 dissolve readily in lipids and pass straight through the bilayer's hydrophobic core. No protein channel is needed for these molecules. This is why respiratory gases exchange so easily between cells and their environment.

4. D — "Selectively permeable" means the membrane lets some substances cross while restricting others, based on size, charge, and polarity. This selectivity is what allows the cell to maintain a different internal composition from its surroundings. Without selectivity, the cell could not control its own chemistry.

5. C — Polar molecules like glucose and charged ions cannot cross the hydrophobic core of the bilayer on their own. They move through specific transport proteins — channels for ions and carriers for molecules like glucose. The specificity of these proteins is what makes the membrane selective.

6. A — Feedback inhibition is the regulation of a metabolic pathway by its own end product, which binds to an earlier enzyme and slows its activity. This is a classic negative-feedback loop that prevents wasteful overproduction. The isoleucine pathway is the textbook example.

7. D — When enough product is present, feedback inhibition switches off further synthesis so the cell does not waste substrates and energy producing more. This makes metabolic pathways self-regulating. The mechanism is one of the simplest examples of cellular efficiency.

8. B — Feedback inhibition is reversible: as the product is used up and its concentration drops, it dissociates from the enzyme and activity resumes. This is what makes the system responsive to changing cellular need. Synthesis automatically scales up when more product is required.

9. C — Homeostasis is the maintenance of a stable internal state. By raising or lowering its output in response to product levels, feedback inhibition holds the product concentration within a steady range. Cellular homeostasis depends on many such feedback loops.

10. A — If the regulatory enzyme can no longer bind isoleucine, the off-switch is broken and synthesis continues even when isoleucine levels are high. The cell would overproduce isoleucine and waste resources doing so. Loss-of-feedback mutations are a recognized cause of metabolic overproduction in microbes.

11. D — Transpiration is specifically the loss of water vapor from a plant, mostly through stomata in the leaves. It differs from root uptake (osmosis), sugar transport (translocation in phloem), and cellular respiration. Understanding the term is foundational to plant physiology.

12. B — Water evaporates from leaf surfaces, creating tension that pulls a continuous column of water up the xylem all the way from the roots. This is the cohesion-tension or "transpirational pull" mechanism. No ATP is required because the energy comes ultimately from the sun, which drives evaporation.

13. A — Heat speeds evaporation, low humidity steepens the water-vapor gradient out of the leaf, wind sweeps away saturated air at the leaf surface, and sunlight drives stomatal opening. All four conditions act in the same direction to maximize transpiration. The opposite (cool, humid, still, dark) minimizes it.

14. C — A thick waxy cuticle creates a physical barrier that limits water loss through the leaf surface. This is a key xerophyte (dry-environment) adaptation. The cuticle does not affect pollination, leaf water uptake, or photosynthetic rate directly.

15. B — Minerals dissolved in soil water are carried upward with the water column in the xylem during transpiration. This is how essential nutrients such as nitrate, phosphate, and potassium reach the leaves. Sugars, by contrast, are transported in the phloem.

16. D — Oxygen is the reactant combined with glucose in aerobic respiration, as shown in the equation $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + ATP$. Oxygen serves as the final electron acceptor in the electron transport chain. Without oxygen, the chain backs up and aerobic respiration cannot proceed.

17. A — Aerobic respiration produces carbon dioxide (exhaled), water (incorporated into body fluids), and ATP (the cell's usable energy currency). These are the three outputs shown on the right side of the balanced equation. The carbon atoms of glucose end up in CO_2 after passing through the Krebs cycle.

18. C — Aerobic respiration produces roughly 36 ATP molecules per glucose, far more than the 2 ATP from glycolysis or anaerobic respiration alone. Most of the yield comes from oxidative phosphorylation on the inner mitochondrial membrane. This high efficiency is why oxygen is so important to large organisms.

19. B — The Krebs cycle occurs in the mitochondrial matrix and the electron transport chain spans the inner mitochondrial membrane. Glycolysis is the only stage that takes place in the cytoplasm. The concentration of ATP-producing machinery in mitochondria is why they are called the "powerhouses" of the cell.

20. D — Large multicellular organisms have enormous energy needs to support tissue maintenance, locomotion, and homeostasis. The roughly 18-fold higher ATP yield of aerobic respiration is essential to meet those demands. This is why obligate anaerobes are nearly all small, single-celled organisms.

21. A — Transcription is the copying of a gene's DNA sequence into a complementary mRNA strand. It precedes translation, which converts the mRNA message into a protein. Both processes together constitute protein synthesis.

22. C — In eukaryotes, transcription happens in the nucleus because that is where the DNA resides. The mRNA must then leave the nucleus before translation can begin. In prokaryotes, which have no nucleus, transcription and translation can occur simultaneously in the cytoplasm.

23. B — RNA contains uracil in place of thymine, and uracil pairs with adenine through two hydrogen bonds just as thymine would. The other RNA base pairings (G–C) are the same as in DNA. This substitution is what distinguishes RNA composition from DNA composition.

24. D — Once transcribed and processed, the mRNA exits the nucleus through a nuclear pore and travels to a ribosome in the cytoplasm. There, the ribosome reads the codons and assembles the corresponding amino acid chain. This export step is unique to eukaryotic cells.

25. A — RNA polymerase binds to the promoter region of a gene, unwinds the DNA, and synthesizes mRNA by adding complementary RNA nucleotides one at a time. It is the central enzyme of transcription. DNA polymerase, by contrast, copies DNA during replication.

26. C — Males have an X and a Y chromosome, so they carry only one allele for any X-linked gene. The two possible male genotypes are therefore X^N Y (normal) and X^d Y (affected). The other answer options confuse male and female genotypes or include impossible combinations.

