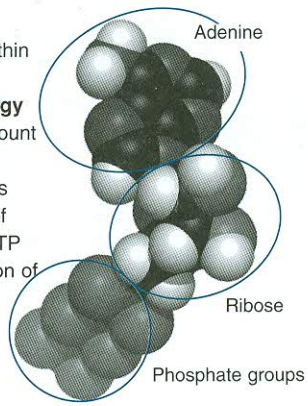
The Role of ATP in Cells

All organisms require energy for their metabolism. The universal energy carrier for the cell is the molecule ATP (**adenosine triphosphate**). ATP transports chemical energy within the cell for use in metabolic processes such as biosynthesis, cell division, cell signaling, thermoregulation, cell motility, and active transport. ATP can release its energy quickly; only one chemical reaction (hydrolysis of the terminal phosphate) is required. This reaction is catalyzed by the enzyme ATPase. Once ATP has released its energy, it becomes ADP (adenosine diphosphate), a low energy molecule that can be recharged by adding a phosphate. This requires energy, which is supplied by the controlled breakdown of respiratory substrates (commonly glucose) in **cellular respiration**.

Adenosine Triphosphate (ATP)

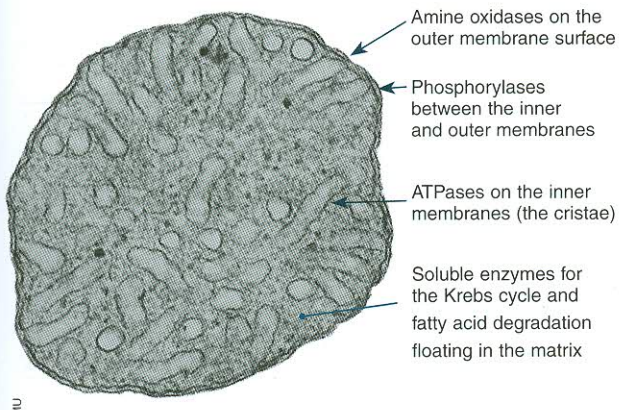
The ATP molecule consists of three components; a purine base (**adenine**), a pentose sugar (**ribose**), and **three phosphate groups** which attach to the 5' carbon of the pentose sugar. The three dimensional structure of ATP is described below.

ATP acts as a store of energy within the cell. The bonds between the phosphate groups are **high-energy bonds**, meaning that a large amount of free energy is released when they are hydrolyzed. Typically, this hydrolysis involves the removal of one phosphate group from the ATP molecule resulting in the formation of adenosine diphosphate (ADP).



The Mitochondrion

Cellular respiration and ATP production occur in the mitochondria. A mitochondrion is bound by a double membrane. The inner and outer membranes are separated by an intermembrane space, compartmentalizing the regions of the mitochondrion in which the different reactions of cellular respiration take place.



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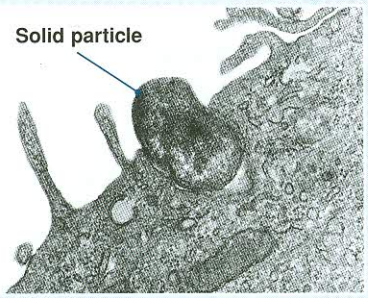
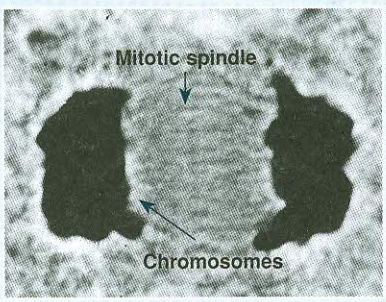
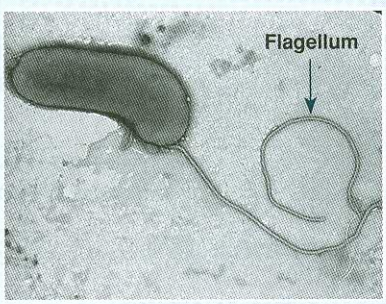
ATP Powers Metabolism



The energy released from the removal of a phosphate group of ATP is used to actively transport molecules and substances across the cellular membrane. **Phagocytosis** (left), which involves the engulfment of solid particles, is one such example.



Cell division (mitosis), as observed in this onion cell, requires ATP to proceed. Formation of the mitotic spindle and chromosome separation are two aspects of cell division which require energy from ATP hydrolysis to occur.



The hydrolysis of ATP provides the energy for motile cells to achieve movement via a tail-like structure called a flagellum. For example, the bacterium, *Helicobacter pylori* (left), is motile. Likewise, mammalian sperm must be able to move to the ovum to fertilize it.

The maintenance of body temperature requires energy. To maintain body heat, muscular activity increases (e.g. shivering, erection of body hairs). Cooling requires expenditure of energy too. For example, sweating is an energy requiring process involving secretion from glands in the skin.

1. In which organelle is ATP produced in the cell? _____
2. Which enzyme catalyzes the hydrolysis of ATP? _____
3. Explain how ATP is involved in:

   (a) Thermoregulation: _____

   _____

   (b) Cell motility: _____

   _____

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