# PRACTICE EXAM 27 — 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.*

Researchers observed white blood cells under a microscope as they encountered bacterial cells. The white blood cells extended their membranes around the bacteria, engulfing them into a membrane-bound vesicle inside the white blood cell. This vesicle then fused with another organelle (a lysosome) inside the cell, which contained digestive enzymes that broke down the bacteria. The white blood cell later released the digested waste products back outside the cell through a different process.

**1.** The process by which the white blood cell engulfs the bacteria into a vesicle is best classified as:

A. Diffusion, in which substances move down a concentration gradient across the cell membrane
B. Osmosis, in which water moves across a selectively permeable membrane to balance solute concentrations
C. Active transport, in which proteins in the membrane pump ions against their concentration gradient
D. Endocytosis, in which the cell membrane folds inward to bring large materials into the cell

**2.** The membrane-bound organelle inside the white blood cell that contains digestive enzymes is the:

A. Mitochondrion, which produces ATP for the cell's energy needs through aerobic respiration
B. Ribosome, which assembles amino acids into proteins based on the mRNA sequence
C. Lysosome, which breaks down materials inside the cell using digestive enzymes
D. Nucleus, which stores the genetic information that controls all cell activities

**3.** The release of digested waste materials from the white blood cell back to the outside of the cell is called:

A. Endocytosis, in which the cell takes materials in by folding the membrane inward
B. Exocytosis, in which a vesicle fuses with the cell membrane and releases its contents
C. Active transport, in which protein pumps move ions across the cell membrane against gradients
D. Facilitated diffusion, in which channel proteins help molecules cross the membrane passively

**4.** Both endocytosis and exocytosis are best classified as types of:

A. Bulk transport, in which large quantities of material are moved into or out of the cell at once
B. Passive transport, in which materials move without any input of energy from the cell
C. Photosynthesis, in which carbon dioxide is converted into glucose using light energy
D. Cellular respiration, in which glucose is broken down to release ATP energy from food

**5.** A cell that engulfs and destroys bacteria is performing an essential function in the body's:

A. Digestive system, which breaks down food into absorbable nutrients in the intestines
B. Circulatory system, which transports blood and oxygen throughout the body
C. Immune system, which defends the body against harmful microorganisms and pathogens
D. Nervous system, which transmits electrical signals between the brain and body parts

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

Many enzymes require additional non-protein helpers, called cofactors, to function properly. Some cofactors are inorganic ions like magnesium ($Mg^{2+}$), zinc ($Zn^{2+}$), or iron ($Fe^{2+}$). Others are organic molecules called coenzymes, often derived from vitamins (such as $NAD^{+}$, which comes from vitamin B3). Researchers tested the activity of an enzyme that requires a cofactor by setting up four reaction mixtures and measuring the rate of product formation. The results are shown below.

| Setup | Components | Rate of Product Formation (µmol/min) |
|---|---|---|
| **1** | Enzyme + substrate only | 5 |
| **2** | Enzyme + substrate + cofactor | 48 |
| **3** | Enzyme + substrate + cofactor remover | 0 |
| **4** | Substrate only (no enzyme) | 0 |

**6.** The data show that this enzyme functions best when:

A. The cofactor has been removed by adding a cofactor-removing chemical to the mixture
B. Both the enzyme and the cofactor are present together with the substrate molecules
C. Only the substrate is present in the reaction mixture with no other components added
D. Only the enzyme is present in the reaction mixture without any of the substrate

**7.** The low rate in Setup 1 (enzyme + substrate only, no cofactor) is best explained by the fact that:

A. The substrate could not enter the active site of the enzyme without the cofactor present
B. The enzyme was completely denatured in the absence of the cofactor in the reaction mixture
C. The substrate spontaneously broke down at a very high rate when no cofactor was added
D. The enzyme alone has some activity, but the cofactor is needed for full normal function

**8.** The complete absence of activity in Setup 3 (with cofactor remover) demonstrates that:

A. The cofactor is essential for the enzyme to function at any measurable level
B. The cofactor remover itself acts as a substrate for the enzyme in the reaction
C. The enzyme can function only when the cofactor remover is also present at all times
D. The cofactor remover increases the activation energy of the enzymatic reaction

**9.** If a person's diet is severely deficient in a particular vitamin used to produce a coenzyme, the most likely consequence is:

A. The body will produce excess amounts of the affected enzyme to compensate for the deficiency
B. The body's metabolism will speed up to make up for the missing coenzyme molecules
C. Certain enzymatic reactions will slow or stop, leading to symptoms of vitamin deficiency
D. The enzymes that require the coenzyme will mutate into versions that no longer need it

