ATP Production

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INTRODUCTION

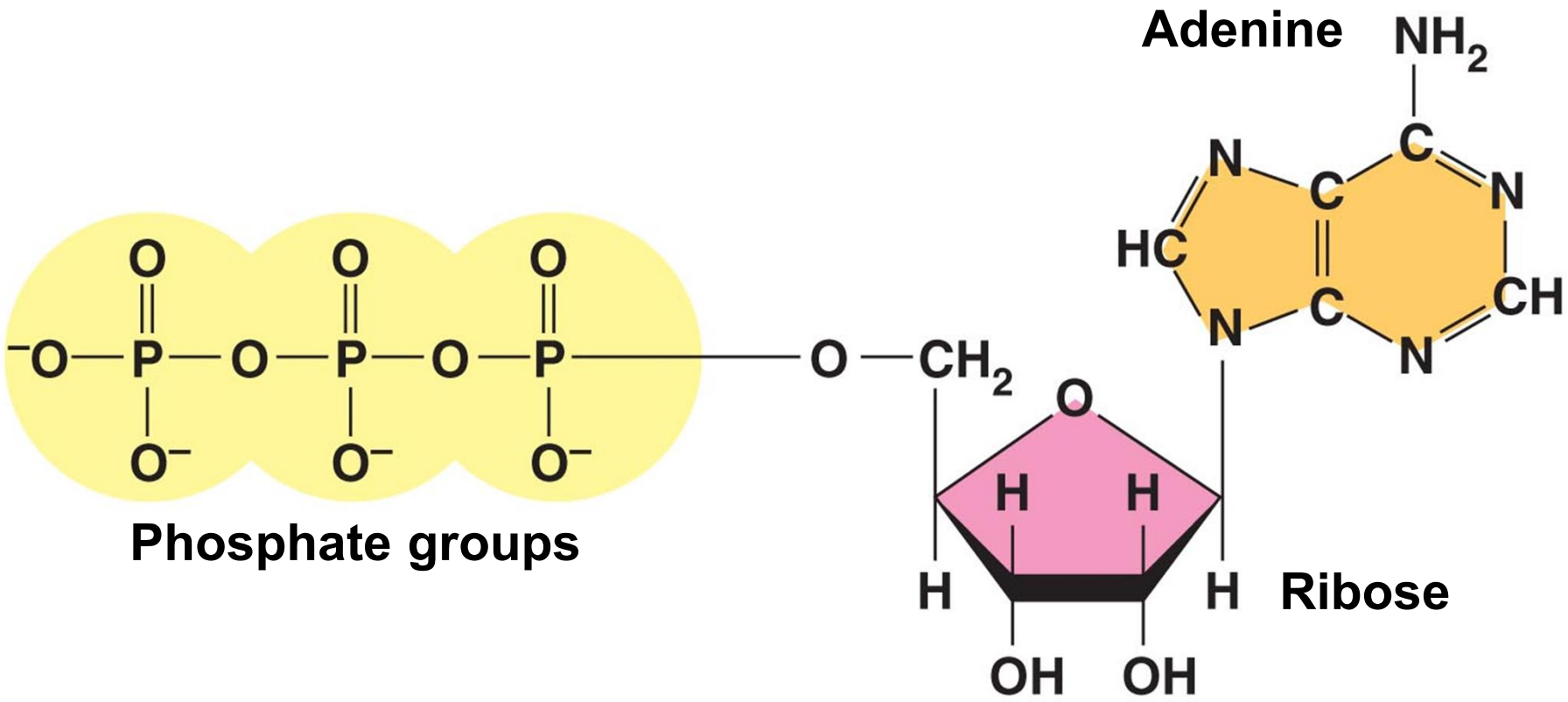
- Living cells require energy from outside sources
- Some animals, obtain energy by eating plants, and some animals feed on other organisms that eat plants
- Photosynthesis generates O_2 and organic molecules, which are used in cellular respiration
- Cells use chemical energy stored in organic molecules to regenerate ATP, which powers work

ATP Adenosine Tri-Phosphate

- **ATP (adenosine triphosphate)** is the cell's energy shuttle

- ATP is composed of:
  - Ribose (a sugar)
  - Adenine (a nitrogenous base)
  - Three phosphate groups

