

Active Transport

Active transport is a crucial biological process that moves molecules and ions across a cell membrane against their concentration gradient, from a region of lower concentration to a region of higher concentration. Unlike passive transport processes such as diffusion and osmosis, active transport requires energy.

The Energy Behind Active Transport

This process is powered by energy released from cellular respiration. The cell's primary energy currency, Adenosine triphosphate (ATP), provides the necessary energy. Specialised protein carriers, also known as 'pumps', are located within the cell membrane. They bind to specific molecules or ions on one side of the membrane, use the energy from ATP to change their shape, and release the molecules on the other side. This allows the cell to accumulate essential substances even when they are scarce in the external environment.

Active Transport in Plants: Ion Uptake by Root Hair Cells

A key example of active transport in plants is the absorption of mineral ions by root hair cells. The concentration of mineral ions (e.g., nitrates, phosphates, potassium) is often much lower in the soil than it is inside the root hair cells.

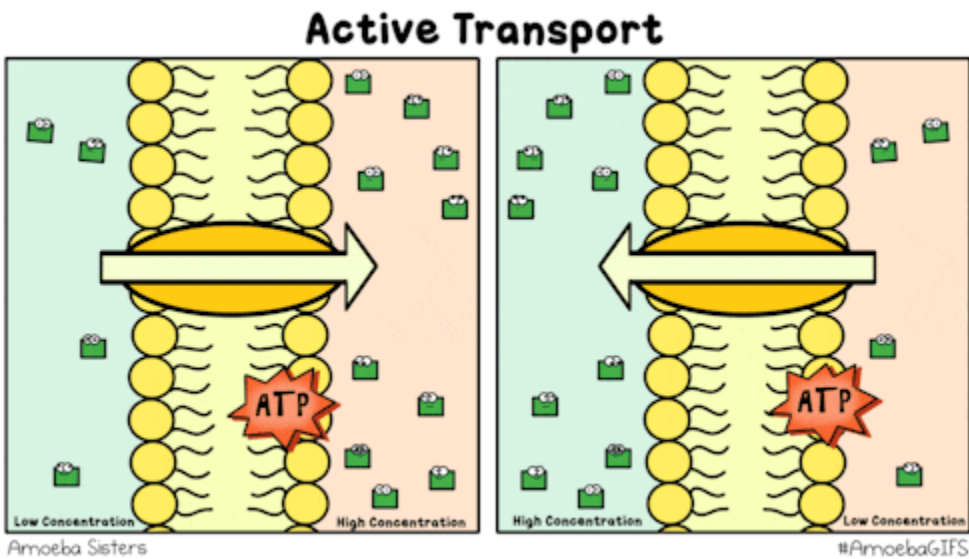
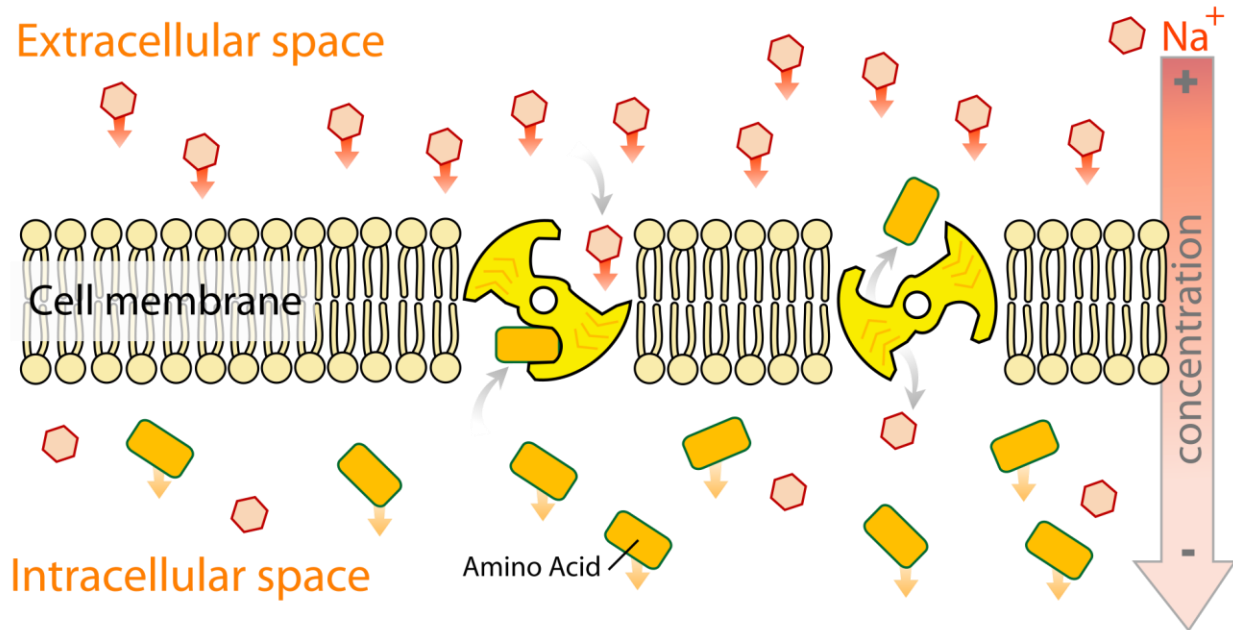
- **The Process:** To absorb these vital minerals, the root hair cells must use active transport.
- **Role of Respiration:** The process requires a constant supply of energy from respiration. If a plant's respiration is inhibited (e.g., by a lack of oxygen in waterlogged soil), active transport will stop, and the plant will be unable to absorb mineral ions.
- **Specialised Cells:** Root hair cells are well-adapted for this function. They have a large surface area to volume ratio, and a large number of mitochondria to provide the energy needed for active transport.