**10.** Vitamins are an essential part of human nutrition primarily because they:

A. Provide most of the energy required for daily activities through cellular respiration
B. Serve as cofactors or as precursors for cofactors needed by many of the body's enzymes
C. Are converted directly into proteins that the body uses to build muscle tissue
D. Function as the genetic material that codes for all of the body's enzymes

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

Students investigated the conditions required for bean seed germination. They placed 10 identical bean seeds into each of four conditions and recorded the number of seeds that germinated (sprouted) after 5 days. The results are shown below.

| Condition | Setup | Number of Seeds That Germinated (out of 10) |
|---|---|---|
| **1** | Damp paper towel, room temperature (22°C), light | 9 |
| **2** | Damp paper towel, room temperature (22°C), dark | 9 |
| **3** | Dry paper towel, room temperature (22°C), light | 0 |
| **4** | Damp paper towel, refrigerator (4°C), light | 1 |

**11.** The results suggest that bean seed germination requires:

A. Adequate water and a sufficiently warm temperature, but not necessarily light
B. Light energy and dry conditions, but not warmth from the surrounding environment
C. Both light and cold temperatures, with no need for water in the surrounding paper
D. Only the genetic information inside the seed, with no environmental factors needed

**12.** The condition that failed to support germination because of insufficient water was:

A. Condition 1, where seeds were on damp paper towel at room temperature with light
B. Condition 2, where seeds were on damp paper towel at room temperature in the dark
C. Condition 4, where seeds were on damp paper towel at refrigerator temperature with light
D. Condition 3, where seeds were on dry paper towel at room temperature with light

**13.** The poor germination in Condition 4 (refrigerator, 4°C) is best explained by:

A. The absence of light energy needed to drive the germination process inside the seed
B. The low temperature slowing down enzyme activity in the seeds, preventing growth
C. The high humidity inside the refrigerator damaging the structural parts of the seed
D. The presence of too much oxygen in the refrigerator interfering with germination

**14.** Comparing Conditions 1 and 2 (light versus dark, both damp and warm), the results show that:

A. Light is essential for bean seed germination to occur in any environmental conditions
B. Darkness completely prevents bean seed germination from occurring at any temperature
C. Bean seeds can germinate equally well in either light or darkness when warm and moist
D. Bean seeds germinate only when the environmental temperature is below 4°C

**15.** During germination, the energy that supports early seedling growth comes primarily from:

A. Food stored in the seed itself before germination, such as starches and oils
B. Photosynthesis carried out by the seedling's first leaves before the seed splits open
C. Nitrogen-fixing bacteria living inside the seed coat and feeding the developing embryo
D. ATP molecules absorbed by the seed directly from the surrounding paper towel

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

The mitochondrion is sometimes called the "powerhouse" of the cell because it produces most of the cell's ATP. A mitochondrion has a smooth outer membrane and a highly folded inner membrane. The folds of the inner membrane are called cristae, and the space inside the inner membrane is called the matrix. The electron transport chain, which produces most of the cell's ATP, is located along the inner membrane. The folding of the inner membrane into cristae greatly increases the surface area available for ATP production. Mitochondria contain their own small loop of DNA and their own ribosomes, suggesting they evolved from free-living bacteria that became part of larger cells billions of years ago.

**16.** The folding of the inner mitochondrial membrane into cristae is important because it:

A. Provides a barrier that prevents water from entering the matrix of the mitochondrion
B. Stores genetic information used to control the activities of the mitochondrion only
C. Separates the cell from the external environment, protecting it from invading viruses
D. Increases the surface area available for the electron transport chain and ATP production

**17.** The presence of DNA and ribosomes inside mitochondria supports the hypothesis that:

A. Mitochondria are products of recent human genetic engineering experiments
B. Mitochondria are not really alive and could not have evolved from any ancestor
C. Mitochondria evolved from free-living bacteria that became part of larger cells long ago
D. Mitochondria are identical in structure to the nucleus of all eukaryotic cells

**18.** A cell with damaged mitochondria would most likely:

A. Produce more ATP than normal because of reduced competition for cellular resources
B. Produce less ATP than normal because most ATP comes from the electron transport chain
C. Convert oxygen back into glucose during cellular respiration to replace lost energy
D. Stop producing $CO_2$ entirely because mitochondria contain all the cell's $CO_2$ sources

**19.** The hypothesis that mitochondria originated from ancient bacteria living inside larger cells is known as the:

A. Endosymbiotic theory, supported by evidence including mitochondrial DNA and ribosomes
B. Cell theory, which states that all living things are made of one or more cells
C. Germ theory, which states that microorganisms cause many human diseases
D. Big bang theory, which describes the origin of the universe in cosmology

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

Genetic engineering allows scientists to insert genes from one organism into another, giving the recipient organism a new trait. One well-known example is "Bt corn," a variety of corn that contains a gene originally from the bacterium *Bacillus thuringiensis* (Bt). The Bt gene codes for a protein toxic to certain insect pests but harmless to humans and most other organisms. When pests eat Bt corn, the Bt protein kills them, reducing crop damage and the need for chemical pesticides. Genetically modified organisms (GMOs) like Bt corn have benefits but also raise concerns about ecological impacts, gene flow to wild relatives, and long-term safety.

