

# Biology 9<sup>th</sup> Grade

## Comprehensive Assessment

### STUDENT INSTRUCTIONS & TEST DETAILS

- Student Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class Period: \_\_\_\_\_
- Total Questions: 20 Multiple-Choice Questions (4 answer choices each).
- Topics: Cell Biology, Cell Energetics, Molecular Genetics, Mendelian Inheritance, Ecology & Evolution.
- Instructions: Choose the best answer for each question. A full answer key with explanations is at the end.

#### Question 1 [Cell Structure & Function]

Which organelle is primarily responsible for generating cellular energy in the form of adenosine triphosphate (ATP) through cellular respiration?

- A) Ribosome
- B) Mitochondrion
- C) Golgi apparatus
- D) Lysosome

#### Question 2 [Cell Transport]

What is the process called when water molecules diffuse across a selectively permeable membrane from an area of higher water concentration to lower water concentration?

- A) Active transport
- B) Facilitated diffusion
- C) Osmosis
- D) Endocytosis

#### Question 3 [Cell Biology]

Which of the following cellular structures is present in plant cells but absent in typical animal cells?

- A) Mitochondria
- B) Endoplasmic reticulum
- C) Cell wall
- D) Nucleus



**Question 4** [Biomolecules & Enzymes]

Enzymes are specialized biological catalysts that speed up chemical reactions in living organisms by:

- A) Lowering the activation energy required for the reaction
- B) Raising the overall temperature of the cell
- C) Permanently changing into the reaction products
- D) Increasing the free energy change ( $\Delta G$ ) of the reaction

**Question 5** [Cell Energetics]

During photosynthesis, what are the primary reactants utilized by autotrophs to synthesize glucose and oxygen?

- A) Glucose and carbon dioxide
- B) Carbon dioxide and water (with light energy)
- C) Oxygen and water
- D) ATP and lactic acid

**Question 6** [Cell Division]

In which phase of the eukaryotic cell cycle is genetic material (DNA) replicated prior to mitosis?

- A) G1 phase
- B) S (Synthesis) phase
- C) Prophase
- D) Cytokinesis

**Question 7** [Cell Division & Reproduction]

How does meiosis differ fundamentally from mitosis regarding chromosome number and daughter cells?

- A) Meiosis produces 2 genetically identical diploid cells
- B) Meiosis produces 4 genetically identical diploid cells
- C) Meiosis produces 4 genetically unique haploid gametes
- D) Meiosis produces 2 genetically unique diploid cells

**Question 8** [Molecular Genetics]

According to Chargaff's rules of base pairing in double-stranded DNA, adenine (A) pairs with thymine (T), and cytosine (C) pairs with:



- A) Uracil (U)
- B) Guanine (G)
- C) Adenine (A)
- D) Thymine (T)

**Question 9** [Protein Synthesis]

What process involves copying a DNA gene sequence into a complementary messenger RNA (mRNA) strand inside the eukaryotic nucleus?

- A) Transcription
- B) Translation
- C) Replication
- D) Translocation

**Question 10** [Protein Synthesis]

A sequence of three consecutive nucleotides on an mRNA strand that specifies a particular amino acid is called a(n):

- A) Anticodon
- B) Peptide bond
- C) Codon
- D) Promoter

**Question 11** [Mendelian Genetics]

In pea plants, tall stem height (T) is dominant over short stem height (t). If two heterozygous tall plants ( $Tt \times Tt$ ) are crossed, what is the expected phenotypic ratio of tall to short offspring?

- A) 1 tall : 1 short
- B) 3 tall : 1 short
- C) 2 tall : 2 short
- D) 4 tall : 0 short

**Question 12** [Genetics & Heredity]

An organism that possesses two identical alleles for a particular trait (e.g., BB or bb) is described as:

- A) Heterozygous
- B) Homozygous
- C) Polygenic



D) Codominant

**Question 13** [Ecology & Energy Flow]

Approximately what percentage of energy is transferred from one trophic level to the next higher trophic level in an ecological pyramid?

- A) 1%
- B) 10%
- C) 50%
- D) 90%

**Question 14** [Ecology & Symbiosis]

A symbiotic interaction in which one organism benefits while the other organism is neither helped nor harmed is known as:

- A) Mutualism
- B) Parasitism
- C) Commensalism
- D) Predation

**Question 15** [Biogeochemical Cycles]

Certain bacteria in soil and root nodules convert atmospheric nitrogen gas ( $N_2$ ) into usable ammonia through a critical process called:

- A) Denitrification
- B) Nitrogen fixation
- C) Photosynthesis
- D) Ammonification

**Question 16** [Evolution & Natural Selection]

Which mechanism of evolution was proposed by Charles Darwin as the process whereby organisms best adapted to their environment tend to survive and produce more offspring?

