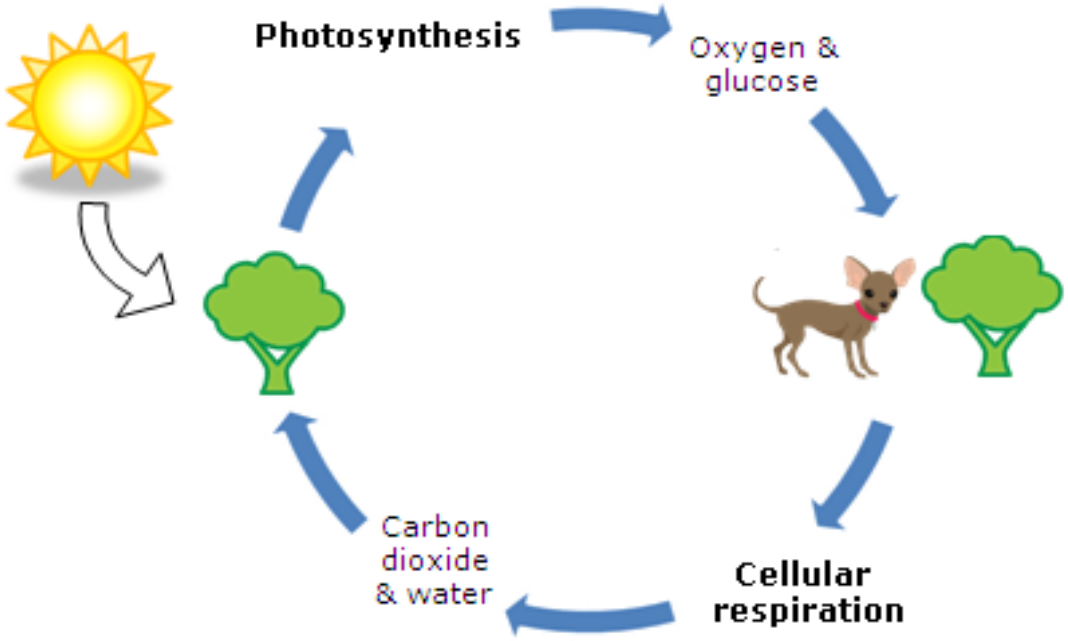
Bioenergetics

Photosynthesis and Respiration

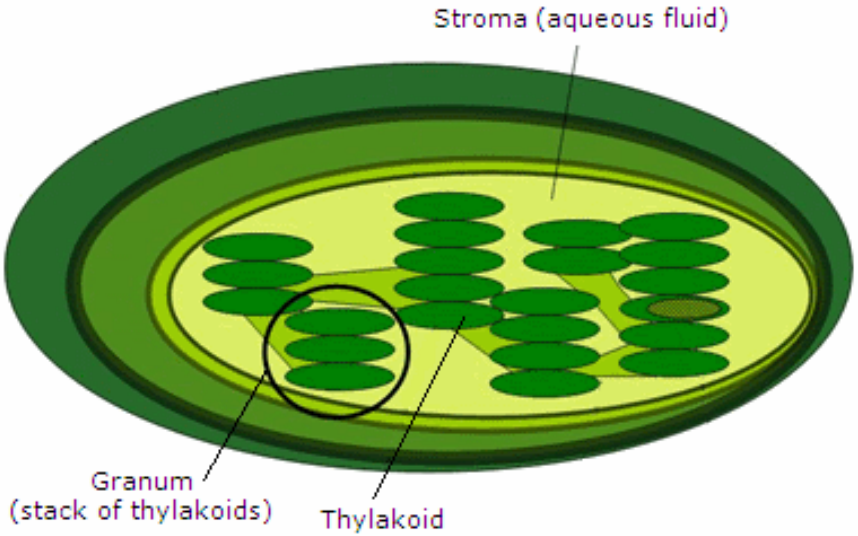
Interdependent Energy Processes



That is, each process is necessary to fuel the other. So, the chemical products of photosynthesis are the chemical reactants of cellular respiration, and the products of cellular respiration are the reactants of photosynthesis.

Photosynthesis

- Occurs in plants, protista (algae), and some bacteria
- Captures light energy and stores it in sugars (chemical energy)
- Photosynthesis occurs within the **chloroplast** of a cell



Sample Question

Which of the following is the only cell organelle that is capable of converting light energy into chemical energy?