**20.** A "genetically modified organism" (GMO) is best defined as an organism that:

A. Was selectively bred over many generations by farmers to enhance certain natural traits
B. Has been exposed to high levels of radiation to induce random genetic mutations in DNA

C. Has had its DNA modified by inserting genes from another organism using lab techniques
D. Has lost all of its original genes and replaced them entirely with genes from another species

**21.** Bt corn contains a gene from a bacterium. The fact that the bacterial gene functions inside a corn plant demonstrates that:

A. Corn plants and bacteria have nearly identical complete genomes from common ancestors
B. The bacterial gene must be modified into corn DNA before it can function inside the plant
C. The bacterium that supplied the gene is closely related to corn in the tree of life
D. The genetic code is essentially universal — different organisms read DNA in the same way

**22.** One benefit of Bt corn for farmers is that it:

A. Increases the genetic diversity of corn crops in the field, preventing future disease outbreaks
B. Reduces the need to spray chemical pesticides on the field, lowering both costs and exposure
C. Provides corn that is naturally resistant to all types of weeds growing in the field
D. Increases the nitrogen content of the corn, eliminating the need for any fertilizer use

**23.** A potential ecological concern with the widespread use of Bt corn is that:

A. The Bt gene could spread to wild relatives of corn through cross-pollination by wind
B. The Bt gene would convert wild plants in the surrounding area into corn plants
C. The Bt corn would compete directly with humans for food in the surrounding region
D. The Bt corn would prevent any other crop from being grown on the same farmland

**24.** Insects exposed to Bt corn over many generations could potentially:

A. Develop the ability to photosynthesize like the corn plants they have been eating
B. Become significantly larger in body size to compensate for the toxic protein they consume
C. Evolve resistance to the Bt protein through natural selection if some individuals carry resistance genes
D. Transform into a new species entirely different from the original insect pest species

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

A geneticist is studying coat color in laboratory mice. The allele for black coat color (B) is dominant over the allele for brown coat color (b). The geneticist has a black mouse but does not know whether it is homozygous (BB) or heterozygous (Bb). To determine the genotype of the unknown mouse, the geneticist performs a test cross by mating the unknown black mouse with a brown mouse (which must be genotype bb, since brown is recessive). The geneticist will then examine the coat colors of the offspring produced.

**25.** If the unknown black mouse is homozygous (BB), what coat colors would be expected in the offspring of the test cross?

A. All offspring will be brown, because the brown parent's allele is dominant in all the offspring
B. All offspring will be black, because every offspring inherits at least one B allele from the parent
C. About half of the offspring will be black and about half will be brown, in roughly equal numbers
D. About one in four offspring will be brown, and three in four will be black on average

**26.** If the unknown black mouse is heterozygous (Bb), what coat colors would be expected in the offspring of the test cross?

A. All offspring will be black, because the dominant B allele will mask the recessive b allele
B. All offspring will be brown, because the homozygous brown mate provides only b alleles
C. About one in four offspring will be brown, and three in four will be black, in a 3:1 ratio
D. About half of the offspring will be black and about half will be brown, in a 1:1 ratio

**27.** The geneticist crosses the unknown black mouse with a brown mouse and obtains 8 black mice and 7 brown mice out of 15 offspring. The most likely genotype of the unknown black mouse is:

A. Heterozygous (Bb), since the appearance of brown offspring shows the parent must carry the recessive allele
B. Homozygous dominant (BB), since the dominant B allele was passed to most of the offspring in the cross
C. Homozygous recessive (bb), since some of the offspring inherited the recessive trait from the parent
D. A mixed genotype that produces different gametes during each round of meiosis it undergoes

**28.** A test cross is most useful for:

A. Determining whether a particular gene is located on a sex chromosome or autosome
B. Identifying whether a trait shows complete dominance or incomplete dominance in offspring
C. Determining whether an individual showing a dominant trait is homozygous or heterozygous
D. Identifying the chromosomal location of the gene controlling a particular physical trait

