GENERAL

life science cell unit study guide schcl

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Life Science Cell Unit Study Guide SCHCL

Welcome to your definitive study guide for the Life Science Cell Unit, specifically tailored for students enrolled in SCHCL (State College High School). Whether you're preparing for a mid term, a final exam, or a standardized test, this comprehensive resource covers every topic you need to master—from the basic structure of a cell to the complex processes that keep living organisms alive.

Why the Cell Unit Is the Cornerstone of Life Science

In biology, the cell is the fundamental unit of life. Understanding its structure, function, and the processes that occur within it provides the foundation for all higher-level concepts in genetics, physiology, and ecology. The SCHCL curriculum emphasizes:

- Cell structure and organelles
- Cellular respiration and photosynthesis
- Cell division (mitosis and meiosis)
- Genetic inheritance and DNA replication
- Cell communication and signaling pathways

Mastering these topics not only helps you excel in exams but also equips you with a deeper appreciation for the complexity of living systems.

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1. Cell Structure and Organelles

1.1 The Cell as a Mini World

Every living organism is made up of cells, which can be **prokaryotic** (lacking a nucleus, e.g., bacteria) or **eukaryotic**(possessing a nucleus and membrane-bound organelles, e.g., plant and animal cells). The SCHCL curriculum focuses primarily on eukaryotic cells, but a brief comparison with prokaryotes helps reinforce key differences.

1.2 Key Organelles and Their Functions

- Cell Membrane: Selective barrier controlling the movement of substances in and out of the cell.

- Cell Wall (plant cells): Provides rigidity and protection.
- Nucleus: Stores genetic material (DNA) and coordinates cell activities.
- Ribosomes: Sites of protein synthesis.
- Endoplasmic Reticulum (ER)

  Rough ER – studded with ribosomes; involved in protein synthesis and modification.
- Smooth ER – synthesizes lipids and detoxifies chemicals.

1.3 Visualizing the Cell

While diagrams are not included in this text version, you can visualize the cell using the following mental map:

1. Outer boundary: Cell membrane (with embedded integral proteins).
2. For plant cells: Cell wall outside the membrane.
3. Central region: Nucleus surrounded by nuclear envelope.
4. Surrounding cytoplasm filled with organelles.

Use flashcards to memorize each organelle's name, location, and function. This visual framework will help you recall details during exams.

2. Energy Production: Respiration and Photosynthesis

2.1 Cellular Respiration – The Energy Factory

Cellular respiration is the process by which cells convert glucose into ATP (adenosine triphosphate), the universal energy currency. It occurs in three main stages:

1. Glycolysis – Occurs in the cytoplasm; breaks down glucose into pyruvate, producing 2 ATP and 2 NADH.
2. Krebs Cycle (Citric Acid Cycle) – Takes place in the mitochondria; each acetyl CoA yields 3 NADH, 1 FADH ,, and 1 ATP (or GTP).
3. Electron Transport Chain (ETC) – Located in the inner mitochondrial membrane; uses NADH and FADH , to pump protons and generate ~34 ATP via oxidative phosphorylation.

Key points for SCHCL:

- Total ATP yield from one glucose molecule: ~36–38 ATP.
- Oxygen is the final electron acceptor; without it, the ETC stalls.
- Anaerobic respiration (fermentation) occurs in the absence of oxygen, yielding only 2 ATP.

2.2 Photosynthesis – Harnessing Light Energy

Photosynthesis takes place in plant chloroplasts and involves two main stages:

1. Light Dependent Reactions – Capture light energy to produce ATP and NADPH; water is split, releasing oxygen.
2. Calvin Cycle (Light Independent Reactions) – Uses ATP and NADPH to fix CO , into glucose.

Important equations for SCHCL:

- Overall reaction: 6 CO , + 6 H ,O + light energy !' C †H • ,O † + 6 O ,
- Key pigments: Chlorophyll a and b; carotenoids.

2.3 Comparing Respiration and Photosynthesis

Both processes involve the transfer of electrons but in opposite directions:

- Photosynthesis: Light energy !' chemical energy (glucose).

- Respiration: Chemical energy (glucose) !’ usable energy (ATP).

Understanding this cycle is crucial for grasping how ecosystems maintain energy flow.

3. Cell Division: Mitosis and Meiosis

3.1 Mitosis – Growth and Repair

Mitosis is the process by which a single cell divides to produce two genetically identical daughter cells. It consists of five phases:

1. Prophase – Chromatin condenses into visible chromosomes; nucleolus disappears.
2. Metaphase – Chromosomes align at the metaphase plate.
3. Anaphase – Sister chromatids separate and move to opposite poles.
4. Telophase – Nuclear membranes reform around each set of chromosomes.
5. Cytofission (Cytokinesis) – Cytoplasm divides, forming two distinct cells.

Key concepts for SCHCL:

- Chromosome number remains constant (diploid).
- Mitotic spindle fibers ensure accurate chromosome segregation.
- Mitotic checkpoints prevent errors.

3.2 Meiosis – Sexual Reproduction

Meiosis reduces chromosome number by half to produce haploid gametes. It includes two successive divisions (Meiosis I and II), each with the same five phases as mitosis.

1. Meiosis I – Homologous chromosomes separate.
2. Meiosis II – Sister chromatids separate.

Important outcomes:

- Four non identical daughter cells.
- Genetic variation through crossing over during prophase I.
- Independent assortment of chromosomes.

3.3 Checkpoints and Quality Control

Both mitosis and meiosis are regulated by checkpoints that monitor:

- Chromosome alignment (spindle assembly checkpoint).
- DNA integrity (DNA damage checkpoint).

Defects in these checkpoints can lead to aneuploidy or cancerous growths.

4. Genetics and DNA Replication

4.1 DNA Structure and Function

DNA is a double helix composed of nucleotides (adenine, thymine, cytosine, guanine). Complementary base pairing (A T, C G) ensures accurate replication.

4.2 DNA Replication – The Semi Conservative Mechanism

During S phase, DNA unwinds and each strand serves as a template for a new complementary strand. Key enzymes include:

- DNA helicase – Unwinds the helix.
- DNA polymerase III – Adds nucleotides.
- DNA polymerase I – Removes RNA primers and replaces them with DNA.
- Ligase – Seals nicks.

4.3 Mendelian Genetics – Laws of Inheritance

Scholars at SCHCL study the following principles:

- Law of Segregation – Alleles separate during gamete formation.
- Law of Independent Assortment – Gene pairs segregate independently.
- Dominance and Recessiveness – Some alleles mask others.

4.4 Gene Expression – From DNA to Protein

The flow of genetic information follows the **central dogma**:

1. DNA !’ RNA (transcription)
2. RNA !’ Protein (translation)

Key steps:

- Promoter regions – Initiate transcription.
- mRNA processing – Capping, polyadenylation, splicing.
- Transfer RNA (tRNA) brings amino acids to ribosomes.
- Polypeptide chains fold into functional proteins.

5. Cell Communication and Signaling

5.1 Types of Signaling

- Autocrine – Cells respond to signals they release.
- Paracrine – Signals affect nearby cells.

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