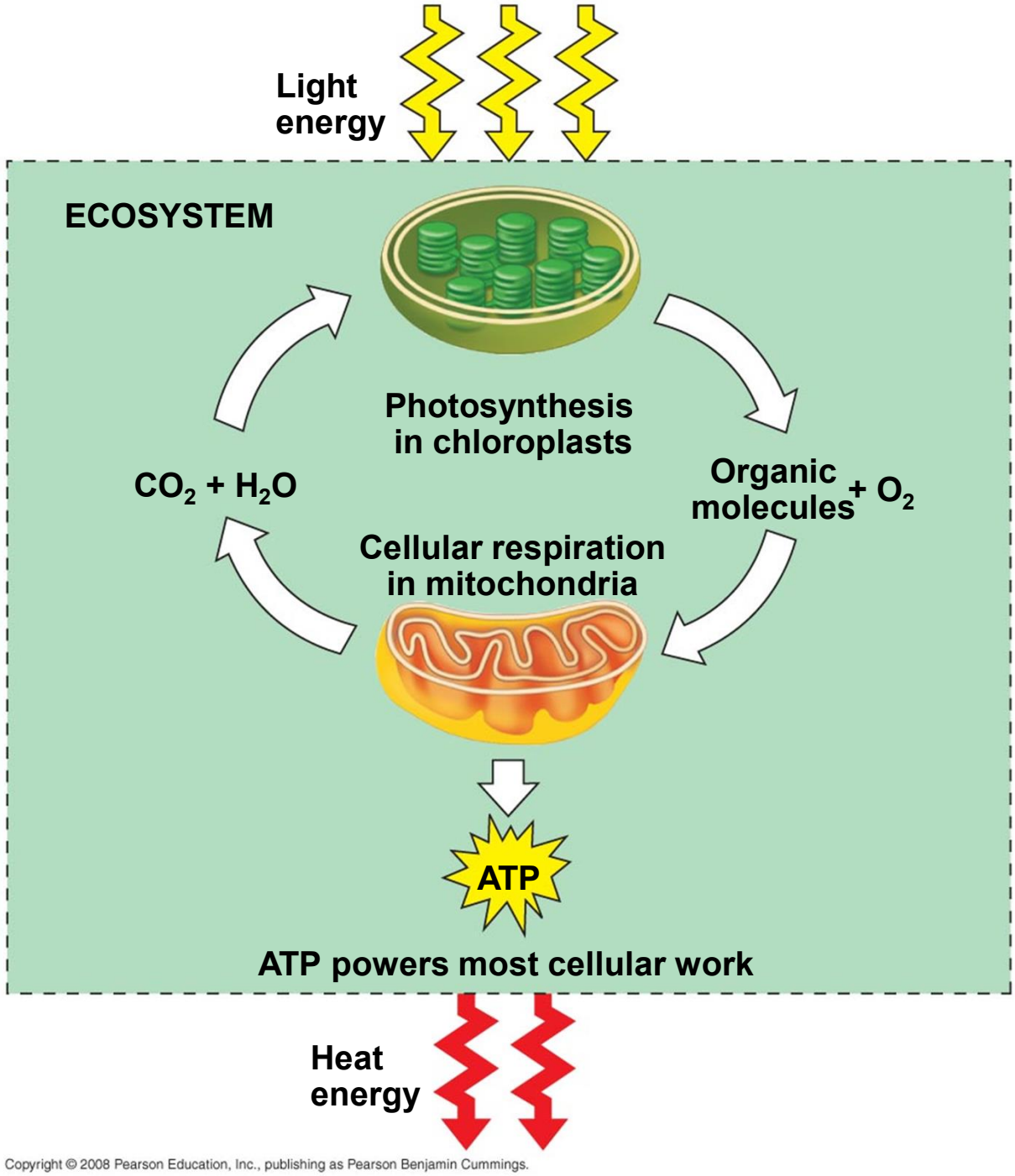
- The cell converts Adenosine Di-Phosphate (ADP) into ATP by the addition of a phosphate.



ATP Production

- Before cells can use the energy of sunlight or energy /calories stored in carbohydrates, they must transfer the energy to molecules of ATP.

