ENERGY AND METABOLISM

Dr. Ahmed Hasan Mohammed

Introduction

- Life can be viewed as a constant flow of energy, channeled by organisms to do the work of living. Each of the significant properties by which we define life—order, growth, reproduction, responsiveness, and internal regulation requires a constant supply of energy.

Energy

- **Energy** is defined as the capacity to do work. It can be considered to exist in two states.
- **Kinetic energy** is the energy of motion. Moving objects perform work by causing other matter to move.
- **Potential energy** is stored energy. Objects that are not actively moving but have the capacity to do so possess potential energy.

Energy Forms

- The most convenient is in terms of heat, because all other forms of energy can be converted into heat. In fact, the study of energy is called **thermodynamics,** meaning heat changes.
- The unit of heat most commonly employed in biology is the **kilocalorie** (kcal). One kilocalorie is equal to 1000 calories (cal), and one calorie is the heat required to raise the temperature of one gram of water one degree Celsius (°C).
- (It is important not to confuse calories with a term related to diets and nutrition, the Calorie with a capital C, which is actually another term for kilocalorie.)
- Another energy unit, often used in physics, is the **joule;** one joule equals 0.239 cal.

Oxidation-Reduction

- During a chemical reaction, the energy stored in chemical bonds may transfer to new bonds. In some of these reactions, electrons actually pass from one atom or molecule to another.
- When an atom or molecule loses an electron, it is said to be oxidized, and the process by which this occurs is called **oxidation.** The name reflects the fact that in biological systems oxygen, which attracts electrons strongly, is the most common electron acceptor.
- Conversely, when an atom or molecule gains an electron, it is said to be reduced, and the process is called **reduction.**
- Oxidation and reduction always take place together, because every electron that is lost by an atom through oxidation is gained by some other atom through reduction. Therefore, chemical reactions of this sort are called **oxidation-reduction (redox) reactions**.

Enzymes

- The chemical reactions within living organisms are regulated by controlling the points at which catalysis takes place. Life itself is, therefore, regulated by catalysts. The agents that carry out most of the catalysis in living organisms are proteins called **enzymes.**
- The reaction thus proceeds much more quickly than it would without the enzyme.
- Because the enzyme itself is not changed or consumed in the reaction, only a small amount of an enzyme is needed

Enzymes

Factors Affecting Enzyme Activity

Temperature

- Increasing the temperature of an uncatalyzed reaction will increase its rate because the additional heat represents an increase in random molecular movement. The rate of an enzyme-catalyzed reaction also increases with temperature, but only up to a point called the *temperature optimum*.

pH

- Ionic interactions between oppositely charged amino acid residues, such as glutamic acid (–) and lysine (+), also hold enzymes together. These interactions are sensitive to the hydrogen ion concentration of the fluid the enzyme is dissolved in, because changing that concentration shifts the balance between positively and negatively charged amino acid residues. For this reason, most enzymes have a **pH optimum** that usually ranges from pH 6 to 8.

Inhibitors and Activators

- A substance that binds to an enzyme and *decreases* its activity is called an **inhibitor.**
- Very often, the end product of a biochemical pathway acts as an inhibitor of an early reaction in the pathway, a process called *feedback inhibition*.
- Enzyme inhibition occurs in two ways: **competitive inhibitors** compete with the substrate for the same binding site, displacing a percentage of substrate molecules from the enzymes; **noncompetitive inhibitors** bind to the enzyme in a location other than the active site, changing the shape of the enzyme and making it unable to bind to the substrate.

- Most noncompetitive inhibitors bind to a specific portion of the enzyme called an **allosteric site** (Greek *allos,* "other" + *steros,* "form"). These sites serve as chemical on/off switches; the binding of a substance to the site can switch the enzyme between its active and inactive configurations.
- A substance that binds to an allosteric site and reduces enzyme activity is called an **allosteric inhibitor**.
- Alternatively, **activators** bind to allosteric sites and keep the enzymes in their active configurations, thereby *increasing* enzyme activity.