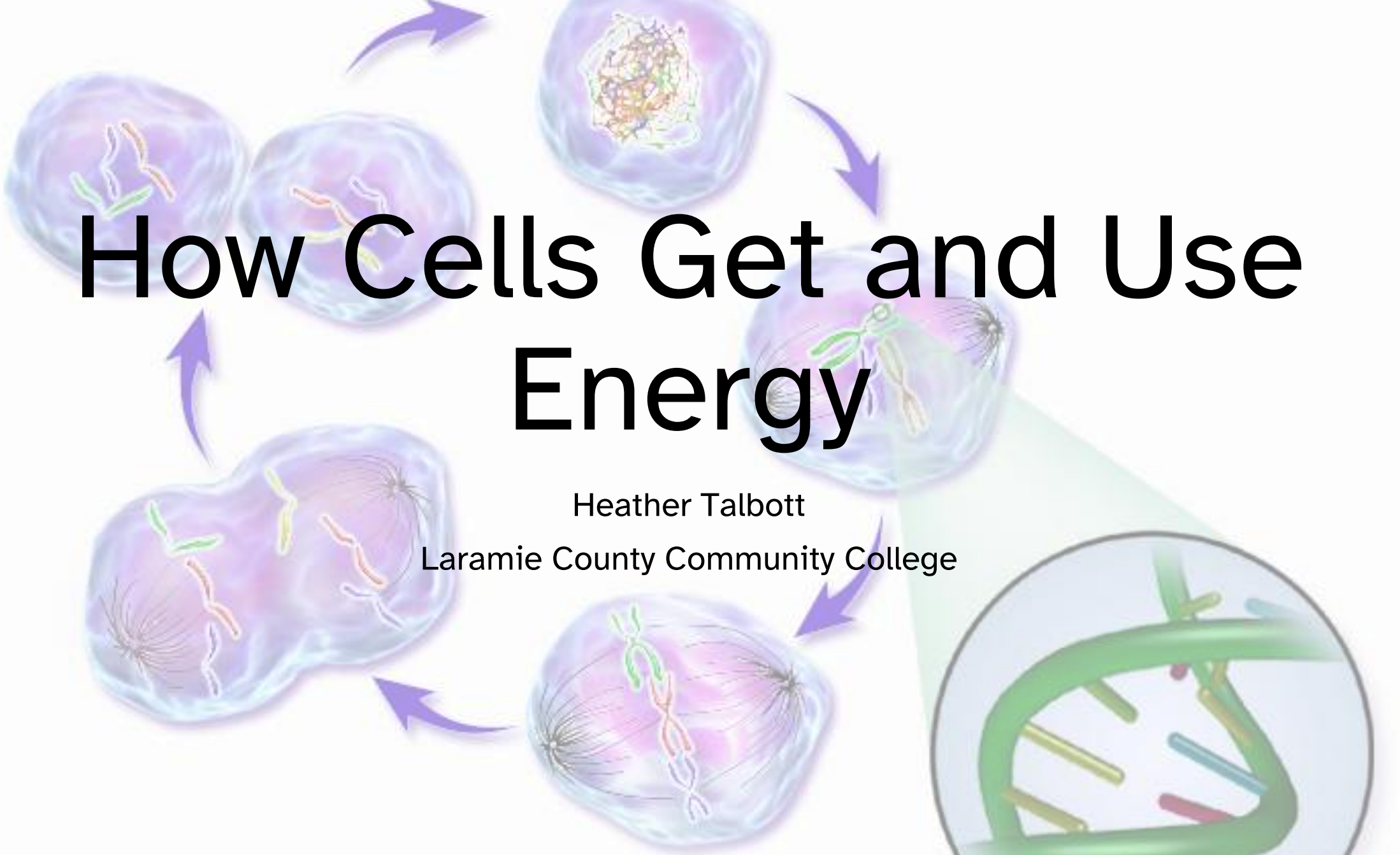
How Cells Get and Use Energy

Heather Talbott

Laramie County Community College



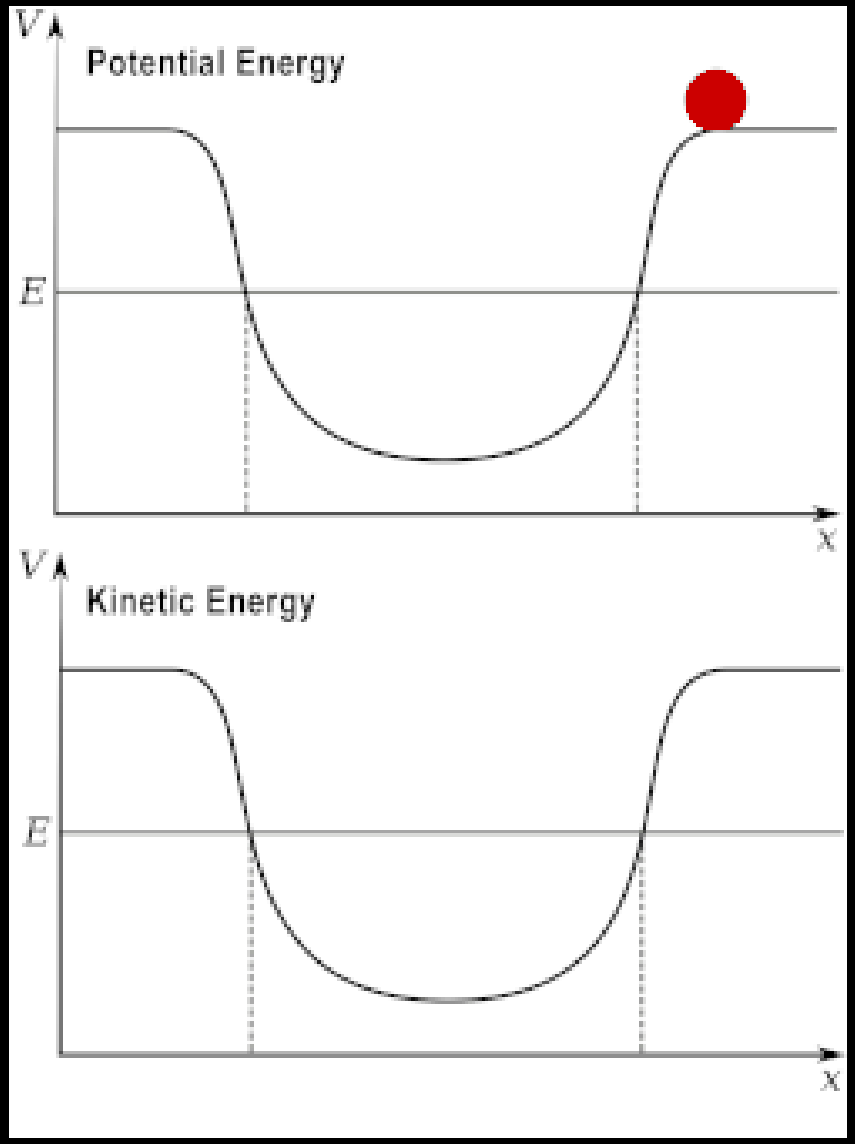
Everything in physiology is about how cells survive, communicate, and work together.

Energy in Cells

- All cell activities require energy
- **Energy**: the ability to do work
- Cells use energy to:
  - Contract muscles
  - Send nerve signals
  - Move substances
  - Build molecules
- Without energy, cells cannot survive
- Most cellular energy comes from food and oxygen

Energy types

- **Potential energy**: energy stored by matter due to its position
  - E.g. energy in food molecules
- **Kinetic energy**: energy associated with matter in motion
  - E.g. contracting muscles, flowing blood
- **Chemical energy**: potential energy stored in the bonds of compounds and molecules