**29.** If the geneticist crossed the unknown black mouse with a brown mouse and obtained 20 black mice and 0 brown mice, the most likely conclusion is that the unknown black mouse is:

A. Heterozygous (Bb), since dominant alleles always produce only dominant offspring in any cross
B. Homozygous (BB), since no recessive offspring appeared in the 20 mice produced from the cross
C. Unable to be classified, because 20 offspring is far too few to determine its genotype
D. Carrying a mutation that has changed the way coat color is inherited in this mouse line

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

On the Hawaiian Islands, a single ancestral species of finch-like bird arrived from another part of the world thousands of years ago. The descendants of this ancestral species have since evolved into more than 50 different bird species, each with a different beak shape adapted to a specific food source. Some species have short, thick beaks for cracking seeds; others have long, curved beaks for sipping nectar from flowers; still others have sharp, slender beaks for catching insects. Many of these species are found only in Hawaii and nowhere else on Earth. The collective name for this group of related species is the Hawaiian honeycreepers.

**30.** The diversification of one ancestral bird species into many different species on the Hawaiian Islands is an example of:

A. Convergent evolution, in which unrelated species develop similar traits in similar environments
B. Genetic engineering, in which scientists deliberately modify the DNA of a species in a lab
C. Parallel evolution, in which related species in different places develop different traits at the same rate
D. Adaptive radiation, in which one ancestral species diversifies into many species filling different niches

**31.** The different beak shapes found in modern Hawaiian honeycreepers most likely arose through:

A. Natural selection, as different food sources favored individuals with different beak shapes
B. Acquired traits passed from individual birds to their offspring within a single lifetime
C. The deliberate efforts of farmers in Hawaii to develop different bird varieties for hunting purposes
D. Random changes in beak shape that occurred at the exact same time in every species

**32.** The fact that most Hawaiian honeycreeper species are found only in Hawaii is best described as:

A. Convergent evolution, in which unrelated species develop similar features in similar environments
B. Cosmopolitan distribution, in which a species is found in many different regions of the world
C. Endemism, in which a species is found naturally in only one specific geographic location
D. Parasitism, in which one organism benefits at the expense of another in the same place

**33.** A short, thick beak well-suited to cracking seeds is an example of:

A. A vestigial structure, which is a remnant of a feature used by an ancestor in the past
B. A homologous structure, which is inherited from a recent common ancestor of the species
C. An analogous structure, which independently evolved in completely unrelated species
D. An adaptation, a heritable trait that improves survival or reproduction in a specific environment

**34.** Adaptive radiation tends to occur most rapidly when a population:

A. Lives in a stable, unchanging environment with no available unoccupied ecological niches
B. Colonizes a new environment containing many unfilled niches and few competing species
C. Is in close competition with many other established species occupying the same area
D. Has very low genetic variation among its members, making natural selection ineffective

**35.** Several Hawaiian honeycreeper species have gone extinct in recent decades. The primary cause of these extinctions is most likely:

A. Human-related factors, including habitat destruction, introduced predators, and introduced diseases
B. The natural process of speciation, which always leads quickly to the extinction of new species
C. Bird flu epidemics that have spread directly through the population from outside Hawaii
D. The complete absence of any food sources for the birds on the Hawaiian Islands

**36.** The Hawaiian honeycreepers and Darwin's Galápagos finches are similar in that both:

A. Were originally domesticated by humans before being released into the wild
B. Underwent migration from Hawaii to the Galápagos Islands over millions of years
C. Are members of exactly the same biological species despite their different locations
D. Demonstrate adaptive radiation following colonization of new island ecosystems

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

Wetlands are areas where water saturates the soil for at least part of the year. Major types include swamps, marshes, and bogs. Wetlands provide many ecological services: they support unique biodiversity (including many endangered species), filter pollutants from water passing through, store carbon in their soils, buffer coastal areas from storms, and provide breeding grounds for fish and birds. Despite their importance, wetlands have been drained or filled in over much of the world for agriculture, urban development, and other human uses. The United States has lost approximately half of its original wetlands since European settlement began.