–ATP transfers energy to many different chemical reactions; almost all metabolic pathways directly or indirectly run on energy supplied by ATP.



Redox Reactions: Oxidation and Reduction

- The transfer of electrons during chemical reactions releases energy stored in organic molecules
- This released energy is ultimately used to synthesize ATP

The Principle of Redox

- Chemical reactions that transfer electrons between reactants are called oxidation-reduction reactions, or **redox reactions**

- In **oxidation**, a substance loses electrons, or is oxidized

- In **reduction**, a substance gains electrons, or is reduced (the amount of positive charge is reduced)

ADP-ATP Cycle

- Cells break phosphate bonds between the last two phosphate groups in a molecule of ATP as needed to supply energy for most cellular functions, when this happens a molecule of ADP (adenosine diphosphate) and a phosphate become available for reuse.

ADP-ATP Cycle

When any of the phosphate bonds are broken or formed, energy is involved.

- Energy is released each time a phosphate is removed from the molecule.
- Energy is stored each time a phosphate attaches to the molecule.
- To constantly supply the cell with energy, the ADP is recycled, creating more ATP which carries much more energy than ADP.

Steps in the ADP-ATP Cycle

- To supply cells with energy, a “high energy” bond in ATP is broken. ADP is formed and a phosphate is released back into the cytoplasm.

ATP ⟶ ADP + phosphate + energy

Steps in the ADP-ATP Cycle

- As the cell requires more energy, ADP becomes ATP when a free phosphate attaches to the ADP molecule.

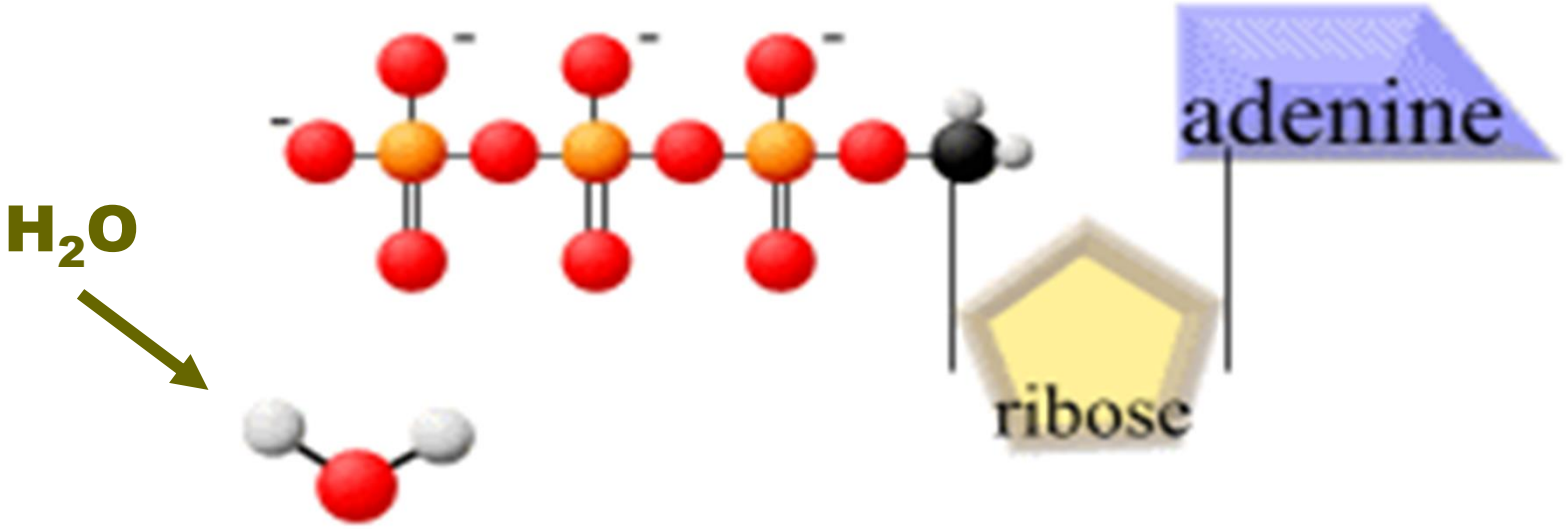
- Then energy needed to create an ATP molecule is much less than the amount of energy produced when the bond is broken.

