PRACTICE EXAM 40 — 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.

Students placed a drop of red food coloring into a beaker of water at 5°C, a beaker at 25°C (room temperature), and a beaker at 60°C. They did not stir any beaker. They timed how long it took for the dye to spread evenly throughout each beaker. Results showed: 5°C beaker — 35 minutes; 25°C beaker — 18 minutes; 60°C beaker — 6 minutes. Diffusion is the movement of molecules from an area of higher concentration to an area of lower concentration, driven by the random motion of molecules.

1. Diffusion is best defined as:

A. The active movement of molecules from low to high concentration using cellular energy
B. The movement of molecules from an area of higher concentration to an area of lower concentration
C. The bulk flow of water across a selectively permeable membrane down a concentration gradient
D. The transport of large molecules by vesicles that fuse with the cell membrane during exocytosis

2. Based on the data, what is the relationship between temperature and the rate of diffusion?

A. As temperature increases, the rate of diffusion increases because molecules move faster
B. As temperature increases, the rate of diffusion decreases because molecules become more orderly
C. Temperature has no measurable effect on the rate of diffusion of dye molecules in water
D. The rate of diffusion is highest at the lowest temperature because molecules attract each other more

3. The energy that drives diffusion comes from:

A. ATP molecules supplied by mitochondria in the cells of the surrounding organisms
B. The chemical bonds of the molecules being diffused as they are broken apart by water
C. Electrical energy that is generated by the dissolved ions in the water of the beaker
D. The kinetic energy of the moving molecules — the thermal random motion of molecules

4. If a student stirred the beaker at 25°C, the dye would mix in less than 1 minute. This shows that:

A. Diffusion stops completely whenever water is being stirred by an outside source
B. Stirring is the only process that allows dye molecules to spread through water at all
C. Stirring speeds the mixing of molecules but is not the same process as diffusion itself
D. Stirring and diffusion produce opposite results in any liquid mixture of dye and water

5. A teacher claims that diffusion in living cells happens "faster than in the beakers." A likely reason is that:

A. Living cells do not actually use diffusion because all transport requires energy in cells
B. Diffusion in cells occurs over much shorter distances than across a whole beaker of water
C. Living cells contain catalysts that speed up the diffusion of every molecule in the cell
D. Cells maintain a much lower temperature than the beakers used in the student experiment

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

A class investigated how enzyme concentration affects reaction rate. They used the enzyme catalase, which breaks down hydrogen peroxide (H_2O_2) into water and oxygen gas. Different amounts of liver homogenate (a source of catalase) were added to identical samples of hydrogen peroxide, and the rate of oxygen gas production was measured. Substrate concentration, temperature, and pH were kept constant in all trials. Results:

Trial	Catalase (drops)	O_2 produced (mL/min)
1	1	3
2	2	6
3	3	9
4	4	12
5	8	24
6	16	25
7	32	25

6. The relationship between enzyme concentration and reaction rate, between Trials 1 and 5, is best described as:

A. Inversely proportional, with more enzyme leading to a slower reaction every time
B. Random, with no clear pattern between enzyme amount and reaction rate at all
C. A bell curve, with reaction rate peaking at some intermediate value of enzyme concentration
D. Directly proportional, with reaction rate increasing in step with the amount of enzyme added

7. Between Trial 5 and Trial 7, the reaction rate stops increasing because:

A. The substrate (hydrogen peroxide) becomes the limiting factor at high enzyme concentrations
B. The enzyme becomes denatured and unable to function in any of the later trials

C. The pH of the reaction mixture changes drastically between Trial 5 and Trial 7
D. The students added a chemical inhibitor that blocked the enzymes from working at all

8. The independent variable in this experiment is the:

A. Volume of oxygen produced per minute by the catalase enzyme in the test tubes
B. Temperature, pH, and substrate concentration of the reaction mixtures used in all trials
C. Amount of catalase enzyme (number of drops of liver homogenate) added to each tube
D. Time, in minutes, that was needed for the reaction in each tube to be completed

9. Catalase is described as a "specific" enzyme because it:

A. Only works in the liver and nowhere else in the body of an organism that contains it
B. Catalyzes one particular reaction — the breakdown of hydrogen peroxide into water and oxygen
C. Functions at every pH level and every temperature without losing any activity at all
D. Can break down many different substrate molecules including starch and proteins in the cell

10. Hydrogen peroxide is a byproduct of normal cellular metabolism that can damage cells. Catalase is therefore important to organisms because it:

