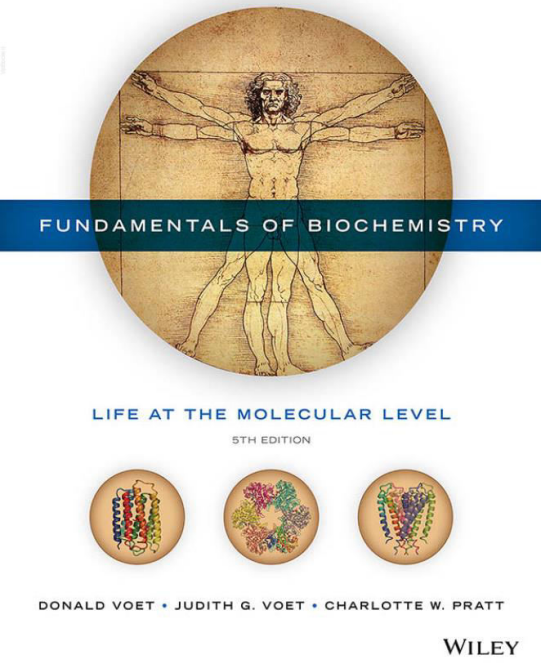
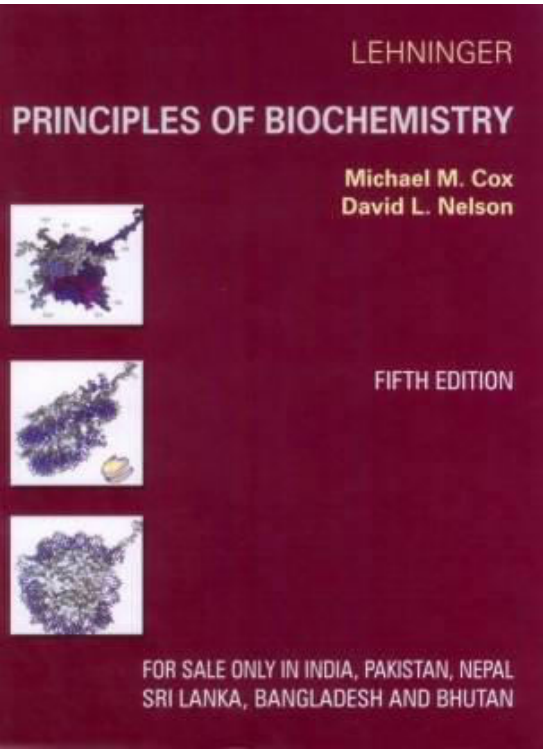
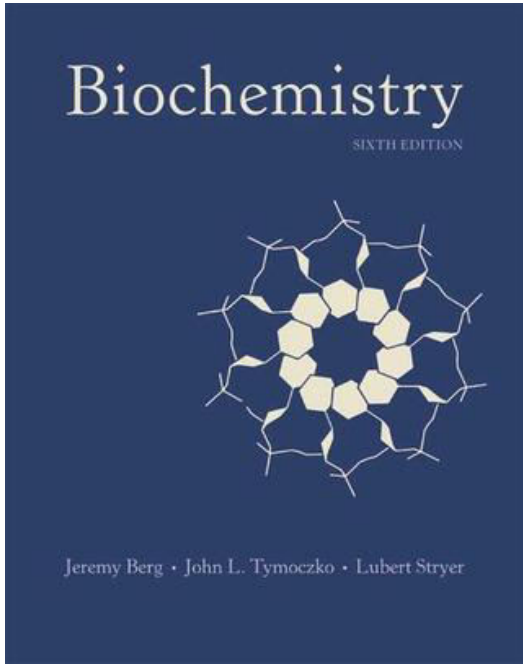


Bi-substrate Reactions



Dr. Akhilendra Pratap Bharati
Assistant Professor
Department of Life Science and Biotechnology



Bi-substrate Reactions

$$A + B \overset{E}{\rightleftharpoons} P + Q$$

- ~60% of known biochemical reactions are bi-substrate reaction.
- Almost all of these bi-substrate reactions are either transfer reactions in which the enzyme catalyzes the **transfer of a specific functional group**, X, from one of the substrates to the other or **oxidation-reduction** reactions in which reducing equivalents are transferred between the two substrates.

$$P{-}X + B \overset{E}{\rightleftharpoons} P + B{-}X$$

Although bi-substrate reactions occur through a vast variety of mechanisms, only a few types are commonly observed.

Sequential Reactions

- Reactions in which **all substrates must combine with the enzyme before a reaction can occur** and products be released are known as **sequential reactions**.

- In such reactions, the group being transferred, X, is directly passed from A (= P—X) to B, yielding P and Q (= B—X). Hence, such reactions are also called single-displacement reactions.

a. **Ordered mechanism**

b. **Random mechanism**

Cleland notation

In a notation developed by **W.W. Cleland**, substrates are designated by the letters A and B in the order that they add to the enzyme, products are designated by P and Q in the order that they leave the enzyme, the enzyme is represented by a horizontal line, and successive additions of substrates and releases of products are denoted by vertical arrows.

a. Ordered mechanism

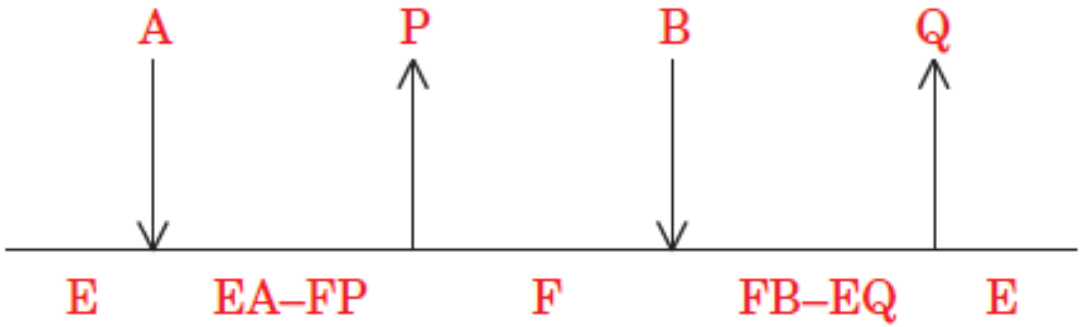
- Where A and B are said to be the leading and following substrates, respectively.
- Many NAD+ and NADP+ requiring **dehydrogenases** follow an **ordered bi-substrate mechanism** in which the coenzyme is the leading substrate.

b. Random mechanism

- Some **dehydrogenases and kinases** operate through Random bi-substrate mechanisms (kinases are enzymes that transfer phosphoryl groups from ATP to other compounds or vice versa).

Ping Pong Reactions

- Group-transfer reactions in which one or more products are released before all substrates have been added are known as **Ping Pong reactions**.



- Here, a functional group X of the first substrate A (= P—X) is displaced from the substrate by the enzyme E to yield the first product P and a stable enzyme form F (= E—X) in which X is tightly (often covalently) bound to the enzyme (Ping).
- In the second stage of the reaction, X is displaced from the enzyme by the second substrate B to yield the second product Q (= B—X), thereby regenerating the original form of the enzyme, E (Pong).