27. B — A carrier female has one normal allele and one Duchenne allele on her two X chromosomes (X^N X^d). She typically does not show the disorder because the dominant normal allele masks the recessive one. Carriers can still pass the recessive allele to their children.

28. A — The mother contributes X^N or X^d to her son with equal 50% probability; the father contributes the Y. Half the sons therefore receive X^d Y (affected) and half receive X^N Y (unaffected). This 50% risk to sons is characteristic of carrier-mother pedigrees.

29. D — Every daughter receives the father's X chromosome, which in this cross is X^N. None can be homozygous X^d X^d, so the probability of an affected daughter is zero. Daughters in this cross are either X^N X^N or X^N X^d carriers.

30. C — Because males have only one X chromosome, a single recessive allele on that X has no dominant partner to mask it, and the disorder is expressed. Females need two copies of the recessive allele to be affected, which is much less common. This is the classic explanation for the male excess in X-linked recessive disorders.

31. B — DNA accumulates mutations over time, so species that diverged more recently have had less time to accumulate sequence differences. Their DNA and proteins are therefore more similar than those of distantly related species. This principle underlies the use of molecular phylogenetics.

32. D — Similar embryonic stages in vertebrates reflect shared developmental programs inherited from a common vertebrate ancestor. Features such as pharyngeal arches appear in fish, chicken, and human embryos because they were present in that ancestor. This is one of Darwin's classic lines of evidence.

33. A — Homologous structures share an underlying pattern (such as the one-bone-two-bones-many-bones-digits arrangement in tetrapod forelimbs) because they are inherited from a common ancestor. Their functions may differ — grasping, swimming, flying — but the bone plan is conserved. Homologies are powerful evidence for descent with modification.

34. C — Vestigial structures are reduced or nonfunctional versions of features that were fully functional in ancestral species. Whales' tiny internal hip bones reflect descent from land-dwelling mammals with hind limbs. Their persistence makes sense only in light of evolutionary history.

35. D — Molecular phylogenies are built on the principle that closely related species share more similar DNA sequences because less time has passed for mutations to accumulate. This makes DNA comparison a powerful tool for inferring relationships. Modern taxonomy increasingly relies on genetic data.

36. B — Carrying capacity (K) is the maximum population of a particular species that an environment can sustain over the long term, given its available resources. It is not the current population, the smallest viable population, or a multi-species total. The concept is central to population ecology.

37. A — Density-dependent factors have stronger effects as populations grow. Competition for food intensifies as more individuals share a fixed resource pool, making it a classic density-dependent factor. Disease spread and competition for mates work similarly.

38. D — A drought reduces water availability regardless of how many individuals are present, so its effect does not depend on density. Density-independent factors are generally abiotic events such as floods, fires, droughts, and severe weather. They can devastate populations of any size.

39. C — When a population exceeds K, resources are insufficient to support all individuals, and death rates rise (or birth rates fall) until numbers drop back toward K. This produces the characteristic oscillation around carrying capacity. The decline is sometimes called an "overshoot-and-crash" pattern.

40. B — As populations grow, individuals are crowded closer together. Crowding intensifies competition for food and space, makes contagious disease spread more easily, and increases the visibility of prey to predators. These intensifying effects are the very definition of density-dependent.

41. A — Deforestation specifically refers to the clearing of forests, generally for agricultural, ranching, logging, or developmental purposes. Reforestation and afforestation describe the planting of trees rather than removing them. The term is widely used in environmental science and policy.

42. D — Trees store carbon in their wood; clearing or burning them releases that carbon to the atmosphere as CO_2. At the same time, removing trees eliminates a major carbon sink. Both effects raise atmospheric CO_2 and drive climate change.

43. C — Biodiversity "hotspots" are regions with exceptionally high species richness, especially of endemic species found nowhere else. The Amazon's combination of vast area, warm climate, and high rainfall supports this extraordinary biodiversity. Many species there remain undescribed by science.

44. B — Forests transpire enormous volumes of water vapor, which feeds back into the atmosphere and contributes to local cloud formation and rainfall. Removing the trees reduces this moisture input and can cause local drying. The Amazon, in particular, generates much of its own rainfall this way.

45. A — The leading driver of biodiversity loss is habitat destruction, and deforestation is the most direct form of habitat destruction in forest ecosystems. When the forest is gone, the species that depended on it lose their homes, food, and breeding sites. Many cannot survive elsewhere.

46. C — Salivary amylase begins digesting starch into smaller sugars (such as maltose) as soon as food enters the mouth. Pepsin, lipase, and other enzymes act later in the digestive tract. The early start of carbohydrate digestion is why chewing crackers eventually tastes sweet.

47. D — The stomach secretes hydrochloric acid (creating an environment of ~pH 2) and the enzyme pepsin, which together begin protein digestion. The stomach also mechanically churns food. Most absorption, however, occurs further downstream in the small intestine.

48. B — The small intestine is where pancreatic and intestinal enzymes complete the chemical breakdown of carbohydrates, proteins, and fats, and where the resulting nutrients are absorbed across villi into the bloodstream. Its enormous surface area, created by villi and microvilli, makes it the absorption powerhouse. The large intestine handles mostly water absorption, not nutrient uptake.

49. A — The large intestine reclaims water from the indigestible material passed in from the small intestine and compacts the remainder into feces for elimination. It also harbors beneficial bacteria. Most nutrient absorption has already taken place before material reaches the colon.

50. C — The liver synthesizes bile, which is then stored and concentrated in the gallbladder before being released into the small intestine. Bile emulsifies fats so that lipase can digest them efficiently. The pancreas contributes digestive enzymes but not bile.