Introduction to Biology

Cell Biology and Genetics Quiz – Answer Key

1. **(C) Mitochondrion.** Mitochondria are the "powerhouses" of the cell, generating ATP through oxidative phosphorylation in cellular respiration.

2. **(C) Transcription.** Transcription occurs in the nucleus where RNA polymerase reads DNA and synthesizes complementary mRNA. Translation (protein synthesis) occurs at ribosomes.

3. **(B) 50%.** Punnett square: Tt × tt yields Tt, Tt, tt, tt offspring—50% heterozygous tall (Tt), 50% homozygous short (tt).

4. **(C) Protein synthesis.** Protein synthesis occurs at ribosomes (in cytoplasm and on rough ER). The cell membrane regulates transport, signaling, and adhesion.

5. **(C) Anaphase.** During anaphase, the centromeres split and sister chromatids are pulled to opposite poles by spindle fibers.

6. **False.** Prokaryotes (bacteria and archaea) lack membrane-bound organelles. They have no nucleus, mitochondria, or other membrane-enclosed structures—only ribosomes and a nucleoid region.

7. **True.** Meselson and Stahl demonstrated semi-conservative replication. Each daughter DNA molecule retains one parental strand paired with one newly synthesized strand.

8. **False.** Mutations can be harmful, neutral, or beneficial. Beneficial mutations provide raw material for evolution through natural selection. Many mutations have no phenotypic effect.

9. **Structure:** DNA is a double helix of two antiparallel polynucleotide strands. Each strand has a sugar-phosphate backbone with nitrogenous bases projecting inward. The four bases are adenine (A), thymine (T), guanine (G), and cytosine (C).

   Complementary base pairing: Hydrogen bonds connect bases between strands—A pairs with T (2 H-bonds), G pairs with C (3 H-bonds). This specificity means each strand contains information to reconstruct the other.

   Structure-function relationships:

   - *Information storage:* The sequence of bases encodes genetic information in codons (triplets specifying amino acids)
   - *Replication:* Complementarity allows accurate copying—each strand templates synthesis of its partner
   - *Stability:* Double helix and H-bonds protect genetic information; sugar-phosphate backbone resists hydrolysis
   - *Accessibility:* Helix can unwind for transcription and replication

10. **Mitosis:**

    - One division producing two diploid (2n) daughter cells

- Daughter cells are genetically identical to parent
- Purpose: growth, repair, asexual reproduction
- Occurs in somatic (body) cells

Meiosis:

- Two divisions producing four haploid (n) daughter cells
- Daughter cells are genetically unique
- Purpose: produce gametes for sexual reproduction
- Occurs in germ cells (gonads)

Sources of genetic variation in meiosis:

(1) *Crossing over:* During prophase I, homologous chromosomes exchange segments, creating new allele combinations.

(2) *Independent assortment:* Homologous pairs orient randomly at metaphase I; with 23 pairs, 2^{23} (>8 million) combinations are possible.

(3) *Random fertilization:* Any sperm can fertilize any egg, multiplying variation.

Why mitosis lacks variation: No homologous pairing, no crossing over, sister chromatids (identical copies) separate rather than homologs.