ADP + phosphate + energy ⟶ ATP

How is the bond broken?

HYDROLYSIS (Adding H_2O)

Assisted by the enzyme ATPase.

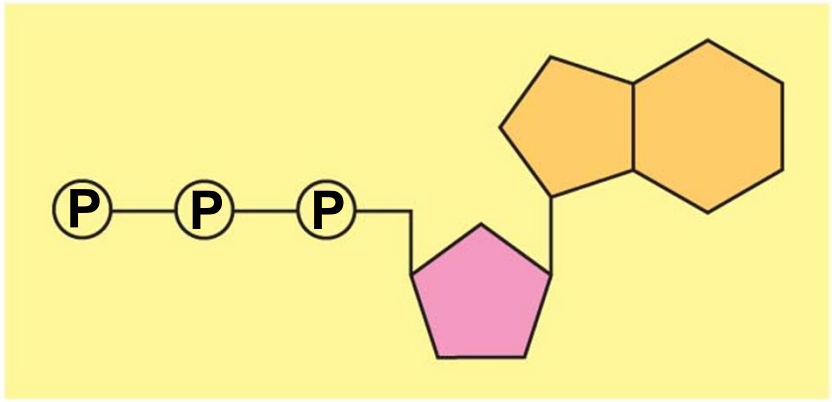


- The bonds between the phosphate groups of ATP's tail can be broken by hydrolysis

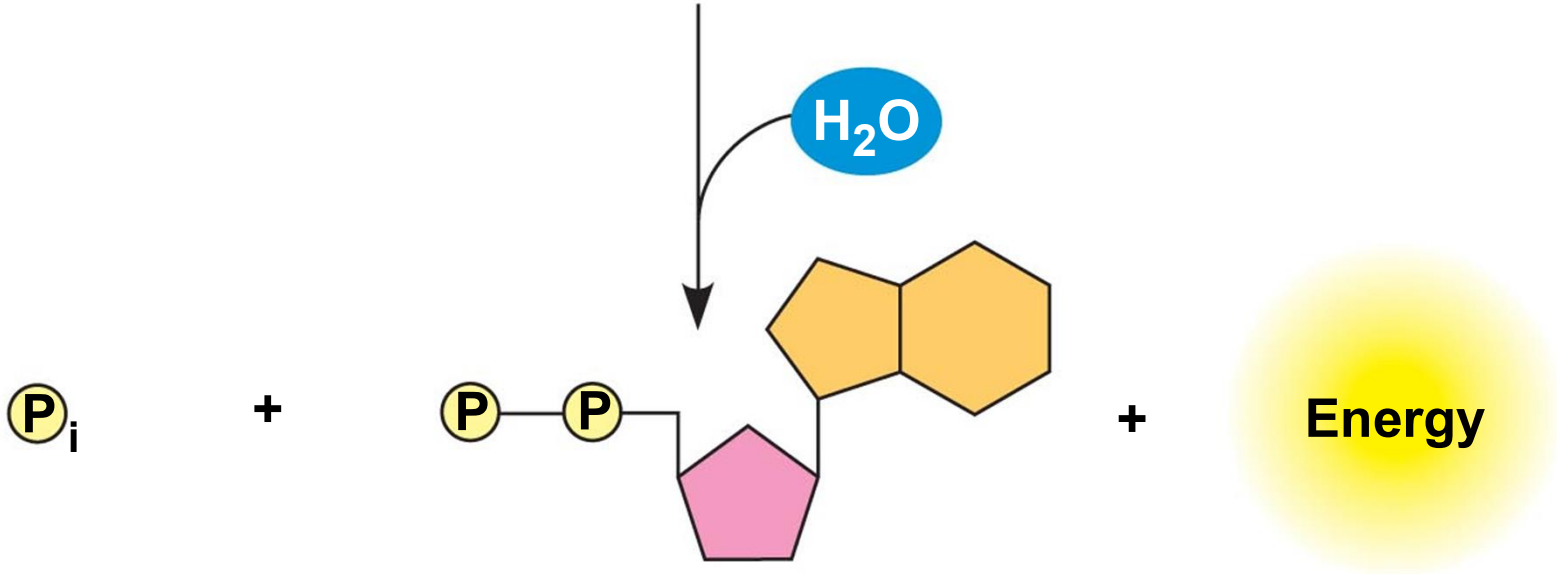
- Energy is released from ATP when the terminal phosphate bond is broken