A. chloroplast

B. mitochondrion

C. endoplasmic reticulum

D. vacuole

Answer: A

- Chloroplasts are organelles only found in plants and some forms of bacteria and protists. In chloroplasts, carbon dioxide and water are transformed into glucose and oxygen when light energy excites the electrons in chlorophyll.

Photosynthesis

- **Requires** energy, which is supplied by the sun
- The process of photosynthesis can be generally expressed by the equation:

carbon dioxide + water + light energy $\longrightarrow$ sugar + oxygen

- The balanced equation is:

$$6CO_2 + 6H_20 + \text{light} \longrightarrow C_6H_{12}O_6 + 6O_2$$

Sample Question

When cells perform photosynthesis, they transform energy from one form to another. Which of the following is true about the transformation process?

I. Chlorophyll absorbs light from the Sun.
II. Oxygen is given off as a by-product.
III. Low-energy carbon molecules, such as CO_2, are formed.
IV. Chemical potential energy is stored in carbohydrate bonds.

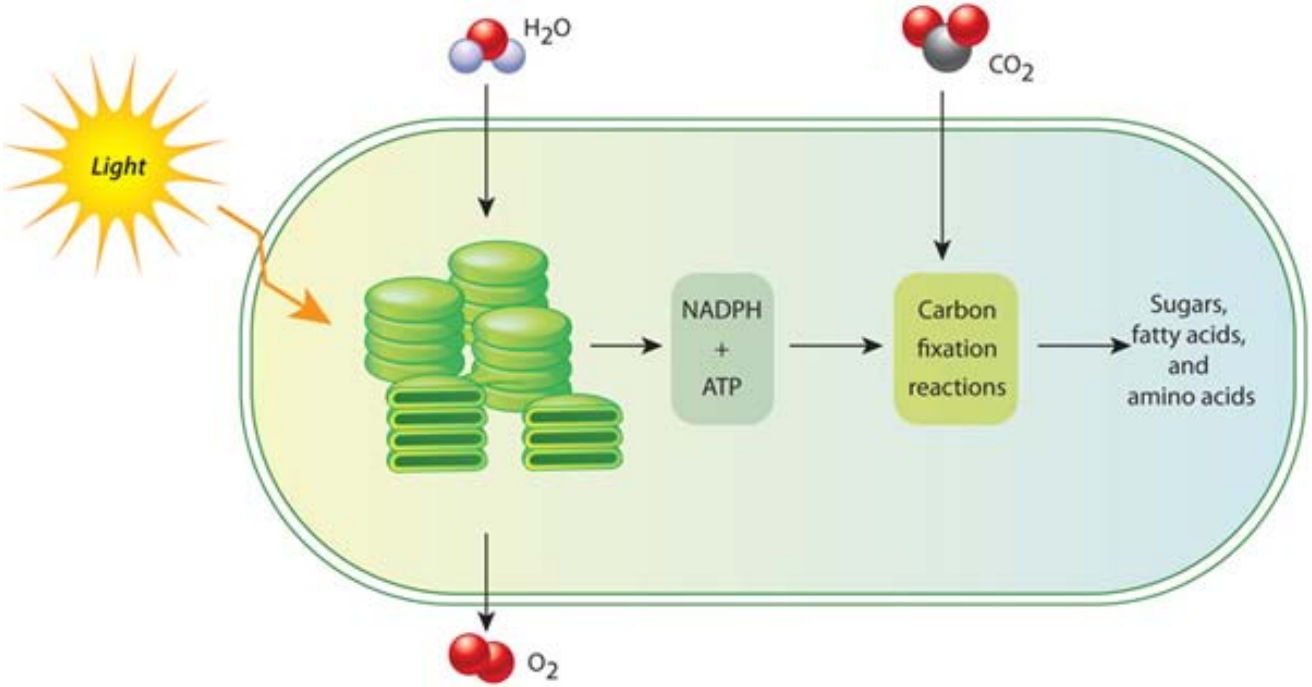
A. I, II, and III only
B. I, II, and IV only
C. I and II only
D. II and IV only

Answer: B

- The process of photosynthesis begins when radiant light energy from the Sun is absorbed by a green pigment in plants called chlorophyll. Carbon from carbon dioxide is then captured by the plant, and higher-energy carbon molecules, such as glucose, are built. Chemical potential energy is stored in glucose's carbohydrate bonds, and these bonds can be broken to fuel the production of ATP. Energy in ATP can then be used to perform cellular work.