**37.** Which of the following is NOT a benefit that wetlands provide to humans and ecosystems?

A. Filtering pollutants from water that passes through wetland soil and vegetation
B. Buffering coastal communities from the destructive effects of large storms
C. Increasing the average rate of soil erosion across nearby agricultural fields
D. Storing significant amounts of carbon in wetland soils and plant biomass

**38.** Wetlands are valuable for biodiversity because they:

A. Contain very few species but each in extremely large numbers of individuals
B. Support unique communities of plants and animals adapted to wet conditions
C. Are colonized only by invasive species that drive out native organisms
D. Prevent the establishment of any breeding grounds for fish and waterbirds

**39.** The destruction of wetlands for agriculture and urban development can lead to:

A. Increased flooding in nearby areas because wetlands no longer absorb excess water
B. Improved water quality in nearby streams due to faster water flow off the cleared land
C. Increased populations of endangered species that depend on wetland habitats for survival
D. Lower atmospheric CO2 levels as drained soils stop releasing stored carbon to the air

**40.** The carbon stored in wetland soils is released into the atmosphere when:

A. New wetland plants are added to the area and begin photosynthesizing actively
B. The wetland is protected and allowed to remain in its natural undisturbed state
C. Wetland animals undergo cellular respiration during their normal life activities
D. Wetlands are drained, exposing peat and organic-rich soils to oxygen for decomposition

**41.** Restoring previously drained wetlands can help combat climate change because:

A. Restored wetlands release stored carbon back into the atmosphere very quickly
B. Restored wetlands prevent the growth of any plants that could absorb CO2
C. Restored wetlands accumulate organic matter, removing CO2 from the atmosphere
D. Restored wetlands warm the surrounding air, helping regulate global climate patterns

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

An endangered species is one that is at serious risk of becoming extinct in the near future. Causes of endangerment include habitat destruction, hunting or overharvesting, climate change, pollution, introduced invasive species, and disease. The decline of a species can disrupt ecosystem function, eliminate unique genetic resources, and represent a permanent loss of biological history. Conservation efforts include legal protections (such as the U.S. Endangered Species Act), protected habitats, captive breeding programs, and the reintroduction of species into the wild. Some species, like the bald eagle and the gray wolf, have recovered after such protections; others remain at high risk.

**42.** The primary cause of species endangerment worldwide is:

A. Habitat destruction by human activities, such as farming, logging, and urban development
B. Predation by natural predators that consume a high percentage of each species daily
C. Genetic mutations that produce harmful traits in individuals across all species
D. Natural disasters, such as occasional earthquakes and volcanic eruptions, in local areas

**43.** The U.S. Endangered Species Act helps protect at-risk species by:

A. Allowing unlimited hunting and harvesting of all endangered species during certain seasons
B. Making it illegal to harm, harass, or kill endangered species without specific permits

C. Encouraging the deliberate introduction of new invasive species to support ecosystems
D. Promoting the destruction of habitats where endangered species are found in the wild

**44.** A captive breeding program is most useful for protecting an endangered species when:

A. The species is already so abundant in the wild that no further protection is required
B. The species has been completely eliminated from every captive setting in zoos
C. The species's natural habitat is fully restored to its pre-disturbance condition
D. Wild populations have become so small that genetic diversity is at risk of being lost

**45.** The recovery of the bald eagle population in the United States illustrates that:

A. Endangered species cannot be saved once their populations have started to decline significantly
B. Conservation laws are ineffective and cannot influence wild populations over time
C. With protection and addressing the causes of decline, endangered species can recover
D. Bald eagle populations naturally fluctuate without any human intervention required

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

The endocrine system is a network of glands that produces hormones — chemical messengers that travel through the bloodstream to target cells throughout the body. Hormones regulate many body processes, including growth, metabolism, reproduction, stress response, and blood sugar levels. Major endocrine glands include the pituitary (often called the "master gland"), thyroid, adrenal, pancreas, and gonads (ovaries and testes). Hormones generally act much more slowly than nerve signals but produce longer-lasting effects. Disorders of the endocrine system, such as diabetes (impaired insulin function) and hypothyroidism (insufficient thyroid hormone), can have wide-ranging effects on health.

**46.** Hormones in the human body are best classified as:

A. Chemical messengers that travel through the bloodstream from glands to target cells
B. Electrical signals that travel along the neurons of the central nervous system
C. Structural proteins that hold together the cells of various body tissues
D. Digestive enzymes that break down food molecules in the small intestine

**47.** The pituitary gland is often called the "master gland" because it:

A. Produces all of the hormones that the human body uses for regulating its activities
B. Releases hormones that regulate the activity of several other endocrine glands
C. Is the largest gland in the human body in terms of both weight and size
D. Functions independently of all other body systems and produces no chemicals

**48.** Hormones generally differ from nerve impulses in that hormones:

A. Travel much faster than nerve impulses but produce shorter-lasting effects in the body
B. Use exclusively electrical signaling to communicate with cells throughout the body
C. Travel more slowly than nerve impulses but tend to produce longer-lasting effects
D. Can only travel to cells that are physically very close to the gland that releases them