- This Third Phosphate bond contains LOTS of Energy

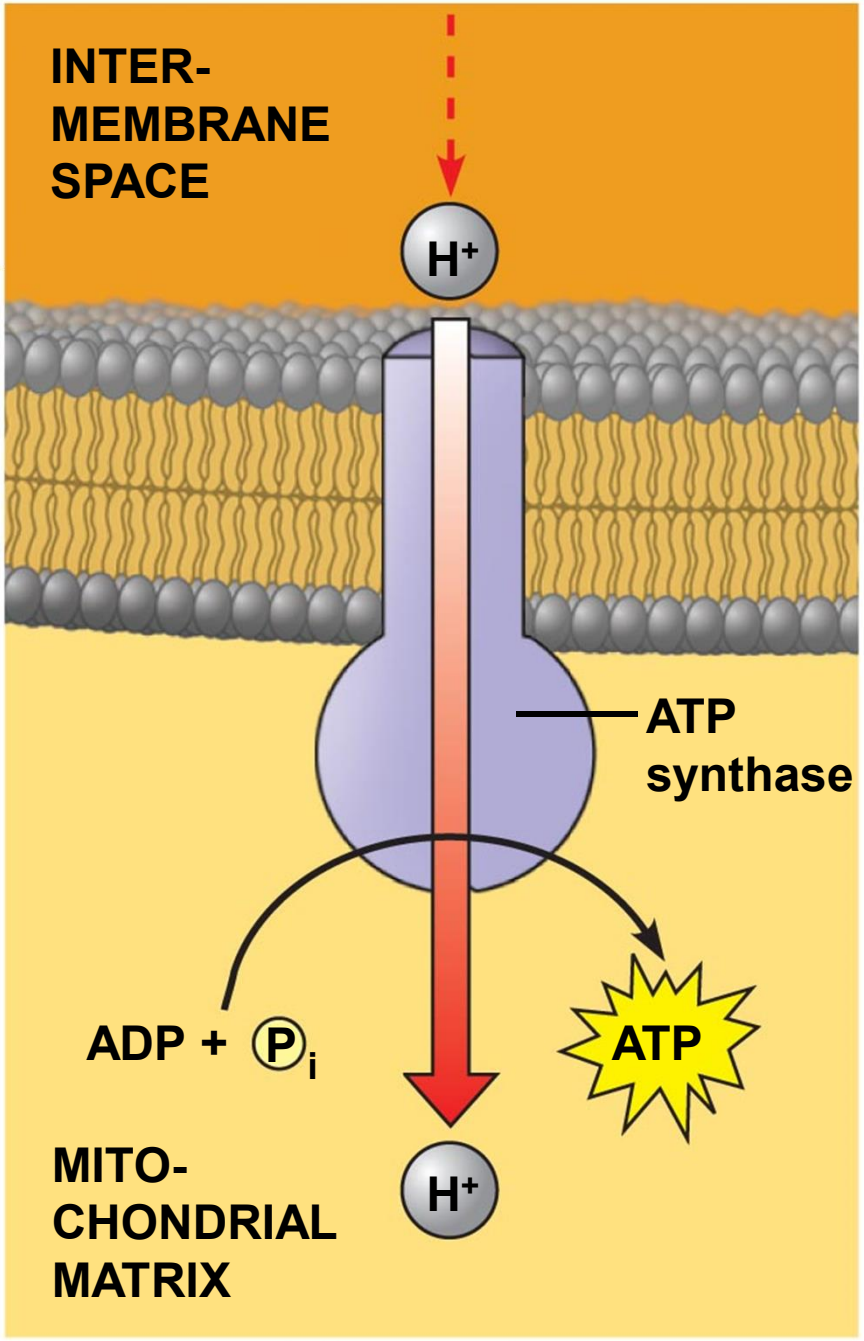
- This release of energy comes from the chemical change to a state of lower free energy, not from the phosphate bonds themselves



