

CHAPTER A — CELL PHYSIOLOGY

A1 — The Fading Action Potential

During a nerve conduction demo, an intern notices action potentials weakening after repeated high-frequency stimulation. The physiology tutor asks what the intern thinks is happening. The intern recalls that ionic gradients and active transport maintain excitability, but the setup uses continuous stimulation with no recovery intervals. The nerve sits in normal Ringer's solution, and ionic pump inhibitors are nearby. The intern must decide what adjustment best restores action potential amplitude without damaging the preparation.

Options

- A. Cool the nerve to slow energy use
- B. Add ouabain to block Na^+/K^+ -ATPase
- C. Allow rest intervals to restore ionic gradients
- D. Increase extracellular K^+ to improve excitability

Reasoning

- Cooling (A) reduces metabolism → slows pump → worse gradient recovery.
- Ouabain (B) stops the Na^+/K^+ pump → complete loss of excitability.
- Rest intervals (C) allow Na^+/K^+ -ATPase to re-establish gradients → AP amplitude returns.
- High K^+ (D) leads to depolarization block.

Correct: C

A2 — The Hypotonic IV Concern

A dehydrated patient arrives after working in extreme heat. A junior physiotherapy observer sees that the nurse has started a hypotonic saline infusion. The intern remembers that water follows osmotic gradients and begins worrying about potential cellular swelling, particularly in neuronal tissue. The team must adjust the fluid plan safely.

Options

- A. Continue hypotonic saline infusion
- B. Switch to isotonic saline
- C. Switch to hypertonic saline
- D. Stop fluids entirely

Reasoning

- Hypotonic saline (A) risks cellular swelling and cerebral edema.
- Isotonic saline (B) correctly restores extracellular volume without shifting fluid into cells.
- Hypertonic saline (C) would pull water out of cells—only used for severe cerebral edema.
- Stopping fluids (D) worsens dehydration.

 **Correct: B**

A3 — The Transporter Misinterpretation

A physiotherapy student assisting in a metabolic lab observes that glucose uptake in cultured skeletal muscle cells remains low despite high extracellular glucose. The mentor asks for an explanation. The student remembers facilitated diffusion, insulin-dependent GLUT4 translocation, and active transport but must select the most logical physiological factor.

Options

- A. Add insulin to stimulate GLUT4 insertion
- B. Increase extracellular sodium for cotransport

- C. Heat the chamber to speed glucose diffusion
- D. Add ATP blockers to observe uptake changes

Reasoning

- Insulin (A) triggers GLUT4 translocation and enhances glucose uptake in muscle.
- Sodium-glucose cotransport (B) is for intestine/kidney—not muscle.
- Heating (C) may increase kinetics but not compensate for absent transporters.
- ATP blockers (D) inhibit processes needed for GLUT4 translocation.

 **Correct: A**

A4 — The Membrane Potential Mystery

During a neuromuscular lab, a student notices that a frog muscle fibre's resting membrane potential is less negative than expected. The student must identify the most plausible cause.

Options

- A. Increased extracellular K^+ concentration
- B. Increased extracellular Na^+ concentration
- C. Increased membrane permeability to Cl^-
- D. Increased Na^+/K^+ pump speed

Reasoning

- High extracellular K^+ (A) reduces gradient → depolarizes membrane.
- Increased Na^+ (B) has minimal effect due to low resting permeability.
- More Cl^- permeability (C) usually stabilizes or hyperpolarizes.
- Faster pump (D) hyperpolarizes.

 **Correct: A**

A5 — The Protein Synthesis Slowdown

A physiotherapy intern shadowing a muscle biology lab sees that protein synthesis in cultured myotubes has drastically slowed after adding a mysterious inhibitor. Ribosomes look intact, but translation halts. The student must deduce which cellular process is likely blocked.

Options

- A. Transcription in the nucleus
- B. mRNA transport through nuclear pores
- C. tRNA charging (aminoacylation)
- D. Golgi packaging

Reasoning

- Transcription (A) affects future proteins but not immediate translation.
- mRNA transport (B) could reduce availability but not stop translation instantly.
- tRNA charging (C) halts elongation → immediate effect.
- Golgi (D) is post-translational.

Correct: C

A6 — The Mitochondrial Fatigue Episode

A student monitoring isolated skeletal muscle fibres sees that after prolonged contractions, ATP levels crash despite adequate oxygenation. The mentor hints at mitochondrial function.

Options

- A. Switch to anaerobic medium
- B. Reduce ADP levels

- C. Increase substrate supply (pyruvate)
- D. Block electron transport to preserve ATP

Reasoning

- Anaerobic medium (A) produces very little ATP.
- Reducing ADP (B) slows ATP synthase → less ATP made.
- Providing more pyruvate (C) supports oxidative phosphorylation.
- Blocking electron transport (D) stops ATP production entirely.

✓ **Correct: C**

A7 — The Aquaporin Experiment

A student studies water movement across cell membranes using kidney tubular cells. After adding a selective aquaporin blocker, the net water flow sharply decreases even though osmotic gradients remain.

Options

- A. Water transport is mostly active
- B. Lipid bilayer allows water to diffuse freely
- C. Aquaporins provide the main pathway for rapid water movement
- D. Osmosis stops when pumps are inhibited

Reasoning

- Water transport is passive, not active (A).
- Bilayer diffusion (B) is slow.
- Aquaporins (C) enable rapid osmosis.
- Osmosis (D) does not depend on pumps.

✓ **Correct: C**

A8 — The Lysosomal Leakage Concern

A physiotherapy intern notices that cultured cells show rapid autolysis after exposure to extreme pH. The student must identify the cellular organelle playing the major role.

Options

- A. Golgi apparatus
- B. Ribosomes
- C. Lysosomes
- D. Mitochondria

Reasoning

Lysosomes contain hydrolytic enzymes active at acidic pH → membrane damage leads to autolysis.

Correct: C

A9 — The Calcium Overload Problem

While observing cardiomyocyte cultures, an intern notices that intracellular Ca^{2+} remains elevated after contraction, preventing proper relaxation.

Options

- A. SERCA pump inhibition
- B. Increased Na^+/K^+ pump activity
- C. Decreased extracellular Ca^{2+}
- D. Gap junction dysfunction

Reasoning

SERCA pumps Ca^{2+} back into SR; inhibition causes prolonged cytosolic Ca^{2+} → impaired relaxation.

✓ **Correct: A**

A10 — The Cell Death Confusion

A tissue sample shows shrinkage, nuclear condensation, and intact membranes. The intern is asked what type of cell death this suggests.

Options

- A. Necrosis
- B. Apoptosis
- C. Autophagy
- D. Swelling injury

Reasoning

Apoptosis → shrinkage + chromatin condensation + membrane integrity.

✓ **Correct: B**