A. Breaks down a potentially harmful substance before it can damage the cells of the body
B. Provides the body with a source of energy from the chemical bonds of hydrogen peroxide
C. Helps the body absorb oxygen directly from the air through the cells in the liver only
D. Produces hydrogen peroxide that is then used to kill harmful bacteria in the body

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

Photosynthesis is the process by which plants, algae, and some bacteria use light energy to convert carbon dioxide and water into glucose and oxygen. The overall equation for photosynthesis is:

$$6\ CO_2 + 6\ H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

In plants, photosynthesis takes place inside chloroplasts. Chloroplasts contain a green pigment called chlorophyll that absorbs light energy, particularly in the red and blue wavelengths of the visible spectrum. The reactions of photosynthesis occur in two main stages: the light-dependent reactions, which capture light energy and produce ATP and oxygen, and the light-independent reactions (Calvin cycle), which use this energy to make glucose from CO_2.

11. The raw materials for photosynthesis are:

A. Glucose and oxygen, which are combined to release the energy stored in their bonds
B. Glucose and ATP, which are converted by the plant into oxygen and water
C. Carbon dioxide and water, which are combined using light energy to make glucose
D. Oxygen and water, which are broken down into hydrogen and oxygen by the plant

12. The products of photosynthesis are:

A. Carbon dioxide and water, which are released back into the surrounding environment
B. Carbon dioxide and oxygen, both of which are released into the surrounding air
C. Water and oxygen, which combine in the leaf to form a sugar that is stored in the cell
D. Glucose and oxygen, of which glucose stores chemical energy and oxygen is released as a byproduct

13. The green color of plants comes from:

A. The cell walls of plant cells, which are pigmented green by lignin and cellulose
B. Chlorophyll, the green pigment found in chloroplasts that absorbs light energy
C. The proteins inside the nuclei of plant cells, which absorb green wavelengths only
D. The carbon dioxide gas trapped inside the leaf, which is colored green by sunlight

14. Chlorophyll absorbs most strongly in which colors of light?

A. Red and blue light, while reflecting most of the green wavelengths back to the eye
B. Green and yellow light, while reflecting most of the red wavelengths back to the eye
C. All colors of visible light equally, which is why chlorophyll appears black to the eye
D. Only ultraviolet light, while reflecting all of the visible wavelengths to the eye

15. The light-dependent reactions of photosynthesis produce:

A. Glucose and carbon dioxide that are released from the plant into the surrounding air
B. Glucose only, which the plant uses for energy during its growth and reproduction
C. Carbon dioxide and water, which are used in the Calvin cycle of the chloroplast
D. ATP and oxygen, with the oxygen released to the atmosphere as a byproduct

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

All living things are made of cells, which fall into two main categories: prokaryotic cells and eukaryotic cells. Prokaryotic cells (found in bacteria and archaea) are generally small and simple. They lack a true membrane-bound nucleus; their DNA floats freely in the cytoplasm in a region called the nucleoid. They also lack other membrane-bound organelles such as mitochondria and chloroplasts. Eukaryotic cells (found in animals, plants, fungi, and protists) are typically larger and more complex. They contain a true nucleus surrounded by a nuclear envelope, and they have many membrane-bound organelles. Despite their differences, all cells contain DNA, ribosomes, a cell membrane, and cytoplasm.

16. A key feature that distinguishes eukaryotic cells from prokaryotic cells is the presence of:

A. DNA, which is found only in eukaryotic cells and not in any prokaryotic cells at all
B. A cell membrane, which is found only in eukaryotic cells and not in prokaryotic cells
C. A true membrane-bound nucleus, which is present in eukaryotic but not prokaryotic cells
D. Ribosomes, which are found only in eukaryotic cells and not in any prokaryotic cells

17. In a prokaryotic cell, the DNA is located:

A. Inside a membrane-bound nucleus, just as the DNA of any eukaryotic cell would be
B. In a region of the cytoplasm called the nucleoid, with no surrounding membrane
C. Inside the mitochondrion, which is the only organelle present in prokaryotic cells
D. In the cell wall, which serves as the storage site for genetic material in prokaryotes

18. Which of the following organisms is made of prokaryotic cells?

A. Bacteria, which are single-celled organisms that lack a membrane-bound nucleus
B. Mushrooms, which are multicellular fungi composed of eukaryotic cells with nuclei
C. Sunflowers, which are plants composed of eukaryotic cells with chloroplasts and a nucleus
D. Humans, which are multicellular animals composed of eukaryotic cells with many organelles