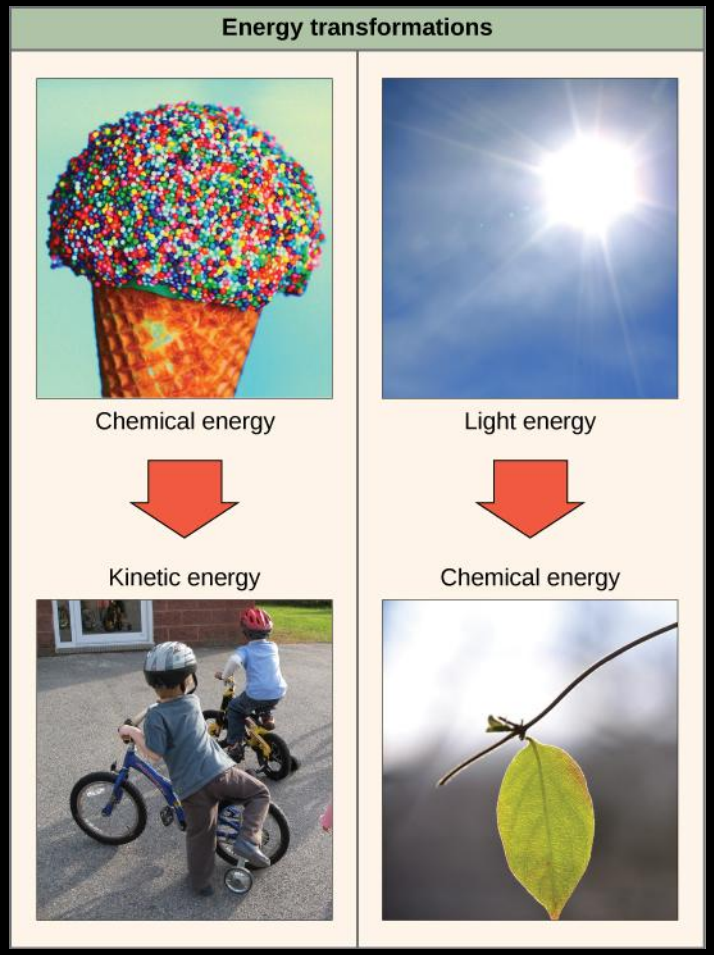


Chemical energy

- Chemical energy is stored in molecular bonds
- Food molecules contain chemical energy
- When bonds are broken or rearranged, energy is released
- Cells capture this energy to make ATP
- **ATP**: is the main usable energy form in cells

Thermodynamics

- Energy cannot be created or destroyed
- Energy can only be changed from one form to another
- Cells do not “make” energy
- Cells convert energy from food into usable forms
- Some energy is always lost as heat



Energy Summary

- Food stores energy
- Cells release energy
- ATP carries energy
- Proteins use energy
- Heat is always produced

Metabolism

Metabolism

- **Metabolism:** all chemical reactions of a cell or organism.

- **Metabolic pathway:** is a series of biochemical reactions that converts one or more substrates into a final product.

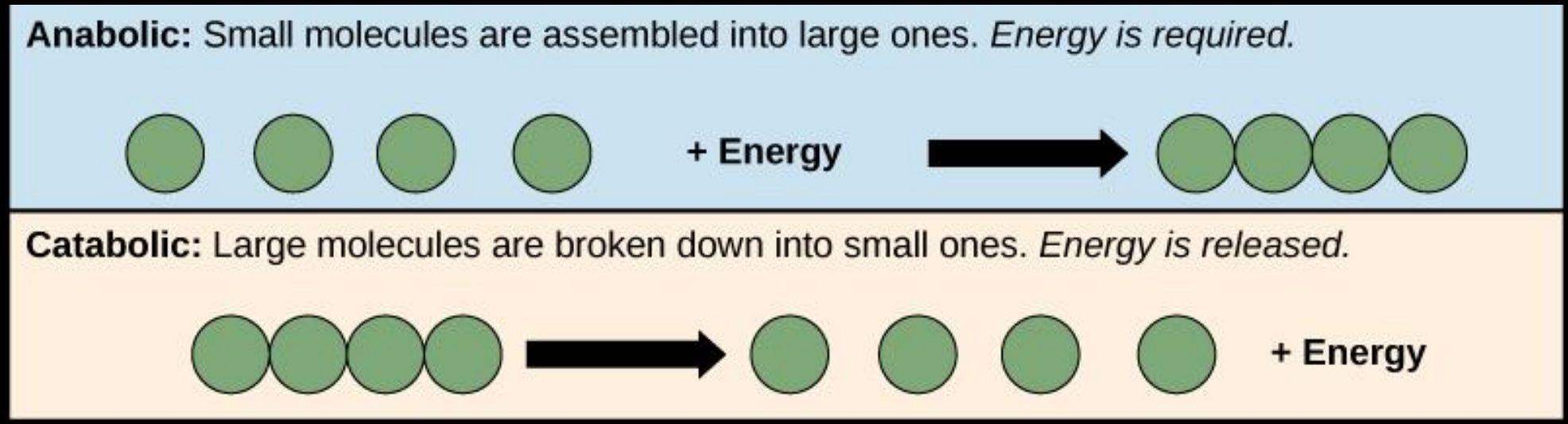
    - For example, energy from the sun is captured during photosynthesis to convert CO_2 and H_2O into glucose ($C_6H_{12}O_6$).

