

I'm not robot!

Home Health & Medicine Health, Nutrition & Fitness metabolism, the sum of the chemical reactions that take place within each cell of a living organism and that provide energy for vital processes and for synthesizing new organic material. Living organisms are unique in that they can extract energy from their environments and use it to carry out activities such as movement, growth and development, and reproduction. But how do living organisms—or, their cells—extract energy from their environments, and how do cells use this energy to synthesize and assemble the components from which the cells are made? What does the word “migration” mean? How many sets of legs does a shrimp have? From poisonous fish to biodiversity, learn more about the study of living things in this quiz. The answers to these questions lie in the enzyme-mediated chemical reactions that take place in living matter (metabolism). Hundreds of coordinated, multistep reactions, fueled by energy obtained from nutrients and/or solar energy, ultimately convert readily available materials into the molecules required for growth and maintenance. The physical and chemical properties of the components of living things dealt with in this article are found in the articles carbohydrate; cell; hormone; lipid; photosynthesis; and protein. Get a Britannica Premium subscription and gain access to exclusive content. Subscribe Now At the cellular level of organization, the main chemical processes of all living matter are similar, if not identical. This is true for animals, plants, fungi, or bacteria; where variations occur (such as, for example, in the secretion of antibodies by some molds), the variant processes are but variations on common themes. Thus, all living matter is made up of large molecules called proteins, which provide support and coordinated movement, as well as storage and transport of small molecules, and, as catalysts, enable chemical reactions to take place rapidly and specifically under mild temperature, relatively low concentration, and neutral conditions (i.e., neither acidic nor basic). Proteins are assembled from some 20 amino acids, and, just as the 26 letters of the alphabet can be assembled in specific ways to form words of various lengths and meanings, so may tens or even hundreds of the 20 amino-acid “letters” be joined to form specific proteins. Moreover, those portions of protein molecules involved in performing similar functions in different organisms often comprise the same sequences of amino acids. There is the same unity among cells of all types in the manner in which living organisms preserve their individually and transmit it to their offspring. For example, hereditary information is encoded in a specific sequence of bases that make up the DNA (deoxyribonucleic acid) molecule in the nucleus of each cell. Only four bases are used in synthesizing DNA: adenine, guanine, cytosine, and thymine. Just as the Morse Code consists of three simple signals—a dash, a dot, and a space—the precise arrangement of which suffices to convey coded messages, so the precise arrangement of the bases in DNA contains and conveys the information for the synthesis and assembly of cell components. Some primitive life-forms, however, use RNA (ribonucleic acid; a nucleic acid differing from DNA in containing the sugar ribose instead of the sugar deoxyribose and the base uracil instead of the base thymine) in place of DNA as a primary carrier of genetic information. The replication of the genetic material in these organisms must, however, pass through a DNA phase. With minor exceptions, the genetic code used by all living organisms is the same. The chemical reactions that take place in living cells are similar as well. Green plants use the energy of sunlight to convert water (H₂O) and carbon dioxide (CO₂) to carbohydrates (sugars and starches), other organic (carbon-containing) compounds, and molecular oxygen (O₂). The process of photosynthesis requires energy, in the form of sunlight, to split one water molecule into one-half of an oxygen molecule (O₂; the oxidizing agent) and two hydrogen atoms (H; the reducing agent), each of which dissociates to one hydrogen ion (H⁺) and one electron. Through a series of oxidation-reduction reactions, electrons (denoted e⁻) are transferred from a donating molecule (oxidation), in this case water, to an accepting molecule (reduction) by a series of chemical reactions; this “reducing power” may be coupled ultimately to the reduction of carbon dioxide to the level of carbohydrate. In effect, carbon dioxide accepts and bonds with hydrogen, forming carbohydrates (C_n[H₂O]_n). Living organisms that require oxygen reverse this process: they consume carbohydrates and other organic materials, using oxygen synthesized by plants to form water, carbon dioxide, and energy. The process that removes hydrogen atoms (containing electrons) from the carbohydrates and passes them to the oxygen is an energy-yielding series of reactions. In plants, all but two of the steps in the process that converts carbon dioxide to carbohydrates are the same as those steps that synthesize sugars from simpler starting materials in animals, fungi, and bacteria. Similarly, the series of reactions that take a given starting material and synthesize certain molecules that will be used in other synthetic pathways are similar, or identical, among all cell types. From a metabolic point of view, the cellular processes that take place in a lion are only marginally different from those that take place in a dandelion. New from Britannica There are 34,000 different species of fish. That’s more than all the other vertebrates (amphibians, birds, reptiles, and mammals) combined. See All Good Facts The energy changes associated with physicochemical processes are the province of thermodynamics, a subdiscipline of physics. The first two laws of thermodynamics state, in essence, that energy can be neither created nor destroyed and that the effect of physical and chemical changes is to increase the disorder, or randomness (i.e., entropy), of the universe. Although it might be supposed that biological processes—through which organisms grow in a highly ordered and complex manner, maintain order and complexity throughout their life, and pass on the instructions for order to succeeding generations—are in contravention of these laws, this is not so. Living organisms neither consume nor create energy: they can only transform it from one form to another. From the environment they absorb energy in a form useful to them; to the environment they return an equivalent amount of energy in a biologically less useful form. The useful energy, or free energy, may be defined as energy capable of doing work under isothermal conditions (conditions in which no temperature differential exists); free energy is associated with any chemical change. Energy less useful than free energy is returned to the environment, usually as heat. Heat cannot perform work in biological systems because all parts of cells have essentially the same temperature and pressure. The modern world is in the midst of an obesity epidemic, which has caused a dramatic increase in people affected by obesity-related disorders including Type-2 Diabetes, cardiovascular disease, hypertension and dyslipidemia. A particularly worrying trend is that children and adolescents are also becoming increasingly obese and consequently are succumbing to metabolic diseases that a decade ago only occurred in adults. To better understand the link between adiposity and metabolic diseases, investigators in the Department of Biochemistry are studying the complex cross-talks occurring among the various organs and tissues that regulate endocrine signaling and nutrients metabolism. This includes attempting to identify the molecular mechanisms that contribute to the physiological control of metabolic homeostasis within each tissue as well as contributing to a better understanding of cells and tissues adaptation to metabolic stress. In particular, research in the Biochemistry Department has historically focused on the biology of the adipose tissue, including mechanistic studies on adipocyte biology, developmental origins of adipocytes, mechanisms of adipose tissue remodeling, production of hormones and cytokines, and characterization of adipogenesis and cross-talk between adipocytes and immune cells. Several investigators in the Biochemistry Department are active participants in the NIDDK-funded Boston Nutrition Obesity Research Center (BNORC) and the Department is currently housing the BNORC Adipose Biology and Nutrient Metabolism Core, whose mission is to facilitate and foster adipose tissue research by providing access to human and mouse cells/tissues, assisting in method development and sponsoring the bi-weekly Adipose and Metabolic Tissue Study Group Seminar Series. Outstanding opportunities for pre-doctoral and post-doctoral training are available through the NIDDK T32 Program in Metabolism, Endocrinology, and Obesity. Faculty conducting research in this area:

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