Active Transport in Animals

Active transport is also vital for many functions in animals.

- **Nutrient Absorption:** In the small intestine, after most of the glucose has been absorbed by diffusion, the remaining glucose and amino acids, which are in low concentration, are absorbed into the blood by active transport. This ensures that the body gets all the available nutrients.
- **Nerve Function:** The sodium-potassium pump is a classic example of active transport. It moves sodium ions out of the cell and potassium ions into the cell, which is essential for

generating nerve impulses and maintaining the electrical potential of nerve and muscle cells.



O Levels Biology Past Paper Questions

Here are 10 constructed-response questions on active transport, along with constructed answers and examiner-style reports.

Question 1

Define active transport and state one key difference between active transport and diffusion.

- **Constructed Answer:** Active transport is the movement of molecules or ions against their concentration gradient, from a region of lower concentration to a region of higher concentration, using energy from respiration. A key difference is that active transport requires energy, whereas diffusion is a passive process that does not.
- **Examiner Report:** Most candidates correctly defined active transport. Common errors included failing to mention the use of energy or the movement "against" a concentration gradient. The best answers clearly stated that diffusion moves substances "down" a concentration gradient.

Question 2

Explain the role of respiration in active transport.

- **Constructed Answer:** Respiration releases the energy that is needed for active transport. This energy is in the form of ATP (adenosine triphosphate), which powers the protein pumps in the cell membrane to move molecules against their concentration gradient.
- **Examiner Report:** Candidates who linked respiration to the production of energy were awarded credit. Top marks were given to those who specifically mentioned ATP as the energy source and its role in powering the protein pumps.

Question 3

Describe how mineral ions are taken up by the root hair cells of a plant.

- **Constructed Answer:** Mineral ions are taken up by root hair cells through active transport. The concentration of mineral ions is often lower in the soil than in the root hair cells. Therefore, the ions must be moved against their concentration gradient, a process that requires energy from respiration.
- **Examiner Report:** A full answer required candidates to identify active transport as the process and explain why it is necessary (moving against a concentration gradient). Some candidates confused this process with osmosis.

Question 4

A root hair cell is placed in a solution with a higher concentration of mineral salts than the cell sap. Explain why the cell would still absorb the salts.

- **Constructed Answer:** The cell will absorb the mineral salts by active transport. This process is used to move substances from a region of lower concentration (the external solution) to a region of higher concentration (inside the cell), which is the definition of moving against a concentration gradient. The process is powered by energy from respiration.
- **Examiner Report:** This question tests the understanding of the concentration gradient. The best answers clearly explained that active transport is used specifically because the cell needs to absorb salts from a less concentrated solution.

Question 5

Suggest two features of a root hair cell that make it well-adapted for its function.

- **Constructed Answer:**
 1. **Large surface area:** The long, thin projection of the root hair cell provides a large surface area for the absorption of water and mineral ions.
 2. **Large number of mitochondria:** A large number of mitochondria are present to provide a continuous supply of energy (ATP) for the active transport of mineral ions.
- **Examiner Report:** Candidates should mention specific features. "Large surface area" is a common correct answer. Linking a high number of mitochondria directly to the energy requirements of active transport is a key point for full credit.

Question 6

Explain why glucose is absorbed in the small intestine by both diffusion and active transport.

- **Constructed Answer:** Initially, when the concentration of glucose in the small intestine is high, it is absorbed into the blood by diffusion. As the concentration of glucose decreases, the concentration gradient becomes less steep. To ensure all the remaining glucose is absorbed and none is wasted, the body uses active transport to move the glucose against its concentration gradient into the bloodstream.
- **Examiner Report:** Many candidates could only explain diffusion. The best answers recognised that both processes occur, with diffusion happening first and active transport "topping up" the absorption when the concentration gradient is no longer favourable for diffusion.

Question 7

How does active transport differ from osmosis? State three differences.