    - The energy stored in glucose is released during cellular respiration, regenerating CO_2 and H_2O. (We will discuss in subsequent lectures.)

Plants, like this oak tree and acorn, use energy from sunlight to make sugar and other organic molecules. Both plants and animals (like this squirrel) use cellular respiration to derive energy from the organic molecules that plants originally produced. (credit “acorn”: modification of work by Noel Reynolds; credit “squirrel”: modification of work by Dawn Huczek)

Anabolic vs Catabolic

- Two types of reactions/pathways are required to maintain the cell's energy balance.
- **Anabolic/synthesis** reactions: generate larger molecules and require energy
- **Catabolic/decomposition** reactions: break down large molecules into smaller molecules release energy



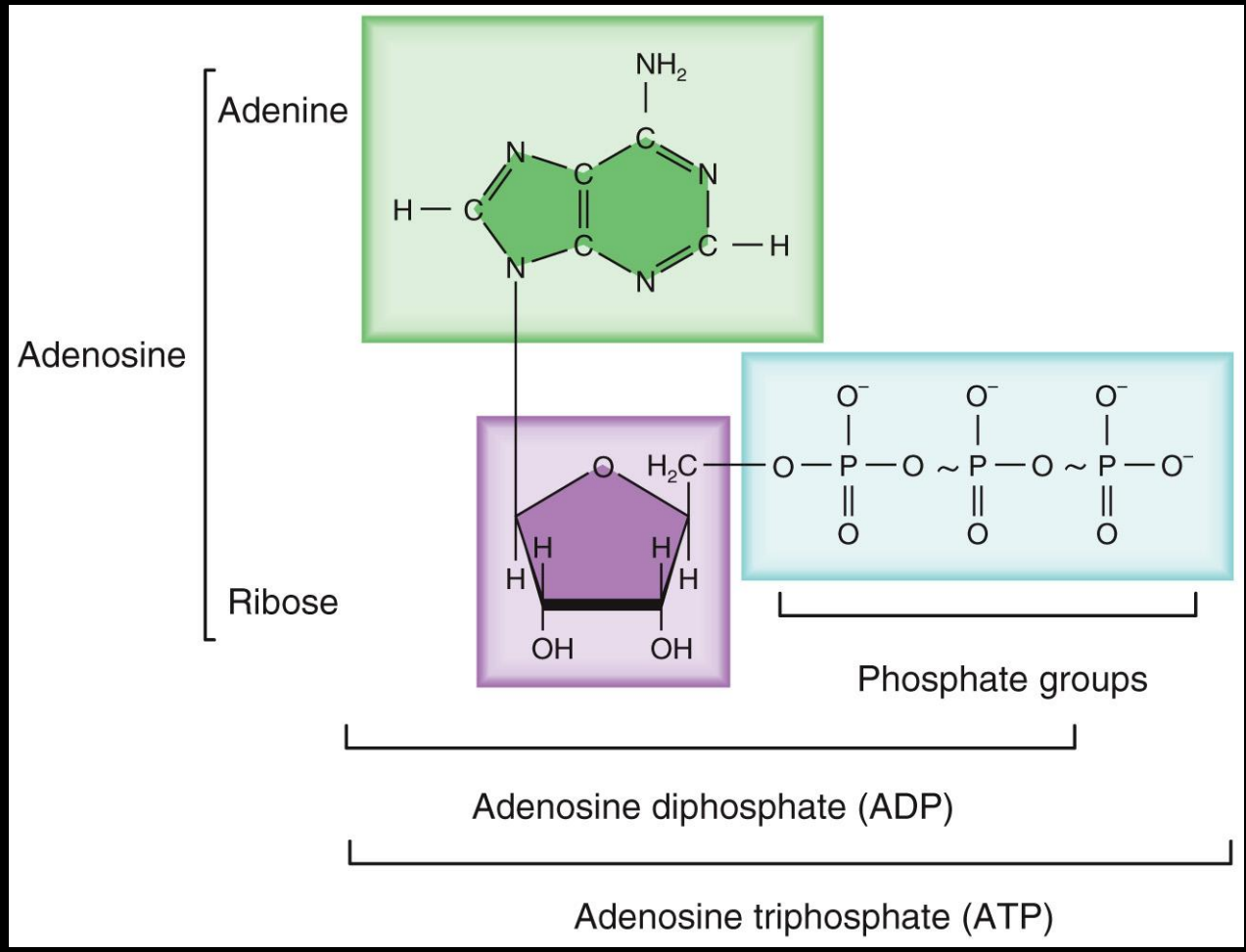
Exergonic/Endergonic

- **Exergonic reaction**: releases more energy than it absorbs
  - in general, exergonic reactions occur as nutrients (ex. glucose) are broken down
