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ATP (Adenosine triphosphosphate) is the Universal currency of Energy or Energy currency of Cell.

Just as commerce is facilitated by the use of a common **currency**, the commerce of the **cell**—metabolism—is facilitated by the use of a common energy **currency**, ***adenosine triphosphate*** (**ATP**). Part of the free energy derived from the oxidation of foodstuffs and from light is transformed into this highly accessible molecule, which acts as the free-energy donor in most energy-requiring processes such as motion, active transport, or biosynthesis.

ATP is a nucleotide consisting of an adenine, a ribose, and a **triphosphate** unit (Figure 1). The active form of **ATP** is usually a complex of **ATP** with Mg^{2+} or Mn^{2+} . In considering the role of **ATP** as an energy carrier, we can focus on its **triphosphate** moiety. ***ATP*** *is an energy-rich molecule because its* ***triphosphate*** *unit contains two phosphoanhydride bonds*. A large amount of free energy is liberated when **ATP** is hydrolyzed to **adenosine** diphosphate (ADP) and orthophosphate (P_i) or when **ATP** is hydrolyzed to **adenosine** monophosphate (AMP) and pyrophosphate (PP_i).

$$ATP + H_2O \rightleftharpoons AMP + PP_i \qquad \Delta G^{\circ\prime} = -10.9 \text{ kcal mol}^{-1} (-45.6 \text{ kJ mol}^{-1})$$

$$ATP + H_2O \rightleftharpoons ADP + P_i \qquad \Delta G^{\circ\prime} = -7.3 \text{ kcal mol}^{-1} (-30.5 \text{ kJ mol}^{-1})$$

The precise $\Delta G^{\circ\prime}$ for these reactions depends on the ionic strength of the medium and on the concentrations of Mg^{2+} and other metal ions. Under typical cellular concentrations, the actual ΔG for these hydrolyses is approximately -12 kcal mol^{-1} (-50 kJ mol^{-1}).

The free energy liberated in the hydrolysis of **ATP** is harnessed to drive reactions that require an input of free energy, such as muscle contraction. In turn, **ATP** is formed from ADP and P_i when fuel molecules are oxidized in chemotrophs or when light is trapped by phototrophs. *This* ***ATP****—ADP cycle is the fundamental mode of energy exchange in biological systems.*

