

2.5_ Specialized Cells: Structure and Function

Elaborated Notes

1. Cell Specialization through Differentiation

Cells in multicellular organisms are not all the same; they become specialized to perform specific functions. This process is called differentiation, where a cell develops a unique structure and characteristics that enable it to carry out a particular job. This specialization makes an organism much more efficient than if every cell had the same function.

2. Specialized Animal Cells

Animals have a variety of specialized cells, each with adaptations to suit its role:

- **Sperm Cells:** These cells are highly adapted for reproduction. They have a **head** containing the nucleus with genetic material. The **mid-piece** is packed with **mitochondria** to provide the energy needed for the tail's movement. The long **tail** is a flagellum that propels the sperm towards the egg.
 - **Nerve Cells (Neurons):** These cells are specialized for transmitting information as electrical signals. They have a long fiber called an **axon** that carries impulses away from the cell body. The axon is often coated in a fatty **myelin sheath** which insulates it and speeds up the impulse transmission. Nerve cells also have tiny branches called **dendrites** that receive signals from other neurons.
 - **Ciliated Epithelial Cells:** Found in the airways, these cells have hair-like projections called **cilia**. The cilia move in a wave-like motion to waft mucus, bacteria, and other particles up to the throat to be swallowed.
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3. Specialized Plant Cells

Plants also have specialized cells that are crucial for their survival:

- **Root Hair Cells:** Located on the outer surface of plant roots, these cells have a long projection, or "hair," that extends between soil particles. This increases the **surface area** for the absorption of water via **osmosis** and mineral ions via **active transport**. They also have many **mitochondria** to provide the energy needed for active transport.
- **Palisade Cells:** Found in the leaves of plants, these cells are located just below the upper epidermis. They are vertically elongated and are packed with **chloroplasts**. This structure

allows them to absorb a large amount of light for **photosynthesis**, making them the primary site of food production in the leaf. The large central vacuole also helps push chloroplasts to the edge of the cell to maximize light absorption.

Pearson Edexcel Curriculum Past Paper Questions

Multiple Choice Questions (10 MCQs)

1. Which adaptation is unique to a root hair cell?

- A. Large number of mitochondria
- B. A large central vacuole
- C. An elongated shape to increase surface area
- D. A cell wall for support

- **Examiner's Report:** The correct answer is C. While root hair cells have a large number of mitochondria and a central vacuole, these are not unique to them. The long, finger-like projection is the specific adaptation for increasing surface area to absorb water and minerals.

2. A sperm cell is highly specialized to...

- A. produce hormones.
- B. absorb sunlight.
- C. carry genetic material to an egg.
- D. transmit electrical signals.

- **Examiner's Report:** The correct answer is C. This is a fundamental concept of reproduction. Students who choose D may confuse sperm cells with nerve cells, while B is an adaptation of plant cells.

3. What is the purpose of the fatty myelin sheath on a nerve cell?

- A. To provide energy for the cell
- B. To speed up the transmission of electrical impulses
- C. To protect the cell from bacteria
- D. To carry genetic information

- **Examiner's Report:** The correct answer is B. Students must understand the specific function of the myelin sheath. A relates to mitochondria, C is a function of the immune system, and D is a function of the nucleus.

4. Which type of cell is responsible for the majority of photosynthesis in a plant leaf?

- A. Root hair cells
- B. Palisade cells
- C. Ciliated epithelial cells
- D. Nerve cells

- **Examiner's Report:** The correct answer is B. This tests knowledge of specific plant cell types. Students often confuse palisade cells with other plant cells or animal cells.

5. Why do root hair cells have many mitochondria?

- A. To provide energy for photosynthesis
- B. To provide energy for active transport of minerals
- C. To provide support for the plant
- D. To absorb water by osmosis

- **Examiner's Report:** The correct answer is B. Students should be able to link the function of mitochondria (energy production) to the process of active transport, which requires energy. Osmosis does not require energy, and photosynthesis is a function of chloroplasts.

6. Which part of a sperm cell contains the genetic material?

- A. Tail
- B. Mid-piece
- C. Head
- D. Mitochondria

- **Examiner's Report:** The correct answer is C. The head of the sperm cell is specifically adapted to house the nucleus and DNA. The mid-piece provides energy, and the tail provides movement.

7. The process by which a cell becomes specialized is called...

- A. Respiration
- B. Reproduction
- C. Differentiation
- D. Photosynthesis

- **Examiner's Report:** The correct answer is C. This is a direct recall of a key biological term. Students should be able to define differentiation as the process of cell specialization.

8. What is the primary function of cilia on ciliated epithelial cells?

- A. To increase surface area for absorption
- B. To move mucus and trapped particles
- C. To transmit electrical signals
- D. To provide a fixed shape

- **Examiner's Report:** The correct answer is B. Cilia's function is movement, which is distinct from the function of microvilli (increasing surface area) or other cellular processes.

9. Palisade cells are typically found...

- A. in the root.
- B. in the nervous system.
- C. in the leaf.
- D. in the circulatory system.

- **Examiner's Report:** The correct answer is C. This question tests knowledge of where different specialized cells are located in a multicellular organism. Palisade cells are a key part of the leaf structure.

10. A large central vacuole in a plant cell helps with which function?

- A. Providing energy for movement
- B. Maintaining a fixed shape and rigidity
- C. Absorbing sunlight for photosynthesis
- D. Transporting water

- **Examiner's Report:** The correct answer is B. The vacuole's turgor pressure provides structural support for the plant. While it holds water, its primary role in specialized cells like palisade cells is to push the cytoplasm and chloroplasts to the cell's edge.
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Theory Question

Describe the structural adaptations of a root hair cell and explain how these adaptations allow it to function effectively.

- **Examiner's Report:** A full-mark answer would describe at least two key adaptations and explain how each contributes to the cell's function.
 - **Adaptation 1: Elongated shape / "Hair":** The response should explain that the long, finger-like projection significantly increases the surface area of the cell. This large surface area allows for a greater rate of water and mineral absorption from the soil.
 - **Adaptation 2: Many mitochondria:** The response should link the high number of mitochondria to the energy-intensive process of active transport. It's essential to state that mineral ions, which are often in lower concentration in the soil than in the cell, require energy to be moved against their concentration gradient into the cell. The mitochondria provide this energy.
 - **Justification:** A strong response would tie these two points together to explain that the combined adaptations of a large surface area for absorption and a high energy supply for active transport make the root hair cell highly efficient at its specialized job of absorbing water and nutrients for the plant.