- A) Artificial selection
- B) Natural selection
- C) Genetic drift
- D) Gene flow



**Question 17** [Comparative Anatomy & Evolution]

The forelimbs of humans, whales, and bats share similar skeletal architecture despite performing distinct functions. These anatomical features are examples of:

- A) Homologous structures
- B) Analogous structures
- C) Vestigial structures
- D) Convergent adaptations

**Question 18** [Classification & Taxonomy]

Which taxonomic category represents the broadest and most inclusive level of biological classification?

- A) Kingdom
- B) Phylum
- C) Domain
- D) Class

**Question 19** [Cell Homeostasis]

If an animal red blood cell is placed in a hypertonic solution (high salt concentration), what will happen to the cell?

- A) It will swell and burst (lyse)
- B) It will lose water and shrivel (crenate)
- C) It will take in solutes and maintain constant volume
- D) It will remain unchanged because water does not move

**Question 20** [Ecology & Population Dynamics]

What ecological term describes the maximum population size of a species that a specific environment can sustainably support over time?

- A) Limiting factor
- B) Biotic potential
- C) Carrying capacity
- D) Exponential threshold



# ANSWER KEY & EXPLANATIONS

## Answer Key

| Q# | Ans      | Q#  | Ans      | Q#  | Ans      | Q#  | Ans      |
|----|----------|-----|----------|-----|----------|-----|----------|
| #1 | <b>B</b> | #6  | <b>B</b> | #11 | <b>B</b> | #16 | <b>B</b> |
| #2 | <b>C</b> | #7  | <b>C</b> | #12 | <b>B</b> | #17 | <b>A</b> |
| #3 | <b>C</b> | #8  | <b>B</b> | #13 | <b>B</b> | #18 | <b>C</b> |
| #4 | <b>A</b> | #9  | <b>A</b> | #14 | <b>C</b> | #19 | <b>B</b> |
| #5 | <b>B</b> | #10 | <b>C</b> | #15 | <b>B</b> | #20 | <b>C</b> |

## Detailed Explanations & Biological Concepts

### Question 1 — Correct Answer: **B** (Mitochondria & Cellular Respiration)

- Mitochondria are often referred to as the 'powerhouses of the cell.'
- They break down nutrient molecules (such as pyruvate derived from glucose) in the presence of oxygen through the Krebs cycle and oxidative phosphorylation.
- This process synthesizes abundant ATP molecules, providing energy for active cellular work.
- Ribosomes assemble proteins, the Golgi modifies/packages proteins, and lysosomes degrade waste.

### Question 2 — Correct Answer: **C** (Osmosis & Passive Transport)

- Osmosis is defined specifically as the passive diffusion of water molecules across a selectively permeable membrane.
- Water moves from an area of higher water concentration (lower solute concentration) to an area of lower water concentration (higher solute concentration).
- Active transport requires energy (ATP) to move molecules against a concentration gradient, which is not required during osmosis.

### Question 3 — Correct Answer: **C** (Plant vs. Animal Cell Structures)

- Plant cells have a rigid outer cell wall composed predominantly of cellulose fibers that provides structural support and protection.
- Animal cells lack a cell wall; they possess only a flexible phospholipid bilayer cell membrane.



- Both plant and animal cells contain nuclei, mitochondria, and endoplasmic reticulum.

**Question 4 — Correct Answer: A** (Enzyme Kinetics & Activation Energy)

- Enzymes are protein catalysts that accelerate biochemical reactions without being consumed or altered permanently.
- They function by binding substrates at their active site and lowering the activation energy barrier necessary to convert substrates into products.
- Enzymes do not alter the overall free energy change ( $\Delta G$ ) or temperature of the biological system.

**Question 5 — Correct Answer: B** (Photosynthesis Chemical Equation)

- Photosynthesis is summarized by the chemical equation:  $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ .
- Autotrophic organisms (plants, algae) absorb carbon dioxide from the air and water through root systems, converting solar energy into chemical energy stored in glucose bonds.

**Question 6 — Correct Answer: B** (Cell Cycle Phases)

- The cell cycle consists of Interphase (G1, S, G2) followed by the M phase (mitosis and cytokinesis).
- During the S (Synthesis) phase of Interphase, the cell replicates its entire nuclear genome so that each chromosome consists of two identical sister chromatids.
- G1 focuses on cell growth and protein synthesis; G2 involves final preparations for division.

**Question 7 — Correct Answer: C** (Meiosis vs. Mitosis Comparison)

- Mitosis consists of one round of nuclear division producing 2 genetically identical diploid somatic cells.
- Meiosis consists of two successive nuclear divisions (Meiosis I and II) preceded by one replication round, yielding 4 genetically distinct haploid gametes (sperm/egg cells) with half the original chromosome number ( $n$ ).