The Stages of Photosynthesis

- 2 Stages: Light Dependent and Light Independent (Light Cycle and Calvin Cycle)
- The light reaction takes place in the thylakoid discs



Sample Question

During photosynthesis, plants capture light energy from the Sun to break weak bonds in reactants, such as carbon dioxide and water, and form carbon-containing molecules, such as glucose. The carbon-containing molecules can then be used

A. to produce inorganic compounds, such as sulfuric acid.

B. to assemble larger molecules, such as DNA, proteins, and fats.

C. to synthesize essential amino acids.

D. all of these

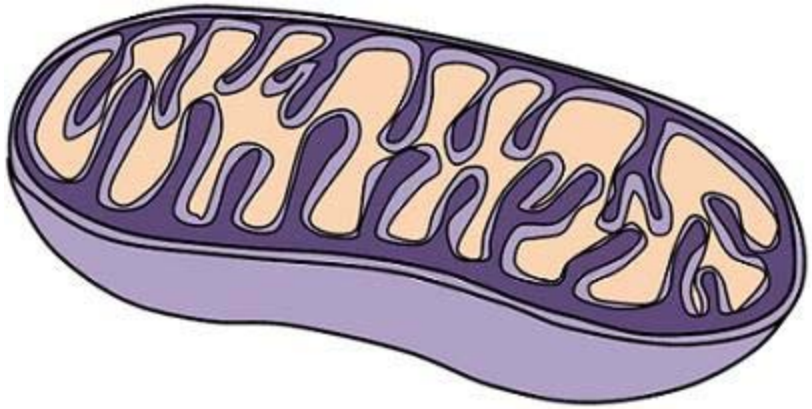
Answer: B

- The cellular processes of photosynthesis and respiration involve the transformation of matter and energy.

  Carbon-containing molecules, such as glucose, that are formed as a product of photosynthesis can be used **to assemble larger molecules, such as DNA, proteins, and fats**.

Cellular Respiration

- Cellular respiration is the breakdown of food for the release of energy
- Occurs in all living organisms
- Cellular respiration occurs in the **mitochondrion** of a cell



Cellular Respiration

- Cellular Respiration **releases** energy
- The process of cellular respiration can be generally expressed by the equation:

sugar + oxygen ⟶ carbon dioxide + water + ATP

- The balanced equation is:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + ATP$$

Cellular Respiration

- Photosynthesis stores energy from the sun in the chemical bonds of the sugar molecules in plants
- When organisms, including plants, need to use the energy stored in the bonds of these molecules, cells perform **cellular respiration**
- Cellular respiration breaks the bonds of the plant sugars and produces **ATP**, which can be used to perform cellular work

Sample Question

During cellular respiration, the bonds of food molecules are broken, so energy can be released to fuel other cellular processes. In order for this to occur, which of the following statements must be true?

