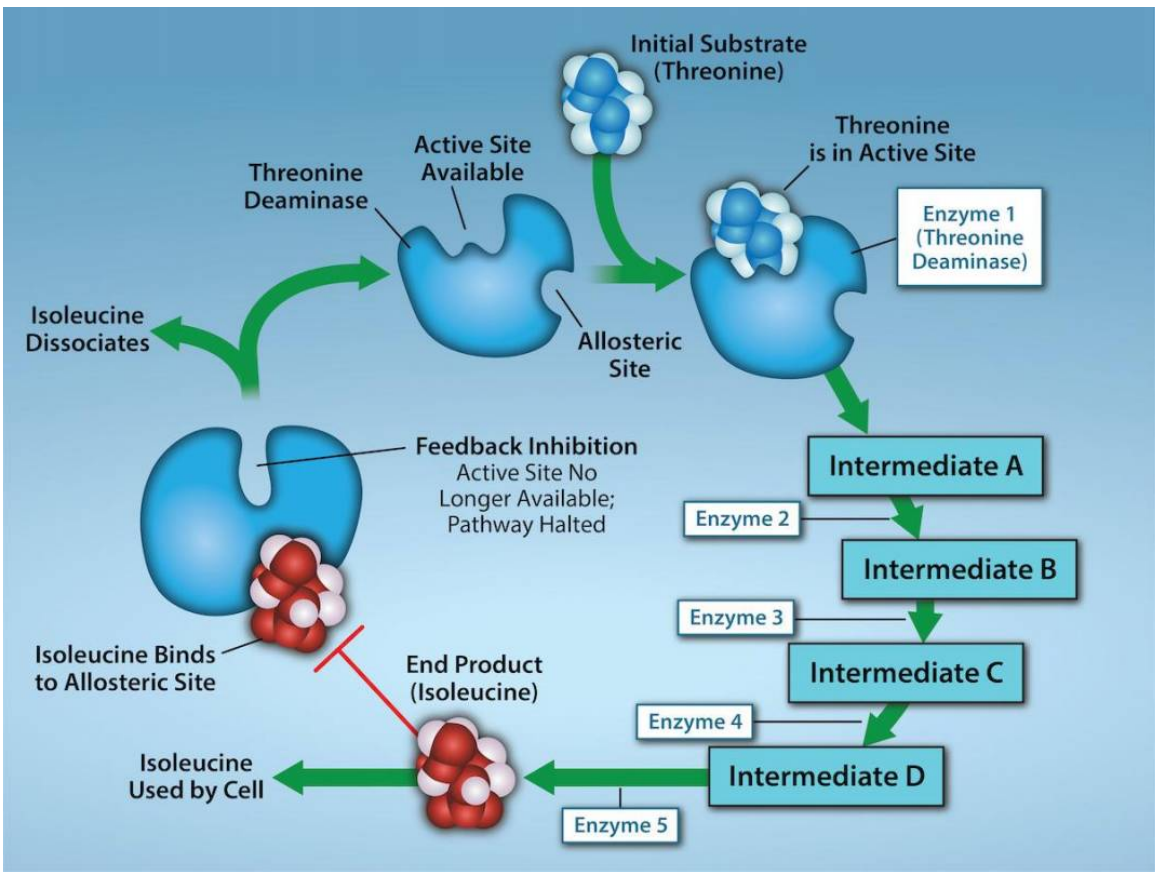
7.2.1

Enzyme Regulation

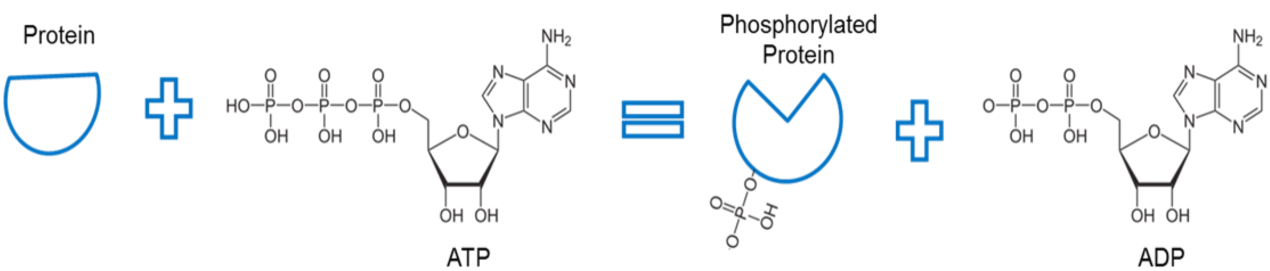
Since activation energy is such an important part to chemical reactions, and since enzymes play an integral part in lowering activation energies, it would make sense that cells have evolved complex mechanisms to regulate enzyme activity. Enzymes can be regulated in ways that increase or decrease their activity. One regulatory pathway is through the use of inhibitor molecules. An inhibitor molecule looks and acts very similarly to the actual substrate but when it binds to the active site it is not catalyzed, instead it simply blocks the binding site. This regulatory function is called **competitive inhibition** . Sometimes molecules can bind to an enzyme in a place that is not the active site, but the binding nevertheless alters that active site in a way the affects binding of the substrate. This is called **noncompetitive inhibition** . Both types of inhibition are effective, but competitive inhibitors are less effective because if the concentration of substrate is increased it can “out compete” the inhibitor molecule for the active site. Additionally, competitive inhibitors can affect the initial rate of enzyme activation



but have little effect on the maximal rate (due to competition of substrate). Noncompetitive inhibitors affect both the initial and maximal rate because they are not in competition with the substrate; if present, they always alter the enzyme's active site and no amount of increased substrate can change that. Noncompetitive inhibitors that alter the active site by binding elsewhere on the protein are also called **allosteric inhibitors** . In contrast, there are also molecules called **allosteric activators** which are molecules that bind to an enzyme to a location away from the active site, but this binding alters the protein slightly, increasing the affinity of the binding site for the substrate. Sometimes, the allosteric inhibitor or activator is the molecule produced by the enzymatic reaction. In this case, the biochemical reaction acts as a **feedback system** to regulate enzyme function, either speeding up or slowing down the reaction. Product feedback regulation is a primary pathway in regulating the amount of ATP produced in the cell. Since ATP is quite unstable, producing too much of it would be wasteful. Therefore, ATP serves as an allosteric inhibitor, while ADP (which is representative of low ATP) serves as an Allosteric activator.

Allosteric activators can be categorized into molecules called **cofactors** and **coenzymes** . Cofactors are often inorganic ions like iron (Fe^{++}) or magnesium (Mg^{++}) or even zinc (ZN^{++}). Cofactors are often integrated into the final product of the biochemical reaction. Coenzymes, as their name suggests, are "helpers" for the enzyme. A good example of coenzymes are vitamins (i.e., Vitamins A, D, E, K, C, folic acid, and B vitamins).

Enzymes activity can also be regulated by other enzymes through phosphorylation. Covalently adding a phosphate to an enzyme can increase activation or can inactivate the enzyme. Enzymes that add phosphates are called **kinases** and enzymes that remove phosphates are called **phosphatases** .



***Phosphorylation**. Image created by JS at BYU-Idaho Fall 2013.*