19. All cells, whether prokaryotic or eukaryotic, contain:

A. A nucleus, mitochondria, chloroplasts, and a true endoplasmic reticulum membrane system
B. Chloroplasts, lysosomes, and Golgi apparatus inside every cell of every organism
C. A cell membrane, cytoplasm, ribosomes, and DNA as basic shared cellular features
D. A nucleolus, centrioles, and a complex cytoskeleton with microtubules in all cells

20. Mitochondria and chloroplasts are NOT found in prokaryotic cells. Prokaryotic cells nevertheless carry out cellular respiration (and some carry out photosynthesis) because:

A. Prokaryotic cells do not actually perform cellular respiration or photosynthesis at all
B. Prokaryotic cells absorb ATP directly from their environment without needing to make any
C. Prokaryotic cells use eukaryotic cells in their environment to perform respiration for them
D. The reactions take place on the cell membrane or in the cytoplasm of the prokaryotic cell itself

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

Translation is the process in which the message carried by mRNA is decoded to make a protein. It takes place at ribosomes in the cytoplasm. The mRNA sequence is read in groups of three nucleotides called codons. Each codon specifies a particular amino acid (or a "stop" signal). Transfer RNA (tRNA) molecules carry amino acids to the ribosome. Each tRNA has an anticodon, a sequence of three nucleotides that is complementary to a codon on the mRNA. When a tRNA's anticodon pairs with the matching mRNA codon at the ribosome, the amino acid it carries is added to the growing protein chain. The genetic code is the system of correspondence between codons and amino acids; it is nearly universal across all organisms.

21. A codon consists of:

A. One nucleotide that specifies one amino acid in the growing protein chain
B. Three nucleotides that together specify one amino acid (or a stop signal)
C. Five nucleotides that specify one amino acid in the growing protein chain
D. Twenty nucleotides that together code for all of the twenty amino acids found in proteins

22. An mRNA codon AUG would pair with a tRNA anticodon of:

A. UAC, which is the complementary base sequence to the codon AUG in mRNA
B. AUG, which would be identical to the codon and not complementary to it at all
C. TAC, which is a DNA sequence rather than an RNA sequence found in tRNA
D. GCU, which is not complementary to AUG and would not bind at the ribosome

23. Translation occurs in the:

A. Nucleus, where DNA is replicated and transcribed into mRNA before any protein is made
B. Mitochondrion, which produces ATP for energy but does not synthesize the cell's proteins
C. Ribosomes, which are found in the cytoplasm of the cell where translation takes place
D. Cell membrane, which controls what enters and leaves the cell but does not make proteins

24. The genetic code is described as "nearly universal" because:

A. All organisms have exactly the same genes and the same sequences in their DNA
B. The same DNA molecule is shared between all of the organisms in a single population
C. All living things use only the four amino acids that are coded for by mRNA codons
D. The same codons specify the same amino acids in almost every organism studied

25. The near-universality of the genetic code is considered strong evidence that:

A. Different species evolved independently and have no shared ancestry with each other
B. All living things share a common ancestor from which the genetic code was inherited
C. The genetic code formed by chance in each species over many generations of evolution
D. The genetic code is not heritable and is reinvented in each generation of every species

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

Gregor Mendel, a 19th-century monk, established the basic laws of heredity through experiments with pea plants. His law of segregation states that during the formation of gametes (meiosis), the two alleles of each gene separate so that each gamete receives only one allele. Mendel worked with traits controlled by a single gene with two alleles, where one allele was dominant and one was recessive. For example, in pea seeds, the allele for yellow color (Y) is dominant over the allele for green color (y). A pea plant with the genotype Yy produces seeds that appear yellow because the dominant Y allele masks the recessive y allele.

26. Mendel's law of segregation states that:

A. During the formation of gametes, the two alleles of each gene separate from each other
B. Two alleles for a trait combine permanently into a single allele in every gamete cell
C. Both alleles for a trait are passed together into the same gamete during meiosis
D. The two alleles for a trait blend together to produce a new allele in the offspring

27. The genotype Yy produces yellow pea seeds because:

A. The two alleles blend together to produce a color halfway between green and yellow
B. The recessive allele y is expressed instead of the dominant allele Y in heterozygotes
C. The Y and y alleles produce equally pigmented offspring with no dominance involved
D. The dominant allele Y masks the recessive allele y, so the seed appears yellow

28. A cross between two Yy pea plants produces a phenotype ratio of:

A. 1:1 yellow to green seeds, the same ratio as in a typical test cross result
B. 1:2:1 yellow to "yellow-green" to green seeds, indicating incomplete dominance
C. 3:1 yellow to green seeds, the classic Mendelian monohybrid ratio for a dominant trait
D. 9:3:3:1 yellow to green to wrinkled to round seeds among the offspring of this cross