A. New compounds with lower energy bonds must be formed when the high energy bonds in food molecules are broken.

B. The energy in the new compounds that are formed must be equal to the energy in the bonds of the food molecules.

C. Energy is created only during the processes of photosynthesis and cellular respiration.

D. New compounds with higher energy bonds must be formed when the low energy bonds in food molecules are broken.

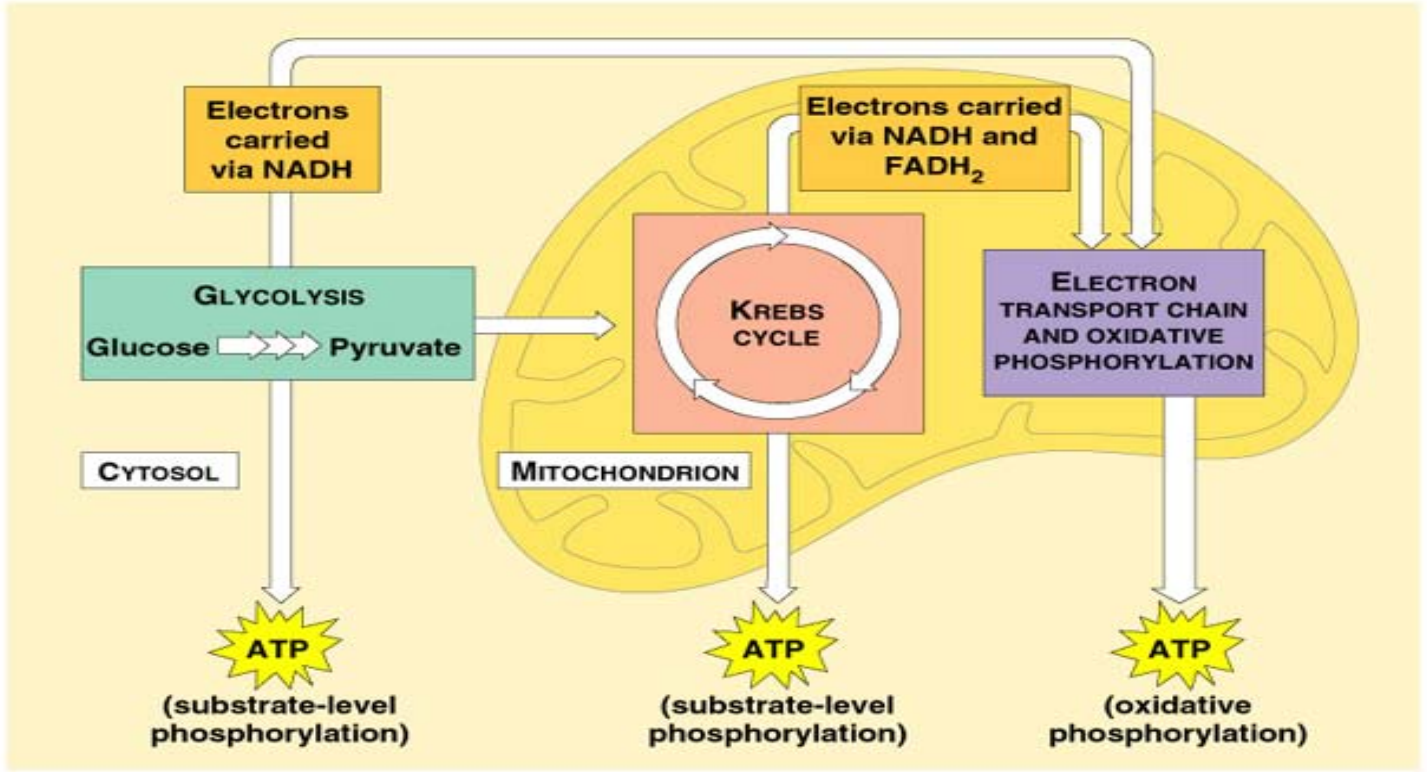
Answer: A

- The cellular processes of photosynthesis and respiration involve the transformation of matter and energy.

