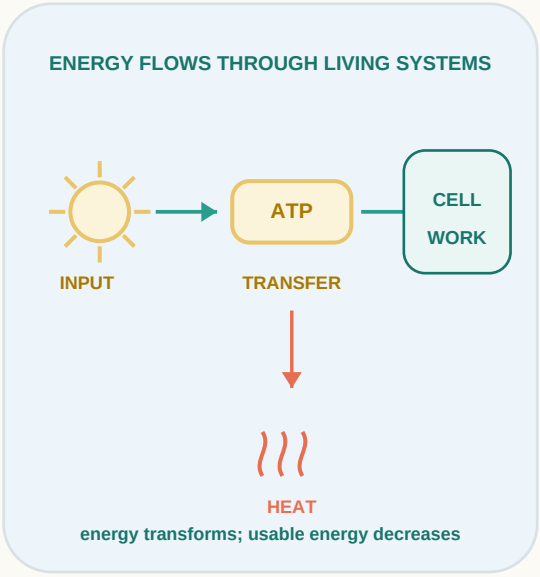
AP BIOLOGY | UNIT 3

TOPIC 3.3

Cellular Energy

Living systems capture, transform, and transfer energy to maintain organization and power cellular processes.



THE CORE CAUSAL CHAIN

ENERGY INPUT
light or food

→

PATHWAYS
controlled reactions

→

ATP
transferable energy

→

CELL WORK
plus heat loss

BY THE END, YOU SHOULD BE ABLE TO...

1. Apply thermodynamic principles to living systems.
2. Explain how ATP couples energy-releasing and energy-requiring reactions.
3. Connect conserved pathways with evidence for common ancestry.

BIG IDEA

Cells maintain local order only by taking in energy and releasing heat and waste to their surroundings.

1 Thermodynamics and energy coupling

Energy is conserved during transformation, but each transfer disperses some energy as heat and reduces the amount available for cellular work.

TWO LAWS, ONE LIVING SYSTEM

1 ENERGY IS CONSERVED

Cells transform energy between light, chemical bonds, gradients, and motion; they do not create energy from nothing.

2 ENTROPY INCREASES

Every transfer disperses some energy, often as heat, so no conversion is completely efficient.

ENERGY-RELEASING AND ENERGY-REQUIRING

EXERGONIC PROCESS



Free energy is released; products have less free energy.

ENDERGONIC PROCESS



Free energy must be supplied; products have more free energy.

ATP COUPLES THE PROCESSES

ENERGY-RELEASING PATHWAY

energy transferred to ATP

→ **ATP** →

CELLULAR WORK

ATP hydrolysis supplies energy

COUPLING DOES NOT BREAK THE RULES

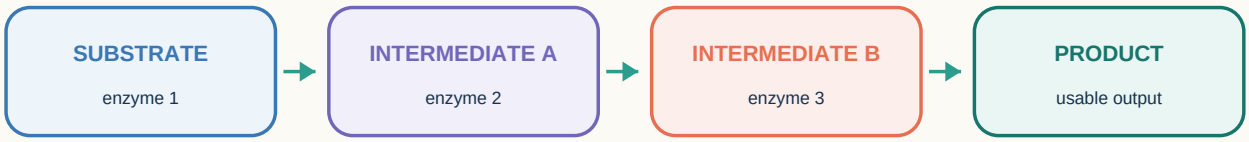
The combined coupled process must have a net negative change in free energy. ATP transfers energy; it is not a permanent energy store.

2

Metabolic pathways and common ancestry

Cells organize energy transformations into enzyme-controlled sequences, and deeply shared pathway features can reveal evolutionary history.

A PATHWAY IS A CONTROLLED SEQUENCE



WHY USE MANY STEPS?

CONTROL

Enzymes can regulate specific steps and redirect pathway flow.

EFFICIENCY

Energy can be captured in manageable transfers instead of one large release.

COORDINATION

Products of one step become substrates for later reactions.

CONSERVED ENERGY PATHWAYS

GLYCOLYSIS



WHERE **cytosol**

WHY IT MATTERS Shared core steps across diverse organisms suggest inheritance from an ancient ancestor.

OXIDATIVE PHOSPHORYLATION



WHERE **energy-transducing membrane**

WHY IT MATTERS Electron transport and chemiosmosis are widespread, supporting deep evolutionary conservation.

EVIDENCE, NOT CERTAINTY FROM ONE TRAIT

A conserved pathway supports common ancestry most strongly when its shared enzymes, sequence, and molecular mechanisms align with other evidence.