29. A pea plant with yellow seeds could have which of the following genotypes?

A. YY or Yy, since both genotypes contain at least one dominant Y allele
B. Only YY, since heterozygous Yy plants always have green seeds in a population
C. Only Yy, since YY plants always have green seeds when self-pollinated in the field
D. Only yy, since two recessive y alleles together always produce yellow pea seeds

30. Mendel's work was significant because it:

A. Demonstrated that traits blend together completely in the offspring of any two parents
B. Established that inheritance involves discrete units (now called genes) passed from parents to offspring
C. Showed that environmental factors are the main determinants of the traits of an organism
D. Proved that acquired characteristics gained during a parent's life are inherited by their offspring

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

Early in the 19th century, the French naturalist Jean-Baptiste Lamarck proposed an early theory of evolution. He suggested that organisms could change during their lifetime in response to their environment, and that these acquired characteristics could be passed to their offspring. His famous example was the giraffe: he proposed that giraffes stretched their necks to reach higher leaves, and that this acquired longer neck was passed on to their offspring. About 50 years later, Charles Darwin proposed a different mechanism: natural selection. Darwin argued that natural variation already exists within a population, that some variants are better suited to the environment, and that these individuals are more likely to survive and reproduce, passing on their advantageous traits. Modern evidence has supported Darwin's mechanism and refuted Lamarck's "inheritance of acquired characteristics."

31. Lamarck's mechanism of evolution proposed that:

A. Random variation already exists in populations, and the environment selects which traits survive
B. New species can only arise when populations become geographically isolated from each other
C. The DNA of an organism is passed unchanged from parent to offspring for many generations
D. Characteristics acquired during an organism's lifetime can be passed on to its offspring

32. Darwin's mechanism of evolution proposed that:

A. All organisms are perfectly adapted to their environment from the moment of their birth
B. The environment changes the DNA of organisms during their lifetime in response to need
C. Natural variation in populations is acted on by selection, favoring individuals best suited to the environment
D. Organisms inherit acquired traits from their parents, which over generations leads to gradual change

33. If giraffes evolved longer necks by Darwin's mechanism, the explanation would be:

A. Giraffes with naturally longer necks survived and reproduced more, passing those alleles to offspring
B. Each giraffe stretched its neck during life, and these stretched necks were inherited by their young
C. The environment changed each giraffe's genes during its lifetime to give it a longer neck
D. All giraffes developed long necks simultaneously by need-based environmental pressure

34. A weightlifter who develops strong muscles and then has a child:

A. Will pass on the strong muscles to the child because acquired traits are always inherited
B. Will not pass on the developed muscles, because acquired characteristics are not heritable
C. Will pass on the muscles only to male children, because only males inherit acquired traits
D. Will pass on the muscles only if the child is born within one year of the lifting training

35. One reason Lamarck's theory was eventually rejected is that:

A. Lamarck's theory was based entirely on observations of fossil organisms only
B. No organisms have ever shown any kind of change over the course of multiple generations
C. Acquired changes to the body do not alter the DNA of the gametes that produce offspring
D. Darwin's theory was published earlier than Lamarck's theory by several centuries

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

Energy flows through an ecosystem from producers (autotrophs) up through successive trophic levels of consumers (heterotrophs). At each trophic level, only about 10% of the energy from the previous level is incorporated into the organisms' bodies (biomass); the other ~90% is lost as heat and waste during metabolism. Because of this energy loss, ecosystems can support very large producer biomass, smaller herbivore biomass, even smaller carnivore biomass, and only a small biomass of top predators. This pattern is often shown as a "biomass pyramid" or an "energy pyramid," with producers at the base and top predators at the apex.

36. The base of an energy pyramid is occupied by:

A. The top carnivores of the ecosystem, which transfer the most energy in the food web
B. The decomposers of the ecosystem, which start the flow of energy in the food web
C. The herbivores of the ecosystem, which obtain their energy directly from sunlight
D. The producers of the ecosystem (autotrophs), which capture energy directly from the sun

37. Approximately what percentage of the energy at one trophic level is incorporated into the biomass of the next trophic level?