**49.** A person with diabetes mellitus has impaired function of which of the following hormones?

A. Estrogen, produced by the ovaries to regulate the menstrual cycle in females
B. Adrenaline, produced by the adrenal glands during stressful or dangerous situations
C. Thyroid hormone, produced by the thyroid gland to regulate the body's metabolism
D. Insulin, produced by the pancreas to regulate blood glucose concentration

**50.** A person with hypothyroidism (insufficient thyroid hormone) would most likely experience:

A. A slowed metabolism, fatigue, weight gain, and sensitivity to cold temperatures
B. An increased metabolism, rapid weight loss, and sensitivity to hot temperatures
C. Greatly increased height and bone growth, far beyond normal human stature
D. A complete loss of immune function, allowing many infections to take hold quickly

# PRACTICE EXAM 27 – EXPLAINED ANSWER KEY (Q1–Q50)

**1. D** — Endocytosis is the active uptake of large materials into the cell by inward folding of the membrane to form a vesicle. White blood cells use a specific form called phagocytosis to engulf bacteria. The other listed processes move only small molecules or water and cannot account for capturing whole bacteria.

**2. C** — Lysosomes contain hydrolytic enzymes that break down macromolecules and engulfed materials at low pH. Their fusion with a vesicle containing bacteria delivers these enzymes to digest the trapped microbe. This intracellular digestion is a major cellular defense against bacterial infection.

**3. B** — Exocytosis is the reverse of endocytosis: a vesicle fuses with the plasma membrane and releases its contents to the outside of the cell. This is how digested waste, hormones, and neurotransmitters are exported. The other listed processes either bring material in or move only small dissolved molecules.

**4. A** — Bulk transport refers to the mass movement of large quantities of material across the membrane in vesicles, which is what both endocytosis and exocytosis accomplish. They are energy-requiring processes, distinct from passive transport. This bulk handling is essential for cells that ingest or secrete large molecules.

**5. C** — White blood cells engulfing and destroying bacteria are part of the immune system's first line of cellular defense. The other body systems serve different functions — digestion, circulation, nervous control — and do not actively target pathogens. Phagocytosis by leukocytes is a key step in clearing infections.

**6. B** — Setup 2 (enzyme + substrate + cofactor) gave by far the highest rate (48 μmol/min), showing that maximum activity requires both components together. The cofactor alone or substrate alone cannot drive the reaction. This is typical of many metabolic enzymes that depend on metal ions or coenzymes derived from vitamins.

**7. D** — The 5 μmol/min rate in Setup 1 shows that the enzyme has some residual activity without its cofactor, but only about 10% of its full rate. Adding the cofactor raised activity nearly tenfold. The cofactor is therefore needed for full normal function but not for any function at all.

**8. A** — Removing the cofactor entirely eliminated activity, proving the cofactor is essential for the enzyme to work. Setup 3's zero rate marks the cofactor as obligatory in this enzymatic reaction. Many real enzymes lose all measurable activity when their metal ions or coenzymes are stripped away.

**9. C** — Vitamins are precursors for many coenzymes; a vitamin deficiency leaves the corresponding enzymes without their helpers and slows or stops the reactions they catalyze. The body cannot compensate by making more of the affected enzyme. This is why specific deficiency diseases (such as scurvy, pellagra, and beriberi) produce predictable symptom patterns.

**10. B** — Many vitamins are themselves coenzymes (such as folate and vitamin B12) or are converted into coenzymes (such as niacin into $NAD^+$). Without these dietary inputs, the body cannot make the cofactors its enzymes need. This is why vitamins are required in only small amounts but are nutritionally essential.

**11. A** — Germination occurred in both light and dark conditions when water was provided at room temperature, so light is not required. Without water (Condition 3) or at low temperature (Condition 4), germination essentially failed. The two essential needs revealed are adequate water and adequate warmth.

**12. D** — Condition 3 used a dry paper towel, providing no water for the seeds, and no germination occurred. Seeds must absorb water to swell and activate the metabolic machinery of germination. This dry condition therefore isolates water as a necessary factor.

**13. B** — Enzyme reactions slow dramatically at low temperatures because molecules move more slowly and collide less often. At 4°C, the metabolic processes needed for germination are too slow to start, even though water is present. This is also why seeds can be stored for years in cool dry conditions without sprouting.

**14. C** — In Conditions 1 and 2, both groups had 9 of 10 seeds germinate; the only difference was light versus dark. Equal results show that light is not necessary for bean seed germination. Many seeds — including bean seeds — germinate fine in soil, where it is completely dark.