  - ex. when a molecule of glucose is completely broken down, the chemical energy in its bonds can be used to produce 32 molecules of ATP
- **Endergonic reaction**: absorbs more energy than it releases
  - a key feature of the body's metabolism is the coupling of exergonic and endergonic reactions; energy released from an exergonic reaction is often used to drive an endergonic one

ATP: The Cell’s Power Supply

Adenosine Triphosphate (ATP)

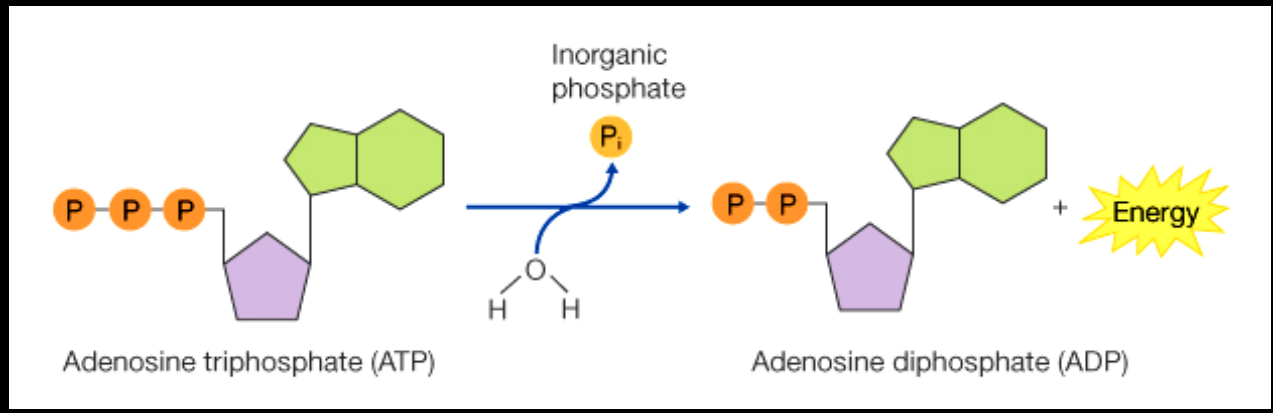
- ATP: molecule that carries energy within cells
- the “energy currency” of living systems
- ATP transfers the energy liberated in exergonic catabolic reactions to power cellular activities that require energy
  - E.g. muscle contraction, transport of substances across cell membranes, synthesis of large molecules, etc.



ATP hydrolysis

- **ATP hydrolysis**: the mechanism that liberates energy from ATP by removing the 3rd phosphate by inserting a water molecule