A. About 10%, with the remaining 90% lost as heat and waste during the metabolism of consumers
B. About 50%, with only the other half lost in the form of metabolic heat to the environment
C. About 90%, with only the other 10% lost as heat from the consumers in the ecosystem
D. Almost 100%, since energy is mostly recycled between trophic levels in any natural ecosystem

38. A consequence of the 10% rule is that:

A. Top predators are the most abundant organisms in any ecosystem on the planet
B. Top predators have the smallest biomass in an ecosystem compared with lower trophic levels
C. Producers have the smallest biomass in an ecosystem because they capture so little energy
D. All trophic levels have an equal biomass in a healthy ecosystem anywhere on the planet

39. The energy lost between trophic levels is mostly:

A. Stored in the bones of the consumers and recycled into the soil after death
B. Recycled back to producers, which use the lost energy to start the next pyramid

C. Stored permanently in the biomass of decomposers at the base of the food web
D. Lost as heat during respiration and not available to organisms at higher trophic levels

40. A grassland might support 10,000 kg of grass per hectare, but only 1,000 kg of grasshoppers and 100 kg of birds that eat the grasshoppers. This pattern reflects:

A. Random variation in the abundance of species at different levels of a food web
B. The fact that birds need much less food than grasshoppers do in order to survive
C. The 10% rule of energy transfer between successive trophic levels of an ecosystem
D. A pyramid inverted from typical ecosystems, in which top predators dominate the biomass

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

An invasive species is a non-native species that has been introduced to a new ecosystem, where it spreads rapidly and causes ecological or economic harm. Zebra mussels (*Dreissena polymorpha*) are a well-known invasive species in North America. Originally native to Eurasia, they were transported to the Great Lakes in the ballast water of cargo ships in the 1980s. In their new environment, they had few natural predators and reproduced rapidly. They have caused major problems by outcompeting native mussels for food and space, clogging water intake pipes for power plants and municipal water systems, and disrupting native food webs. Invasive species are considered one of the leading threats to biodiversity worldwide.

41. An invasive species is best defined as a:

A. Non-native species that spreads rapidly and causes ecological or economic harm
B. Native species whose population has expanded in its original range over time
C. Species that has lived in an ecosystem since the formation of the original community
D. Species that is being deliberately introduced by conservationists to restore an ecosystem

42. Zebra mussels arrived in the Great Lakes most likely as a result of:

A. Deliberate introduction by scientists who wanted to study how they would respond
B. Transport in the ballast water of cargo ships traveling from Eurasian ports
C. Migration along ocean currents from their native range to the Great Lakes
D. Escape from aquariums where they had been kept as decorative organisms

43. Zebra mussels have been able to spread so rapidly in the Great Lakes partly because they:

A. Reproduce more slowly than native species, which gives them a longer lifespan
B. Are eaten by every other species in the lakes including most native predators

C. Have few natural predators in their new environment compared with their native range
D. Require very specific water conditions that are only found in Great Lakes ports

44. A major ecological impact of zebra mussels is that they:

A. Increase the populations of native mussels by providing them with new sources of food
B. Improve water quality so dramatically that native fish populations always increase
C. Add new prey species to the lake that increase the biodiversity of all native species
D. Outcompete native mussels for food and space, reducing the populations of native species

45. One effective strategy to reduce the spread of zebra mussels and other aquatic invasive species is to:

A. Require ships to exchange or treat their ballast water before entering new water bodies
B. Introduce more invasive species to the lakes to balance out the effects of zebra mussels
C. Remove all native mussels from the lakes so that zebra mussels have nothing to compete with
D. Add fertilizers to the lakes to promote algal blooms that would outcompete the mussels

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

The human respiratory system brings oxygen into the body and removes carbon dioxide. Air enters through the nose or mouth and passes down the trachea, which branches into two bronchi leading to the lungs. Inside the lungs, the bronchi divide into smaller and smaller airways called bronchioles, which end in tiny air sacs called alveoli. The alveoli are surrounded by capillaries, where the exchange of gases takes place: oxygen diffuses from the alveoli into the blood, and carbon dioxide diffuses from the blood into the alveoli to be exhaled. Breathing is powered mainly by the diaphragm, a sheet of muscle below the lungs. When the diaphragm contracts and flattens, the chest cavity expands and air is pulled into the lungs (inhalation). When the diaphragm relaxes, the chest cavity shrinks and air is pushed out (exhalation).

