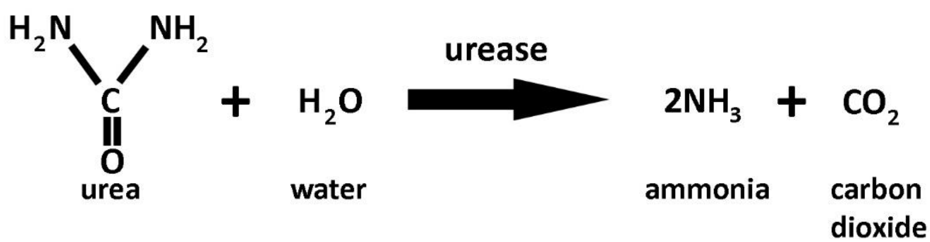
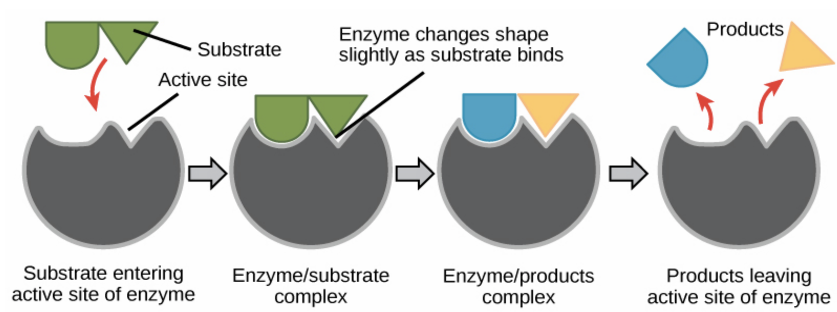
Enzymes

Enzymes are proteins without which life could not exist. Life exists because of the thousands of chemical reactions that make necessary molecules, breakdown waste products and perform all the processes cells and organisms require to grow, reproduce and sustain themselves. Enzymes are responsible for "doing" all of these chemical reactions.

Enzymes are often called biocatalysts (biological catalyst). A catalyst makes a reaction happen faster. In the case of enzymes they make reactions that would naturally happen, happen much more quickly. If it were not for enzymes the processes necessary for life would occur much too slowly for life to exist. For example, the enzyme urease breaks down urea (a component of urine) to release ammonia.




If urea were placed in a sterile bottle scientists estimate that it would take 40,000 years for a single molecule of ammonia to form. However, if enzyme urease is present it will bind urea and release 600,000 ammonia molecules every minute. Urease is a fairly common enzyme found in microbes which helps explain why urine 'in the wild' gives off an ammonia smell very shortly after being excreted. In the world of biochemistry, urease is actually a pretty slow enzyme; acetylcholinesterase which breaks down a neurotransmitter (acetylcholine) released by neurons is the fastest known enzyme with a breakdown rate of 30,000,000 molecules of acetylcholine per molecule of enzyme per minute. Wow! The rate of reaction is called the turnover rate. Acetylcholine would have a turnover rate of 30,000,000 molecules of acetylcholine per molecule of enzyme.




*https://www.khanacademy.org/science/biology/energy-and-enzymes/introduction-to-enzymes/a/enzymes-and-the-active-site*

Enzymes make reactions happen faster by lowering the **activation energy**. An in depth discussion of activation energy will not be given here, just consider activation as the energy needed to start the reaction. Enzymes function by binding **substrates** onto their surface and orienting the molecules in such a way that bonds in the substrate/s can be broken or reformed. Substrates are what the enzymes manipulate or act upon. The substrates in the reaction described above are urea and water. Urea and water bind to a special region of the enzyme called the **active site**. The active site is where the chemistry happens. Once the substrates are bound to the active site, the enzyme, in this case urease, then bends and breaks the existing bonds and reforms bonds to produce ammonia and carbon dioxide. Ammonia and carbon dioxide are the **products** of the reaction. Once formed they are released from the enzyme's active site.

The urease reaction may look very familiar to chemical reactions shown in other modules. There is one really important difference and one semantic difference. In chemical reactions, the compounds entering the reaction are called reactants. In enzyme pathways, the substances entering the reaction are called substrates, not reactants. The one really important difference is that in enzymatic reactions the enzyme is not 'used up'. The enzyme remains intact and functional throughout the reaction. Once product/s are generated and released the enzyme is ready to start again.

There have been approximately 75,000 enzymes identified in the human body. Why so many enzymes you may ask? Enzymes in general are <u>very specific</u>. An enzyme, like urease does one thing, it breaks down urea. There are so many enzymes because each enzyme binds a very limited number of substrates and produces a very limited number of products. To accomplish all of the essential life processes and meet the needs of a cell or organism thousands of individual enzymes, each catalyzing their own specific reaction are required.

The specificity of the enzyme is determined by the shape of its active site. Remember enzymes are proteins and have distinctive levels of structure. Changing the structure of the protein (enzyme) may change the shape of the active site which in turn impacts the enzyme's ability to catalyze the reaction. When the enzyme's shape has been altered to the point where its function is diminished, it is said to be denatured. In some cases denaturation is permanent, in others when the denaturing agent is removed the enzyme resumes its function. For example if you boil a fertilized chicken egg, the chicken will not hatch because the enzymes that mediate growth and development have been permanently denatured. However, an enzyme may be denatured by cold temperatures and therefore not function in cold temperatures, but when re-warmed it may return to its functional shape. Temperature, pH and heavy metals can change the structure of proteins and can have a dramatic impact on enzyme activity. Keep in mind that enzymes within living organisms function in very different environments under various conditions and therefore have different values for optimal activity. For example, glands in the mouth secrete digestive enzymes into saliva. These enzymes start the digestive process in the mouth in a relatively neutral environment (pH 7) as opposed to digestive enzymes secreted by glands in the stomach (pH 1). Stomach digestive enzymes function well between pH 1 and pH 2, but would denature at higher pH. Digestive enzymes in saliva function well around neutrality but denature and stop functioning in the stomach. Each enzyme is suited to its function and its working environment.

Summary

1. Enzymes are proteins.
2. Enzymes are biocatalysts that make reactions happen faster.
3. Enzymes are very specific, binding to a very limited number of substrates.
4. Substrates bind to the active site of the enzyme.
5. Products are the end result of the enzymes actions.
6. Enzymes are not consumed in the reaction.
7. Enzymes are very fast.
8. Enzyme activity is affected by pH, temperature and heavy metals. If the shape of the enzyme's active site is altered and the enzyme can no longer function, the enzyme is said to be denatured.