Adenosine triphosphate (ATP)



Inorganic phosphate **Adenosine diphosphate (ADP)**



How ATP Performs Work

- The three types of cellular work are:
  - mechanical
  - transport
  - chemical
- Each is powered by the hydrolysis of ATP
- In the cell, the energy from the exergonic reaction of ATP hydrolysis can be used to drive an endergonic reaction

Phosphorylation

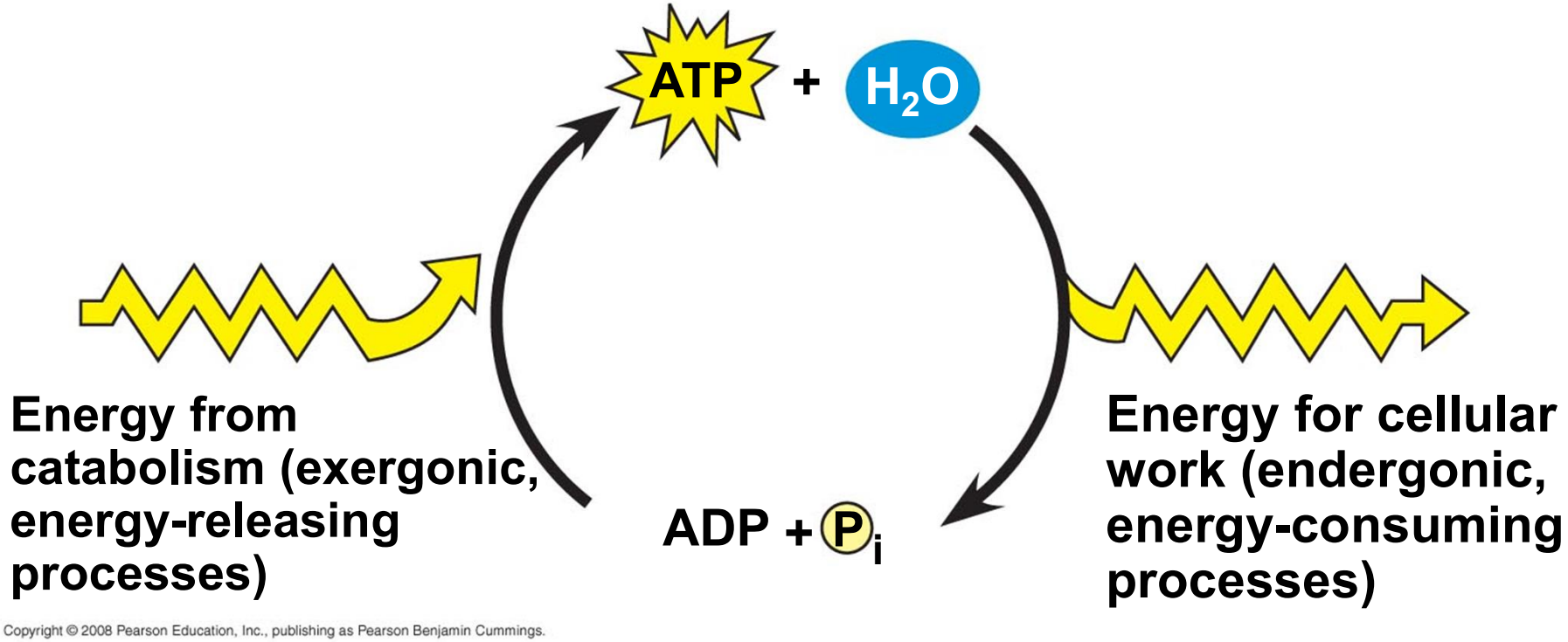
- ATP drives endergonic reactions by phosphorylation, transferring a phosphate group to some other molecule, such as a reactant

- The recipient molecule is now **phosphorylated**

Phosphorylation

- The process of Phosphorylation converts a relatively low energy compound (ADP) into a higher energy compound (ATP)