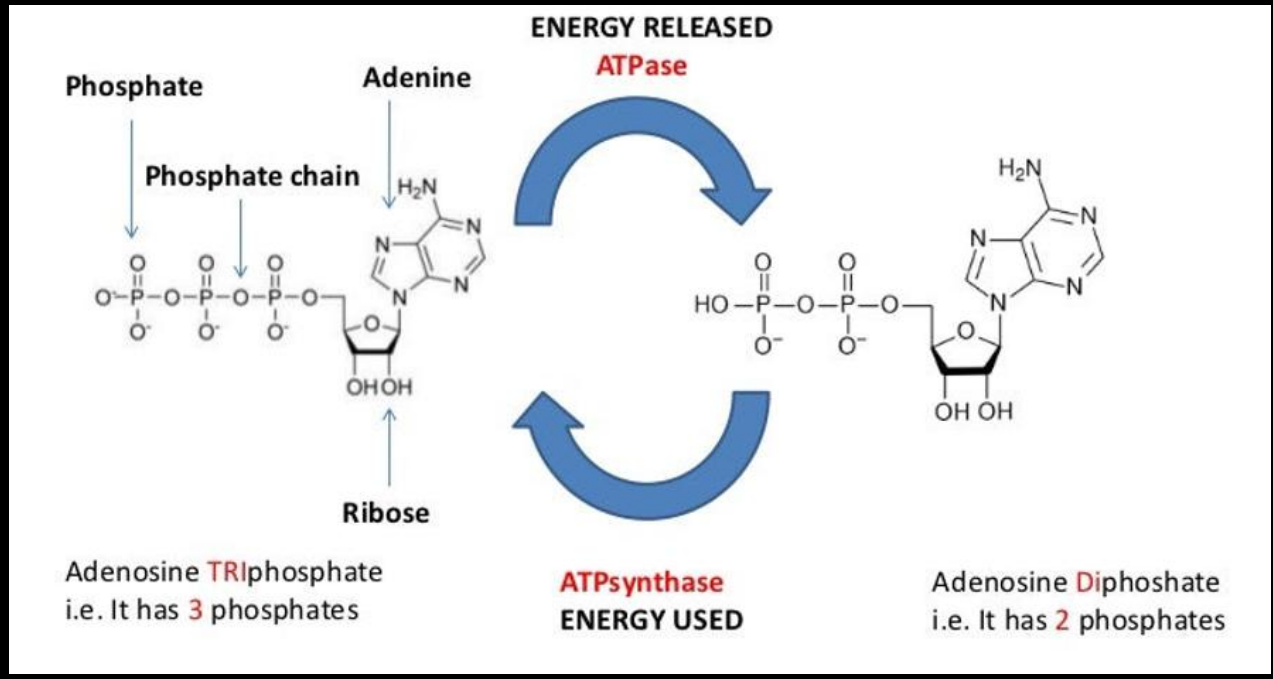
- **ATPase**: the enzyme that catalyzes the hydrolysis of ATP
  - Removal of the 3rd phosphate produces a molecule called adenosine diphosphate (ADP)



ADP phosphorylation

- **ADP phosphorylation**: the mechanism to create new ATP from ADP by adding a phosphate group

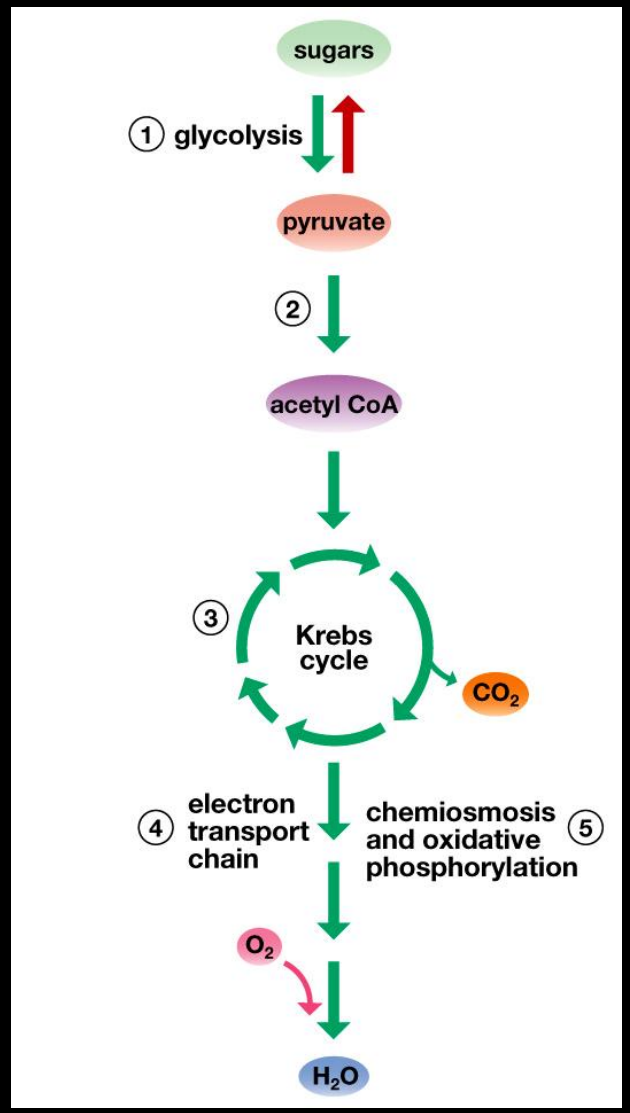
- **ATP synthase**: the enzyme that catalyzes ADP phosphorylation