46. Gas exchange between air and blood takes place in the:

A. Trachea, the main airway that carries air from the throat down toward the lungs
B. Alveoli, the tiny air sacs at the ends of the smallest airways in the lungs
C. Bronchi, the two large airways that branch off the trachea into the lungs
D. Diaphragm, the muscle that powers most of the breathing movements of the body

47. During inhalation, the diaphragm:

A. Relaxes and rises upward into the chest cavity, pushing the air out of the lungs
B. Remains still and unchanging while air enters the lungs by other means entirely

C. Contracts and flattens, expanding the chest cavity and pulling air into the lungs
D. Contracts and rises upward into the chest cavity, pushing air out of the lungs at once

48. Oxygen moves from the alveoli into the blood by:

A. Diffusion, since the alveoli have a higher concentration of oxygen than the blood
B. Active transport, with the cells using ATP to pump oxygen into the blood
C. Endocytosis, with cells engulfing oxygen in vesicles before pumping it into the blood
D. Osmosis, with oxygen moving across a selectively permeable membrane like water

49. A correct sequence of air flow during inhalation is:

A. Mouth → bronchioles → trachea → alveoli → bronchi → into the blood
B. Trachea → mouth → alveoli → bronchi → bronchioles → into the blood
C. Mouth → alveoli → trachea → bronchi → bronchioles → into the blood
D. Mouth → trachea → bronchi → bronchioles → alveoli → into the blood

50. The structure of the alveoli (millions of tiny sacs surrounded by capillaries) is well suited to gas exchange because it:

A. Provides a strong barrier that prevents oxygen from entering the blood too quickly
B. Maximizes the surface area available for gas exchange between air and blood
C. Stores large amounts of oxygen in the lungs until it is needed by the body for use
D. Filters out harmful particles in the air so that they cannot reach the bloodstream

PRACTICE EXAM 40 – EXPLAINED ANSWER KEY (Q1–Q50)

1. B — Diffusion is defined as the net movement of molecules from regions of higher concentration to regions of lower concentration, driven by random molecular motion. It does not require cellular energy because it follows the concentration gradient. The other options describe active transport, osmosis, or exocytosis.

2. A — As temperature rises, molecules move faster and collide more often, spreading more quickly through the medium. The data show the mixing time dropping from 35 minutes at 5°C to just 6 minutes at 60°C, a clear positive relationship. This is one of the basic physical principles underlying all transport processes.

3. D — Diffusion is powered by the thermal (kinetic) energy of the molecules themselves; no ATP or external energy input is needed. This is why diffusion is classified as a form of passive transport. Increasing temperature adds kinetic energy and speeds the process.

4. C — Stirring is bulk fluid movement (convection), which physically mixes the solution and overshadows the slower random motion of diffusion. The dye would still diffuse on its own without stirring; stirring simply gets it there faster. The two processes are distinct mechanisms of mixing.

5. B — Diffusion is efficient only over very short distances because the time required rises sharply with distance. Inside cells (and across cell membranes), the distances involved are micrometers, not centimeters. This is why cells stay small and why circulatory systems are needed in large organisms.

6. D — In Trials 1–5, the rate of O_2 production rises in step with the amount of catalase added, indicating a directly proportional relationship. Each additional drop of catalase provides more active sites, which speeds the reaction. This pattern holds only while substrate is plentiful.

7. A — Once enough enzyme is present to handle all available H_2O_2, adding more enzyme no longer increases the rate because the substrate has become the limiting factor. The reaction rate plateaus at about 25 mL/min in Trials 6 and 7. This is the classic "substrate saturation" plateau seen with excess enzyme.

8. C — The independent variable is the factor the experimenter deliberately changes between trials, which here is the number of drops of catalase. Oxygen production is the dependent variable (the measured outcome), and the other factors are held constant. Identifying these variables is a key experimental-design skill.

9. B — Enzymes have specific three-dimensional active sites that fit only certain substrates, much like a lock and key. Catalase is built to bind and break down hydrogen peroxide specifically, and does not act on starch, proteins, or other molecules. This specificity is a defining property of all enzymes.

10. A — Hydrogen peroxide is generated as a toxic byproduct of normal metabolism and can damage membranes, proteins, and DNA. Catalase quickly converts it to harmless water and oxygen, protecting the cell. This is why cells in many tissues — especially the liver — produce abundant catalase.

11. C — The reactants on the left side of the photosynthesis equation are CO_2 and H_2O. Light energy drives the conversion of these inputs into glucose and oxygen. Identifying the raw materials is fundamental to understanding the process.

12. D — The right side of the equation shows glucose ($C_6H_{12}O_6$) and oxygen as the products of photosynthesis. The glucose stores chemical energy for the plant, while oxygen is released to the atmosphere. This output of oxygen is the source of nearly all atmospheric O_2.

13. B — Chlorophyll, the green pigment located inside chloroplasts, gives plants their characteristic color. It absorbs light energy needed to drive the photosynthetic reactions. The wavelengths it does not absorb (mostly green) are reflected back to our eyes.

14. A — Absorption spectra for chlorophyll show two main absorption peaks — one in the blue range and one in the red range — with relatively little absorption in the green. Because green is reflected rather than absorbed, plants appear green. This is why grow lights are often tuned to include red and blue wavelengths.