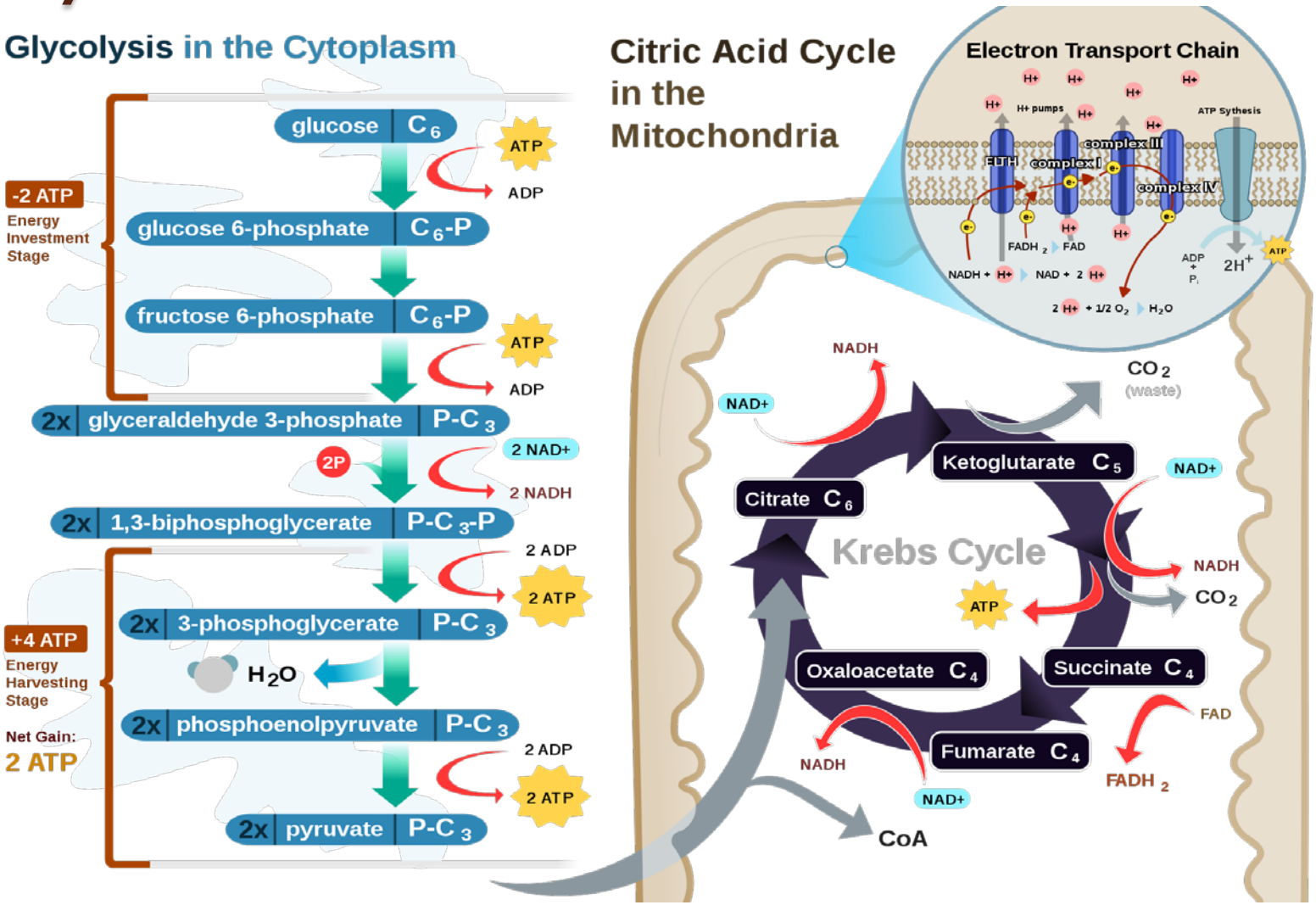
  According to the law of conservation of energy, energy can neither be created nor destroyed. So, in order to obtain *excess* energy to fuel cellular processes, **the bonds formed in the new compounds must have less energy than the bonds in the original food molecules**.

The Stages of Cellular Respiration

- 4 Stages: Glycolysis, pyruvate oxidation, Krebs cycle, and oxidative phosphorylation



