

# Exergonic and Endergonic Reactions

## Encyclopedia Article

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# Exergonic and Endergonic Reactions

Exergonic refers to chemical reactions that proceed spontaneously from reactants to products with the release of energy. Endergonic reactions require energy input to proceed. Although the terms are often used rather loosely, they are precisely defined thermodynamic concepts based on changes in an entity called Gibbs free energy ( $G$ ) accompanying reactions. Reactions in which  $-G$  decreases are exergonic, and those in which  $-G$  increases are endergonic. Exergonic reactions often involve the breakdown of organic compounds found in food, whereas endergonic reactions frequently entail synthesis of complicated molecules. Biological metabolism contains many examples of both types, and living organisms have developed elaborate techniques for coupling the two.

Although a negative  $-G$  indicates that energy must be added to the system before a reaction will occur, it tells us nothing about the rate at which it will progress. As is often the case, it may go very slowly if substantial activation energy is required to start the reaction. Living organisms have found a way around this problem by forming protein catalysts, called enzymes, that effectively reduce the amount of activation energy needed, and allow the reaction to proceed at a satisfactory rate. Enzymes do not affect the free energy of the reaction, and will not enable reactions to proceed that are not energetically feasible.

By coupling exergonic and endergonic reactions, organisms are able to use the available energy in food they consume to construct complex proteins, lipids, nucleic acids and carbohydrates needed for their growth and development. A well-known example involves coupling the formation of energy-rich adenosine triphosphate (ATP) from adenosine diphosphate (ADP) and phosphate (an endergonic reaction), with the transfer of hydrogen, removed from organic food materials, to oxygen (an exergonic reaction). The process is called oxidative phosphorylation. Energy stored in ATP may be used subsequently when the exergonic conversion of ATP back to ADP and phosphate is coupled with the endergonic synthesis of a needed cellular component.