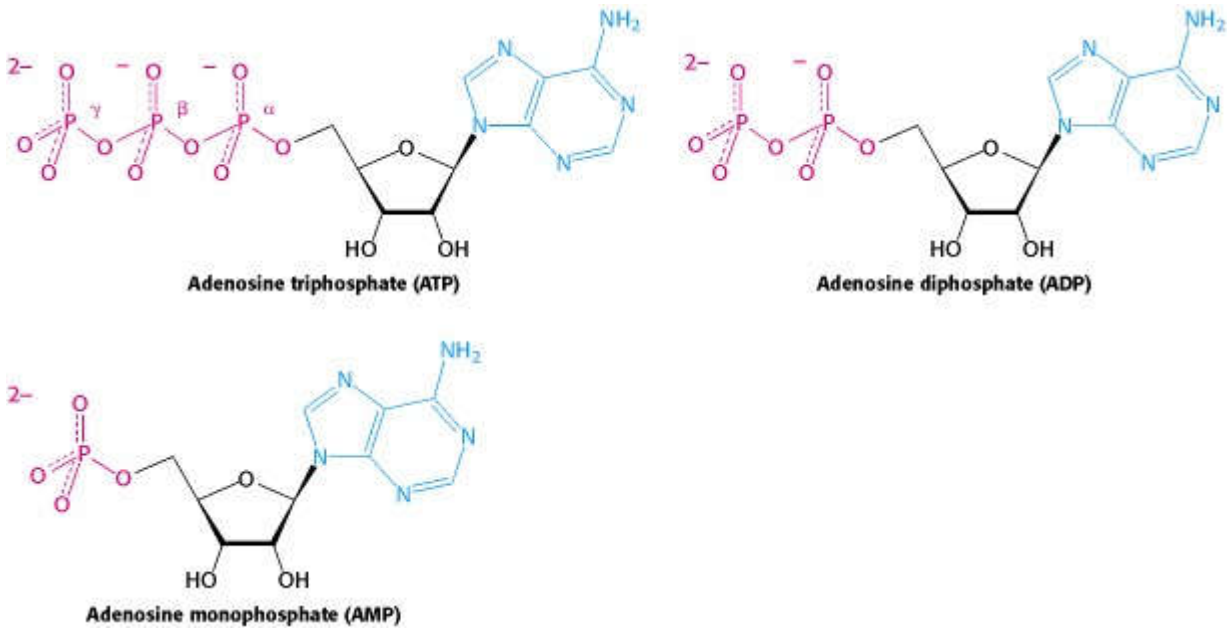

Figure 1.Structures of ATP, ADP, and AMP

These adenylates consist of adenine (blue), a ribose (black), and a tri-, di-, or monophosphate unit (red). The innermost phosphorus atom of **ATP** is designated P_α, the middle one P_β, and the outermost one P_γ

Enzymes can catalyze the transfer of the terminal phosphoryl group from one nucleotide to another. The phosphorylation of nucleoside monophosphates is catalyzed by a family of nucleoside monophosphate kinases, as discussed in Section 9.4.1. The phosphorylation of nucleoside diphosphates is catalyzed by nucleoside diphosphate kinase, an enzyme with broad specificity. It is intriguing to note that, although all of the nucleotide triphosphates are energetically equivalent, **ATP** is nonetheless the primary cellular energy carrier. In addition, two important electron carriers, NAD^+ and FAD, are derivatives of **ATP**. *The role of **ATP** in energy metabolism is paramount*.

The high phosphoryl transfer potential of ATP enables it to serve as the energy source in muscle contraction, active transport, signal amplification, and biosyntheses. The hydrolysis of an ATP molecule changes the equilibrium ratio of products to reactants in a coupled reaction by a factor of about 10^8. Hence, *a thermodynamically unfavorable reaction sequence can be made highly favorable by coupling it to the hydrolysis of a sufficient number of ATP molecules.*

ATP is generated by the oxidation of fuel molecules such as glucose, fatty acids, and amino acids. The common intermediate in most of these oxidations is acetyl CoA. The carbon atoms of the acetyl unit are completely oxidized to CO_2 by the citric acid cycle with the concomitant

formation of NADH and $FADH_2$. These electron carriers then transfer their high potential electrons to the respiratory chain. The subsequent flow of electrons to O_2 leads to the pumping of protons across the inner mitochondrial membrane (Figure 30.1). This proton gradient is then used to synthesize ATP. Glycolysis also generates ATP, but the amount formed is much smaller than that in oxidative phosphorylation. The oxidation of glucose to pyruvate yields only 2 molecules of ATP, whereas the complete oxidation of glucose to CO_2 yields 30 molecules of ATP.

Things to read ----------

NADPH (nicotinamide adenine dinucleotite phosphate) is the major electron donor in reductive biosynthesis.

> In most biosyntheses, the products are more reduced than the precursors, and so reductive power is needed as well as ATP. The high-potential electrons required to drive these reactions are usually provided by NADPH. The pentose phosphate pathway supplies much of the required NADPH.
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> ***Biomolecules are constructed from a small set of building blocks.*** The highly diverse molecules of life are synthesized from a much smaller number of precursors. The metabolic pathways that generate ATP and NADPH also provide building blocks for the biosynthesis of more-complex molecules. For example, acetyl CoA, the common intermediate in the breakdown of most fuels, supplies a two-carbon unit in a wide variety of biosyntheses, such as those leading to fatty acids, prostaglandins, and cholesterol. Thus, *the central metabolic pathways have anabolic as well as catabolic roles.Biosynthetic and degradative pathways are almost always distinct.* For example, the pathway for the synthesis of fatty acids is different from that of their degradation. This separation enables both biosynthetic and degradative pathways to be thermodynamically favorable at all times. A biosynthetic pathway is made exergonic by coupling it to the hydrolysis of a sufficient number of ATP molecules. The separation of biosynthetic and degradative pathways contributes greatly to the effectiveness of metabolic control.