- **Constructed Answer:**

1. Active transport requires energy, while osmosis is a passive process that does not.
2. Active transport moves substances against a concentration gradient, while osmosis moves water down a water potential gradient.
3. Active transport can transport many different molecules and ions, while osmosis is specifically the movement of water.

- **Examiner Report:** This question requires a clear comparison. Common errors included confusing the concentration gradients or stating that osmosis moves "down a concentration gradient" without specifying it's for water.

Question 8

Why is active transport essential for the survival of a plant?

- **Constructed Answer:** Active transport is essential because it allows the plant to absorb vital mineral ions from the soil. The concentration of these ions is often very low in the soil, so without active transport, the plant would be unable to obtain the nutrients required for growth, such as nitrates for protein synthesis or magnesium for chlorophyll production.
- **Examiner Report:** Candidates should link the necessity of active transport to the low concentration of mineral ions in the soil. Naming specific ions or their purpose (e.g., nitrates for proteins) strengthens the answer.

Question 9

A substance called cyanide inhibits respiration. Explain the effect of adding cyanide to a solution containing root hair cells on their ability to absorb mineral ions.

- **Constructed Answer:** Adding cyanide will stop respiration. Since active transport requires energy from respiration, the root hair cells will be unable to carry out active transport. As a result, they will not be able to absorb mineral ions from the surrounding solution.
- **Examiner Report:** This is a higher-order thinking question. Candidates must show an understanding of the link between respiration and active transport. The best answers explicitly stated that without the energy from respiration, the active transport pumps would fail.

Question 10

Briefly describe the mechanism of an active transport protein pump.

- **Constructed Answer:** An active transport protein pump is a carrier protein in the cell membrane. It has a specific shape that binds to a molecule or ion. The binding triggers the protein to use energy from ATP, causing its shape to change. This change in shape moves the molecule across the membrane and releases it on the other side. The pump then reverts to its original shape.
- **Examiner Report:** Answers were judged on their ability to describe the "pump" mechanism. Key terms were "carrier protein," "binding," "change in shape," and "use of ATP/energy." Simply stating that it "pushes" molecules was insufficient.

O Levels Biology Multiple-Choice Questions (MCQs)

1. Which process moves molecules from a region of low concentration to a region of high concentration?

A) Diffusion
B) Osmosis
C) Active Transport
D) Facilitated Diffusion

2. What is the source of energy for active transport?

A) Sunlight
B) Heat
C) Respiration
D) Diffusion

3. The uptake of mineral salts by the root hair cells of a plant is an example of:

A) Osmosis
B) Diffusion
C) Active Transport
D) Plasmolysis

4. Which of the following is NOT a feature of active transport?

A) It requires energy.

- B) It uses carrier proteins.
- C) It moves substances down a concentration gradient.
- D) It is important for the absorption of glucose in the small intestine.

5. Why is active transport necessary for a plant to absorb mineral ions from the soil?

- A) The soil contains a higher concentration of ions than the root cells.
- B) The soil contains a lower concentration of ions than the root cells.
- C) The ions are too large to move by diffusion.
- D) The ions are water-soluble.

6. Which statement correctly describes a similarity between active transport and diffusion?

- A) Both move substances against a concentration gradient.
- B) Both are passive processes.
- C) Both require energy from respiration.
- D) Both involve the movement of substances.

7. A cell has a high concentration of potassium ions inside and a low concentration outside.
Which process is used to bring more potassium ions into the cell?

- A) Diffusion
- B) Osmosis
- C) Active transport
- D) Plasmolysis

8. An investigation is carried out to determine the rate of ion uptake by a plant's roots. If the temperature of the soil is decreased, what would happen to the rate of ion uptake and why?

- A) It would increase, because ions move faster at lower temperatures.
- B) It would decrease, because respiration rate decreases at lower temperatures.
- C) It would remain the same, as active transport is not affected by temperature.
- D) It would increase, as the concentration gradient becomes steeper.

9. Which of the following processes is crucial for the function of nerve cells?

- A) Osmosis
- B) The sodium-potassium pump
- C) Simple diffusion
- D) Photosynthesis

10. What is the main reason why active transport is sometimes called "pumping"?

- A) It moves substances in a cyclical motion.
- B) It forces substances to move uphill against a gradient.
- C) It uses water as a driving force.
- D) It requires a pump-like organelle.

MCQ Answers

- 1. C) Active Transport
- 2. C) Respiration
- 3. C) Active Transport
- 4. C) It moves substances down a concentration gradient.
- 5. B) The soil contains a lower concentration of ions than the root cells.
- 6. D) Both involve the movement of substances.
- 7. C) Active transport
- 8. B) It would decrease, because respiration rate decreases at lower temperatures.
- 9. B) The sodium-potassium pump
- 10. B) It forces substances to move uphill against a gradient.