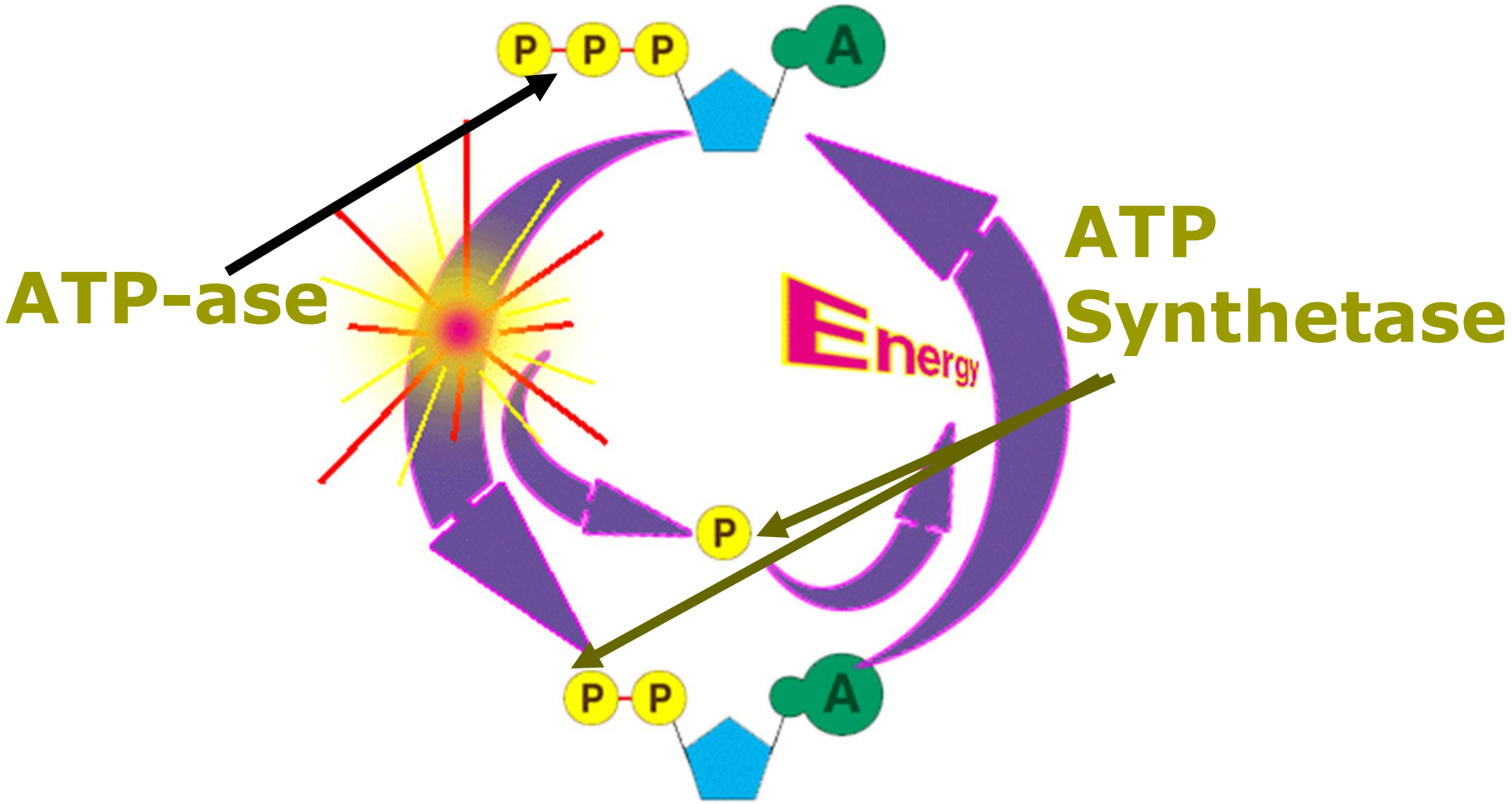
- ADP (Adenosine Di-Phosphate)- Contains an Adenosine, a ribose group, and two Phosphate groups.



The Regeneration of ATP

- ATP is a renewable resource that is regenerated by addition of a phosphate group to adenosine diphosphate (ADP).

- Requires **ATP synthase and H ions** (from water.)
  - The energy to phosphorylate ADP comes from catabolic reactions in the cell.
  - The chemical potential energy temporarily stored in ATP can then be used to drive most cellular work.



THANK YOU