How Cells Get Energy

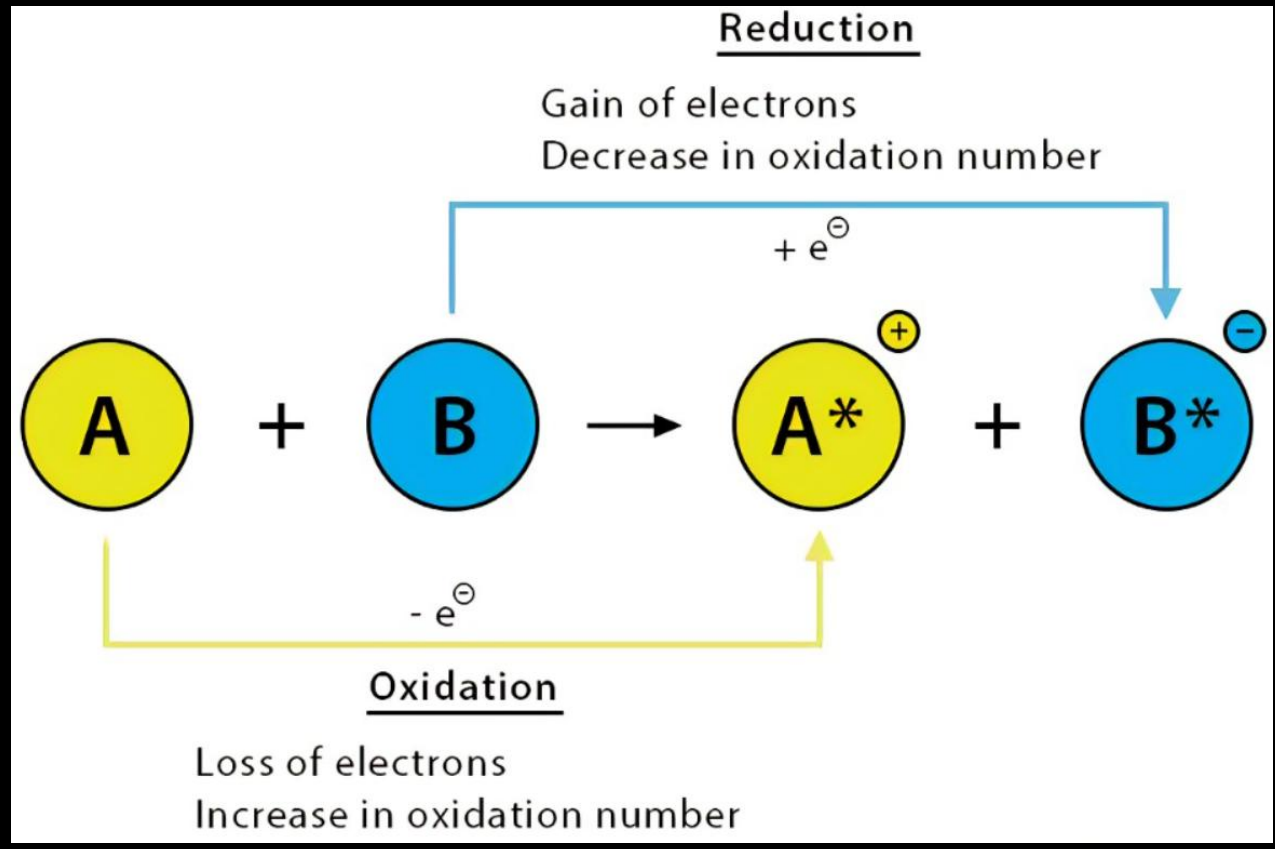
Cellular Respiration

- The overall process (inputs and outputs) for cellular respiration is:
- Glucose sugar (C6H12O6) and oxygen (O2) are the inputs
- ATP, carbon dioxide (CO2), water (H2O), and heat are the outputs
- Electrons and protons are transferred from glucose to oxygen through a series of reactions
- High energy e- in sugars to low energy e- in H2O



Redox Reactions

- **Reduction reaction**: the addition of electrons
- **Oxidation reaction**: the removal of electrons
- **Redox reaction**: reduction and oxidation reactions must be paired and cooccur
  - OIL RIG (Oxidation is loss; Reduction is gain)
  - Ions are fundamental for life for electrical charge, nerve signals, heart function, and many more functions



Resources

- Dingess, Paige (2025)
- Grammarly. (2026). Grammarly (Version 14.1268.0) [Software]. https://www.grammarly.com/
- OpenAI. (2026). ChatGPT (GPT-5) [Large language model]. https://chat.openai.com/

Creation and Copyright Information

- Last updated: Jan 29, 2026
- Last updated by: Heather Talbott
-