**15. A** — Seeds store food (typically starches, lipids, or proteins) in tissues such as the endosperm or cotyledons. The seedling uses this stored energy to grow until its first leaves can begin photosynthesis. This is why germinating cereal grains have long been a major human food source.

**16. D** — The electron transport chain is embedded in the inner mitochondrial membrane, so folding that membrane into cristae multiplies the area available for ATP-producing complexes. More surface area

means more ATP can be made per mitochondrion. Cells with high energy demands have especially extensive cristae.

**17. C** — Mitochondria's own circular DNA, their own ribosomes, and their double membrane all resemble bacterial features. The simplest explanation is that mitochondria descended from a free-living bacterium engulfed by an ancestral eukaryotic cell. This is the endosymbiotic theory.

**18. B** — Most of the cell's ATP is produced in mitochondria via the electron transport chain. Damaged mitochondria therefore yield far less ATP, even if glycolysis continues normally. Cells with high energy demands, such as muscle and neurons, are especially affected by mitochondrial dysfunction.

**19. A** — The endosymbiotic theory proposes that mitochondria (and chloroplasts) originated as free-living bacteria that came to live inside larger ancestral cells. Their own DNA, own ribosomes, and double membrane support this hypothesis. The theory was popularized by Lynn Margulis in the 1960s and is now widely accepted.

**20. C** — A GMO is an organism whose genome has been deliberately altered using genetic engineering, typically by inserting DNA from another species. This differs from selective breeding (slow, between members of the same species) and from radiation-induced mutation. Modern recombinant DNA techniques make GMO production routine.

**21. D** — A bacterial gene placed in a corn plant still produces its protein because all known organisms read the same triplet codon code. This universality of the genetic code is among the strongest pieces of evidence for the common ancestry of all life. It is also what makes genetic engineering across species possible.

**22. B** — Because Bt corn produces its own insecticidal protein, farmers spray fewer chemical pesticides over the field. This saves money and reduces farmworker exposure to broad-spectrum chemicals. Reduced pesticide use is one of the most often-cited benefits of Bt crops.

**23. A** — Bt corn can cross-pollinate with related wild grasses, potentially spreading the Bt gene into wild populations where its ecological effects are unpredictable. This is one of several ecological concerns regulators consider before approving GMOs. Gene flow has been documented in several other crops as well.

**24. C** — Heavy use of Bt corn applies strong selection pressure: any rare individuals with mutations conferring resistance to the Bt protein survive and reproduce. Over generations, resistance can spread through the pest population. This is the same evolutionary process by which insects evolve resistance to chemical pesticides.

**25. B** — A homozygous BB parent supplies only B alleles, while the brown parent supplies only b alleles. Every offspring is therefore Bb — heterozygous and black in phenotype. No brown offspring should appear from this cross.

**26. D** — A heterozygous Bb parent produces equal numbers of B and b gametes, while the bb parent produces only b gametes. The cross yields half Bb (black) and half bb (brown), the classic 1:1 ratio. This is the defining outcome of a test cross with a heterozygote.

**27. A** — The appearance of brown (bb) offspring is the giveaway: a brown offspring must have received a b allele from each parent. Since one parent is the brown (bb) tester, the unknown black parent must have contributed a b — so the unknown is heterozygous Bb. The roughly 1:1 ratio also fits a Bb × bb cross.

**28. C** — A test cross specifically asks whether a dominant-looking individual is homozygous (BB) or heterozygous (Bb) by crossing it with a homozygous recessive (bb). Heterozygotes yield recessive offspring; homozygotes do not. This is the classic method developed by Mendel and still used in genetics labs today.

**29. B** — If even a single bb offspring would expose a heterozygous parent, then 20 black offspring with zero brown strongly suggests the unknown is BB. The probability of producing 20 black mice in a row from a Bb × bb cross would be $(1/2)^{20}$, essentially zero. The data therefore point firmly to homozygous BB.

**30. D** — Adaptive radiation is the rapid diversification of an ancestral lineage into many species, each adapted to a different ecological niche. The Hawaiian honeycreepers are a textbook example, just like Darwin's Galápagos finches. Island archipelagos often host striking cases because they offer many empty niches.

**31. A** — Different available foods favored individuals with beaks better suited to those foods, and these individuals left more offspring. Over generations, beaks specialized for different niches. This is natural selection in action.

**32. C** — Endemism refers to species that occur naturally in only one geographic location. The Hawaiian honeycreepers — most of which exist only in Hawaii — are a classic example. Endemic species are often especially vulnerable to extinction because their populations cannot recover from elsewhere.

**33. D** — An adaptation is any heritable trait that improves an organism's chances of surviving and reproducing in its environment. A seed-cracking beak fits this definition precisely. The other terms describe historical relationships among structures, not specifically advantageous traits.