15. D — The light-dependent reactions split water, release oxygen as a byproduct, and generate ATP and NADPH. These energy-rich molecules then power the Calvin cycle, which builds glucose from CO_2. The two stages together complete photosynthesis.

16. C — The defining difference between eukaryotic and prokaryotic cells is the presence of a true membrane-bound nucleus in eukaryotes. Both cell types share DNA, ribosomes, and a cell membrane, so those features cannot distinguish them. The membrane-bound nucleus is what the prefix "eu-karyon" (true nucleus) means.

17. B — In prokaryotic cells, the DNA is concentrated in a region of the cytoplasm called the nucleoid, but there is no surrounding membrane. This distinguishes prokaryotic DNA organization from the membrane-enclosed nuclear material of eukaryotes. Prokaryotic DNA is also typically a single circular chromosome.

18. A — Bacteria are the most familiar group of prokaryotes; they are single-celled and lack a membrane-bound nucleus. Mushrooms, sunflowers, and humans are all built from eukaryotic cells. Recognizing major taxonomic groupings as pro- or eukaryotic is foundational to biology.

19. C — Every known cell has a cell membrane, cytoplasm, ribosomes, and DNA, regardless of whether it is prokaryotic or eukaryotic. These shared features point to the common ancestry of all life. Other organelles like nuclei, mitochondria, and chloroplasts are restricted to eukaryotic cells.

20. D — In prokaryotes, the reactions of cellular respiration occur on the inner surface of the plasma membrane and in the cytoplasm, where the necessary enzymes are located. Photosynthetic bacteria similarly use their membranes for the light-dependent reactions. This is consistent with the endosymbiotic theory that mitochondria and chloroplasts originated from such bacteria.

21. B — A codon is a sequence of three consecutive mRNA nucleotides that codes for one amino acid (or for a stop signal). The triplet nature of the code is one of the most fundamental properties of molecular biology. There are 64 possible codons specifying 20 amino acids plus start/stop signals.

22. A — Base pairing follows the rules A–U and G–C in RNA. The complement of AUG, read in the antiparallel direction, is UAC. This is why tRNA carrying methionine has the anticodon UAC.

23. C — Translation takes place at ribosomes, which are located in the cytoplasm (free or attached to the rough ER in eukaryotes). The ribosome reads each codon of the mRNA and recruits the matching tRNA. Transcription occurs in the nucleus; translation does not.

24. D — "Nearly universal" means that almost every organism studied uses the same set of codon-to-amino-acid assignments. This is why a human gene placed in a bacterium produces the same protein. A few minor variations exist in some mitochondria and a few microbes, but the system is essentially shared by all life.

25. B — A shared, complex feature like the genetic code is extremely unlikely to have arisen independently in unrelated lineages. The simplest explanation is that all current life inherited the code from a common ancestor. This is one of the strongest pieces of molecular evidence for universal common descent.

26. A — The law of segregation states that the two alleles for each gene separate from one another during gamete formation, so each gamete carries only one allele. This separation occurs during meiosis I when homologous chromosomes are pulled apart. The law explains why offspring receive one allele from each parent.

27. D — In a dominant–recessive relationship, even one copy of the dominant allele (Y) produces the dominant phenotype, masking the recessive y. Yy peas therefore look identical to YY peas — both are yellow. Only yy plants show the recessive green phenotype.

28. C — A Yy × Yy cross produces offspring in genotype ratio 1 YY : 2 Yy : 1 yy, which translates to a phenotype ratio of 3 yellow : 1 green. This classic 3:1 monohybrid ratio is one of Mendel's central findings. It is the signature of a single-gene cross between heterozygotes.

29. A — Because Y is dominant, any pea with at least one Y allele will appear yellow. Both homozygous (YY) and heterozygous (Yy) genotypes produce the yellow phenotype. A test cross is required to distinguish between them.

30. B — Mendel's breakthrough was recognizing that inheritance involves discrete particulate units passed unchanged from parents to offspring, rejecting the prevailing idea of "blending" inheritance. These units are now known as genes. His framework is the foundation of modern genetics.

31. D — Lamarck proposed that traits an organism develops during its lifetime — like a stretched giraffe neck — could be passed to offspring. This is the "inheritance of acquired characteristics." It is the central feature that distinguishes Lamarckism from later evolutionary theories.

32. C — Darwin proposed that heritable variation already exists in populations and that the environment selects for individuals with the most advantageous traits. Those individuals survive and reproduce, passing the favorable alleles to the next generation. This mechanism — natural selection — is the cornerstone of modern evolutionary biology.