**Question 8 — Correct Answer: B** (DNA Structure & Complementary Base Pairing)

- In DNA, nitrogenous bases form hydrogen bonds in specific complementary pairs: Adenine (A) pairs with Thymine (T) via two hydrogen bonds, and Cytosine (C) pairs with Guanine (G) via three hydrogen bonds.
- Uracil (U) is found in RNA rather than DNA.

**Question 9 — Correct Answer: A** (Central Dogma: Transcription)

- Transcription is the synthesis of an RNA molecule using a DNA template strand, carried out by RNA polymerase inside the nucleus.
- Translation occurs downstream in the cytoplasm at ribosomes, converting mRNA sequences into polypeptide chains (proteins).

**Question 10 — Correct Answer: C** (Genetic Code & Codons)



- A codon is a three-nucleotide sequence on mRNA that encodes a specific amino acid (or a stop signal) during protein synthesis.
- An anticodon is the complementary triplet sequence situated on a transfer RNA (tRNA) molecule that matches the codon.

**Question 11 — Correct Answer: B** (Monohybrid Cross & Punnett Square)

- Crossing two heterozygous individuals ( $Tt \times Tt$ ) gives genotypes: 1  $TT$  : 2  $Tt$  : 1  $tt$ .
- Because the  $T$  allele is completely dominant over the  $t$  allele, both  $TT$  and  $Tt$  plants display the tall phenotype (1 + 2 = 3 tall), while  $tt$  plants display the short phenotype (1 short).
- The expected phenotypic ratio is therefore 3 tall : 1 short (75% tall, 25% short).

**Question 12 — Correct Answer: B** (Genetics Terminology)

- Homozygous indicates that an individual has two identical alleles for a given gene (homozygous dominant 'BB' or homozygous recessive 'bb').
- Heterozygous describes having two different alleles for a trait (e.g., 'Bb').

**Question 13 — Correct Answer: B** (The 10% Rule in Ecology)

- According to Lindeman's efficiency rule (the 10% Rule), only approximately 10% of the energy stored as biomass in one trophic level is passed to the next level.
- The remaining roughly 90% is lost to the environment as metabolic heat or remains unassimilated (waste/undigested material).

**Question 14 — Correct Answer: C** (Symbiotic Relationships)

- Commensalism (+/0) is a symbiotic relationship where one species benefits and the other species experiences neutral impact (neither harmed nor benefited), such as barnacles attaching to whales.
- Mutualism (+/+) benefits both species, and parasitism (+/-) harms the host.

**Question 15 — Correct Answer: B** (Nitrogen Cycle)

- Atmospheric nitrogen ( $N_2$ ) has a strong triple covalent bond that plants cannot directly break down.
- Nitrogen fixation is performed by specialized bacteria (such as *Rhizobium* in legume root nodules) that reduce  $N_2$  gas into ammonia ( $NH_3/NH_4^+$ ), making nitrogen bioavailable to primary producers.

**Question 16 — Correct Answer: B** (Natural Selection & Adaptation)

- Natural selection describes differential reproductive success among individuals possessing heritable variations that enhance fitness in a specific environment.
- Over successive generations, adaptive traits become more prevalent within the population.



**Question 17 — Correct Answer: A** (*Evidence for Evolution: Homology*)

- Homologous structures are anatomical features in different organisms that share common ancestral evolutionary origins and developmental patterns, even if their current functions differ (e.g., human arm, whale flipper, bat wing).
- Analogous structures share similar functions but evolved independently through convergent evolution (e.g., bird wing vs. insect wing).

**Question 18 — Correct Answer: C** (*Taxonomic Hierarchy*)

- The standard modern hierarchy of classification from broadest to most specific is: Domain → Kingdom → Phylum → Class → Order → Family → Genus → Species.
- The three overarching domains of life are Archaea, Bacteria, and Eukarya.

**Question 19 — Correct Answer: B** (*Tonicity & Cell Osmoregulation*)

- In a hypertonic extracellular environment, the solute concentration outside the cell is greater than inside the cell cytoplasm.
- Water leaves the cell down its concentration gradient through osmosis, causing the animal red blood cell to dehydrate, shrivel, and undergo crenation.

**Question 20 — Correct Answer: C** (*Population Ecology: Carrying Capacity*)

- Carrying capacity (designated as 'K') is the maximum population size that a specific ecosystem's available resources (food, water, territory, shelter) can sustain indefinitely.
- When populations approach carrying capacity, environmental resistance and density-dependent factors slow down growth from exponential to logistic.