Focus in on: Glycolysis and Krebs cycle



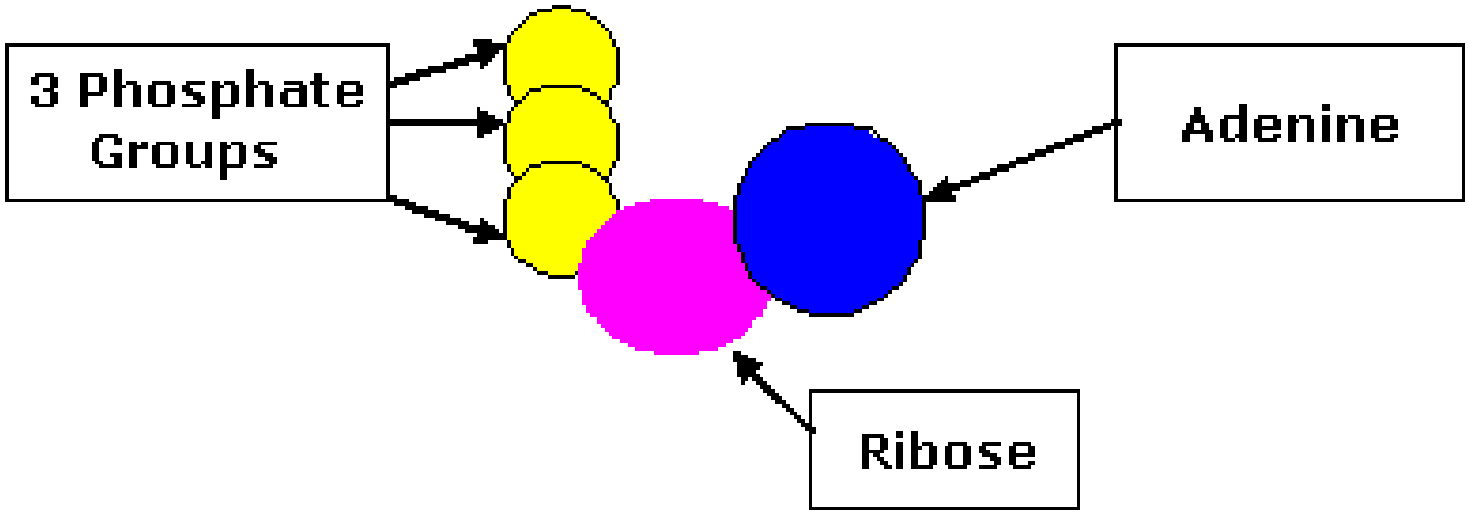
Macromolecules for Energy Storage

- Cells depend on specific types of macromolecules to store energy
- Other than sugar, two macromolecules used for energy storage include **ATP** and **lipids**.

ATP - Adenosine triphosphate

- ATP contains adenine, ribose, and three phosphate groups
- Each of the phosphate bonds stores a large quantity of energy, which is released for use when the bond is broken
- ATP is **broken down** in metabolism to fuel chemical reactions, ATP can also be **created** by chemical reactions to store energy

ATP - Adenosine triphosphate



Sample Question

Through the process of **hydrolysis**, cells remove phosphate groups from molecules of ATP to form molecules of ADP.
This hydrolytic reaction results in

A. the breaking of low-energy bonds to produce free energy.

B. the formation of low-energy bonds to store free energy.

C. the breaking of high-energy bonds to produce free energy.

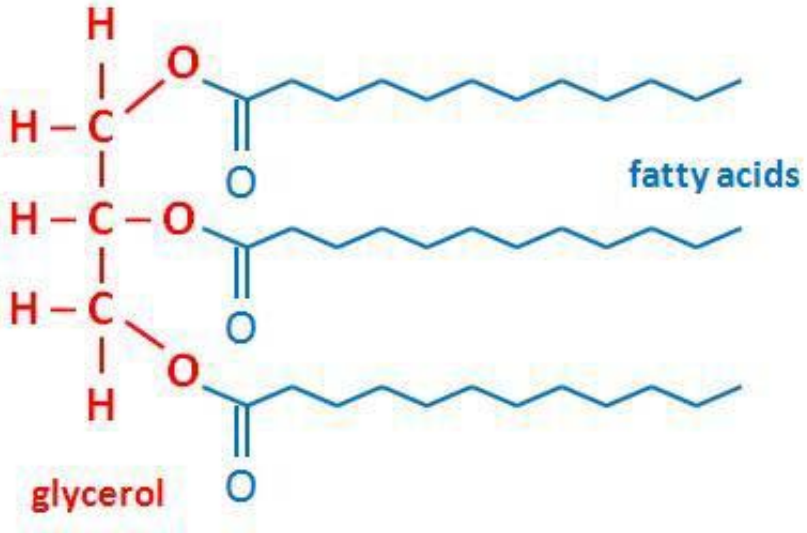
D. the formation of high-energy bonds to store free energy.

Answer: C

- Adenosine triphosphate, or ATP, is a macromolecule used by the body for energy storage. ATP contains adenine, ribose, and three phosphate groups. Each of the phosphate bonds stores a large quantity of energy which is released for use when the bond is broken.
- When this reaction occurs in reverse, cells perform **dehydration** reactions to add phosphate groups to ADP and store energy for later use.

Lipids

- Macromolecules used by the body for long-term energy storage
- Contain high-energy bonds that can be broken by cells to release energy to do cellular work



Sample Question

In order to function properly, cells must perform many reactions. Metabolism is the sum of all the chemical reactions in an organism. During metabolism, ATP

I. is broken down to fuel chemical reactions.

II. is created by chemical reactions.

III. is shuttled from one cell to another.

A. I and II only
B. I, II, and III
C. I and III only
D. III only

Answer: A

- During metabolism, ATP is **broken down to fuel chemical reactions**, or it can be **created by chemical reactions**.

  Metabolism is often divided into two main categories - catabolism and anabolism. *Catabolism* is the set of chemical reactions that breaks large molecules into smaller units. During catabolic processes, ATP (energy) is created and released. *Anabolism* is the set of chemical reactions that builds large molecules from smaller units. During anabolic processes, ATP (energy) is broken down and used for fuel.

  ATP is not shuttled from cell to cell.