33. A — Under Darwin's mechanism, neck length already varied among ancestral giraffes; those with longer necks could feed on higher leaves, survived better in lean times, and left more offspring with the long-neck alleles. Over many generations the average neck length increased. No "stretching" or need-driven inheritance is involved.

34. B — Lifting weights changes muscle tissue but does not alter the DNA in the lifter's gametes, so the trait cannot be transmitted to offspring. Children inherit alleles, not the parent's developed characteristics. This is one of the simplest disproofs of Lamarckian inheritance.

35. C — Acquired changes — exercise, scars, stretched necks — occur in somatic tissues and do not modify the DNA carried in egg or sperm. Without changes to the gametes' DNA, the trait cannot be passed on. This insight, formalized by Weismann, helped retire Lamarck's theory.

36. D — Producers (autotrophs such as plants and algae) form the base of every energy pyramid because they capture solar energy directly and convert it into chemical energy. All higher trophic levels ultimately depend on this primary production. Decomposers recycle nutrients but are typically drawn separately, not at the base.

37. A — Ecologists summarize energy flow with the "10% rule": roughly 10% of the energy at one trophic level is captured as biomass at the next, while the rest is lost mainly as heat from respiration. This dramatic loss is why food chains rarely have more than four or five links. The actual percentage varies but 10% is the textbook approximation.

38. B — Because so little energy is passed up each level, only a small biomass of top predators can be supported by even a very productive ecosystem. This is why apex predators are rare. The pyramid narrows sharply toward the top.

39. D — Most energy is dissipated as heat during the work of cellular respiration at each trophic level — fueling movement, growth, and homeostasis. This heat cannot be recaptured by other organisms. Some energy is also locked away in feces and dead organic matter consumed by decomposers.

40. C — The roughly tenfold drop in biomass between each level (10,000 → 1,000 → 100 kg) matches the 10% energy transfer rule almost exactly. The pattern is a direct consequence of energy loss at each step. Most real ecosystems show this same general shape.

41. A — An invasive species is specifically a non-native species that establishes, spreads, and causes harm — ecological, economic, or both — in its new range. Many non-native species are harmless; the defining feature of invasives is their negative impact. The distinction matters for conservation policy.

42. B — Cargo ships take on ballast water in foreign ports to maintain stability and dump it on arrival. This water frequently contains larvae and small organisms — including the planktonic larvae of zebra mussels — that can establish in the new ecosystem. Ballast-water introductions are a major pathway for aquatic invasive species worldwide.

43. C — Species introduced to a new range often leave behind the predators, parasites, and diseases that controlled them at home — the "enemy release" effect. In the Great Lakes, zebra mussels face few effective predators, allowing populations to explode. This advantage is a common feature of successful invaders.

44. D — Zebra mussels are highly efficient filter feeders that strip plankton from the water and attach in dense colonies to surfaces native mussels need. Native unionid mussels have declined dramatically as a result. Loss of these native species reduces biodiversity and disrupts the food web.

45. A — Because ballast water is the main introduction pathway, regulations requiring ships to exchange ballast at sea or treat it before discharge directly cut the supply of new invasive organisms. Many jurisdictions, including the U.S. and Canada, now mandate such practices. Prevention is far cheaper than control after an invader becomes established.

46. B — Alveoli are the thin-walled air sacs at the end of the smallest airways, and gas exchange between air and capillary blood occurs across their walls. The trachea, bronchi, and bronchioles are conducting passages, not exchange surfaces. The combined surface area of all human alveoli is roughly the size of a tennis court.

47. C — When the diaphragm contracts, it flattens and moves downward; this increases the volume of the thoracic cavity and lowers the pressure inside, drawing air into the lungs. This is the active phase of normal breathing. Exhalation is generally passive as the diaphragm relaxes back upward.

48. A — Oxygen moves passively from the alveolar air (high O_2 concentration) into the capillary blood (lower O_2) by simple diffusion across the thin alveolar membranes. No ATP is required because the gas follows its partial-pressure gradient. The same gradient — in reverse — drives CO_2 from blood to alveoli.

49. D — Air follows the conducting pathway: mouth (or nose) → pharynx/larynx → trachea → bronchi → bronchioles → alveoli, where gas exchange occurs and oxygen enters the blood. The other listed sequences scramble this anatomy. Knowing this pathway is fundamental to understanding pulmonary physiology.

50. B — Millions of tiny alveoli give the lungs an enormous internal surface area, which directly increases the rate of gas exchange (more area = more diffusion). The thin walls and dense capillary network also shorten the diffusion distance. This is a textbook example of structure matching function.