**34. B** — Adaptive radiation accelerates when a population reaches an environment full of unoccupied niches and few competitors. Islands and post-mass-extinction recoveries are classic examples. Crowded, stable environments rarely produce explosive radiations.

**35. A** — Native Hawaiian birds face habitat loss, introduced predators (such as rats and cats), and avian malaria spread by introduced mosquitoes — all human-related pressures. These factors have driven many honeycreepers extinct and threatened many more. Conservation work in Hawaii now focuses on controlling introduced species and preserving remaining habitats.

**36. D** — Both groups of birds descended from an ancestral colonist that reached an island archipelago and diversified into many specialized species filling different niches. The parallel between the two cases is

one reason adaptive radiation is so well documented. They are independent examples of the same evolutionary pattern.

**37. C** — Wetlands actually reduce erosion in surrounding lands by absorbing runoff and stabilizing soils with their vegetation. Increased erosion is therefore not a wetland benefit, making C the "NOT" answer. The other three options accurately describe real wetland services.

**38. B** — Wetland soils, water, and vegetation create unique habitats supporting plants and animals not found elsewhere. Many threatened and endangered species depend on these specialized conditions. Wetland loss therefore eliminates entire communities of organisms.

**39. A** — Intact wetlands act as natural sponges, absorbing rainfall and runoff and releasing it slowly. When they are drained, water moves more quickly through the landscape, raising peak flood levels in nearby areas. This is one reason wetland restoration is increasingly seen as part of flood management.

**40. D** — When wetlands are drained, peat and other organic-rich soils that had been waterlogged are exposed to oxygen, allowing decomposer microbes to break down the stored carbon and release CO2. Drained wetlands can therefore become large net emitters of greenhouse gases. This is why restoring wetlands is now an active climate strategy.

**41. C** — In wet conditions, organic matter accumulates because decomposition is slow under low-oxygen conditions. Restoring wetlands recreates these conditions and pulls CO2 from the atmosphere into the growing plant biomass and soil carbon stores. The net effect is removal of CO2 from the atmosphere.

**42. A** — Habitat destruction — primarily through agriculture, logging, and urban development — is the leading cause of biodiversity loss worldwide. When an organism's home is destroyed, no behavioral change can compensate. Habitat protection is therefore the single most effective conservation tool.

**43. B** — The Endangered Species Act makes it unlawful to "take" listed species (kill, harm, harass, etc.) without specific authorization and requires the protection of critical habitat. It has been credited with saving multiple species from extinction. Compliance and enforcement are key to its effectiveness.

**44. D** — Captive breeding is most valuable when wild populations have shrunk to the point where chance events and inbreeding threaten remaining genetic diversity. Maintaining a genetically diverse captive population safeguards the species and provides individuals for future reintroduction. The California condor and black-footed ferret are well-known examples.

**45. C** — The bald eagle's recovery from near-extinction (caused mainly by DDT and habitat loss) followed the banning of DDT and protection under the Endangered Species Act. By removing the cause of decline and protecting remaining birds, populations rebounded over several decades. The species was eventually removed from the endangered species list in 2007.

**46. A** — Hormones are chemical messengers secreted by endocrine glands into the bloodstream, which delivers them to distant target cells bearing matching receptors. This long-distance chemical signaling is fundamentally different from electrical signaling along neurons. Recognizing hormones as bloodborne chemicals is foundational to understanding endocrine physiology.

**47. B** — The anterior pituitary releases hormones (such as TSH, ACTH, FSH, and LH) that direct the activity of the thyroid, adrenal cortex, ovaries, and testes. By controlling these other endocrine glands, the pituitary occupies a master role in the system. The hypothalamus, in turn, controls the pituitary.

**48. C** — Endocrine signaling takes seconds to minutes to reach target cells through the bloodstream, much slower than the millisecond timescale of nerve impulses. However, hormones can persist in circulation and produce effects that last hours, days, or even longer. This complementary slow-but-lasting design is well-suited to maintaining long-term homeostasis.

**49. D** — Diabetes mellitus results from either insufficient insulin production (type 1) or reduced cell response to insulin (type 2). In both cases, insulin signaling fails and blood glucose remains elevated. Recognizing insulin as the affected hormone is central to understanding diabetes.

**50. A** — Thyroid hormone sets the body's metabolic rate, so insufficient levels (hypothyroidism) slow nearly every metabolic process. Patients typically feel tired, gain weight despite normal eating, and feel cold easily. Hyperthyroidism (excess thyroid hormone) produces the opposite pattern of symptoms.