February 2006: Alpha-amylases

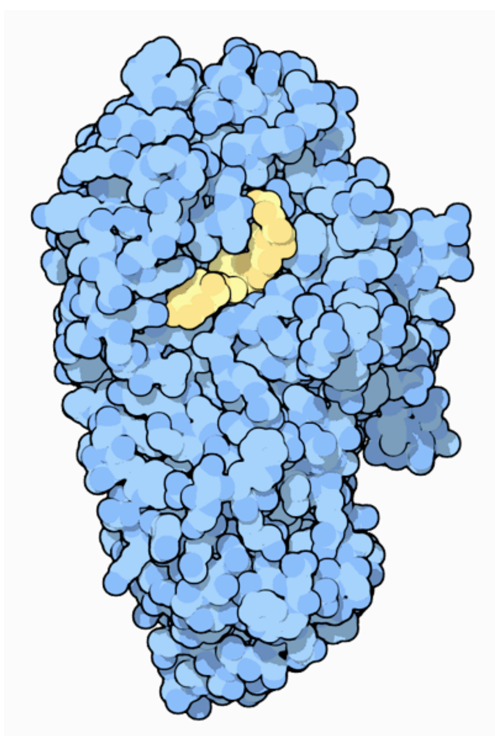
Glucose is a major source of energy in your body, but unfortunately, free glucose is relatively rare in our typical diet. Instead, glucose is locked up in many larger forms, including lactose and sucrose, where two small sugars are connected together, and long chains of glucose like starches and glycogen. One of the major jobs of digestion is to break these chains into their individual glucose units, which are then delivered by the blood to hungry cells throughout your body.

Attacking Starch

Alpha-amylase begins the process of starch digestion. It takes starch chains and breaks them into smaller pieces with two or three glucose units. Two similar types of amylase are made in your body--one is secreted in saliva, where it starts to break down starch grains as you chew, and the other is secreted by the pancreas, where it finishes its job. Then, these little pieces are broken into individual glucose units by a collection of enzymes that are tethered to the walls of the intestine.

Amylase in Action

Since amylase needs to perform its job in the unpleasant environment of the intestine, it is a small, stable enzyme resistant to unfavorable conditions. The amylase shown here (PDB entry 1ppi) is made by the pancreas in pigs. A small chain of five sugars (colored yellow) is bound in the active site, which is found in a large cleft on the enzyme. Structures for the two human enzymes (which look very similar) are available in PDB entries 1smd and 1hny. As you look through the PDB, you will also find many structures of alpha-amylases and other starch-digesting enzymes from bacteria and plants.



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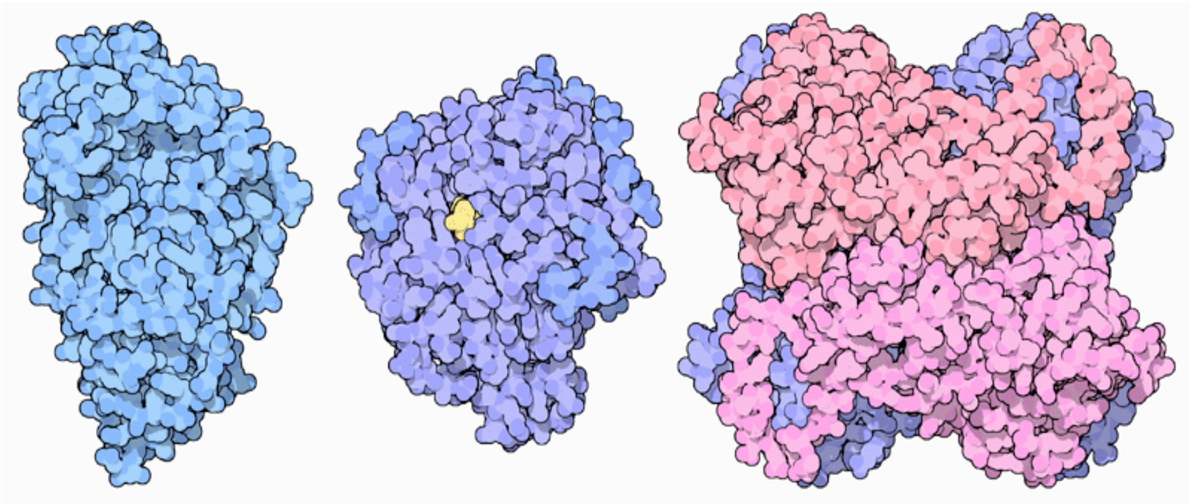
Industrial Strength



Alpha-amylase is used in large quantities in the production of high fructose corn syrup, a mixture of sugars created from corn that is similar in taste and sweetness to the sucrose obtained from sugar beets and sugar cane. The process requires three steps, each performed by a different enzyme. Amylase performs the first step of breaking starch into small pieces. Bacterial amylases, like the one shown on the left from PDB entry 2taa, are typically used since they are easy to obtain in large quantities. The second step is performed by a fungal glucoamylase, shown here in the center from PDB entry 1dog. It breaks the small chains into individual glucose units. Unfortunately, glucose does not have a particularly palatable taste, so a third step must be added. This is performed by glucose isomerase, also known as xylose isomerase, as shown on the right from PDB entry 4xia. This enzyme converts some of the glucose into fructose, creating a tasty mixture that is used to sweeten everything from soft drinks to power bars. However, this cheap and widely available sweetener may come with some disadvantages: a quick search on the WWW will reveal a whirlwind of controversy about the role of high fructose corn syrup in obesity and diabetes.

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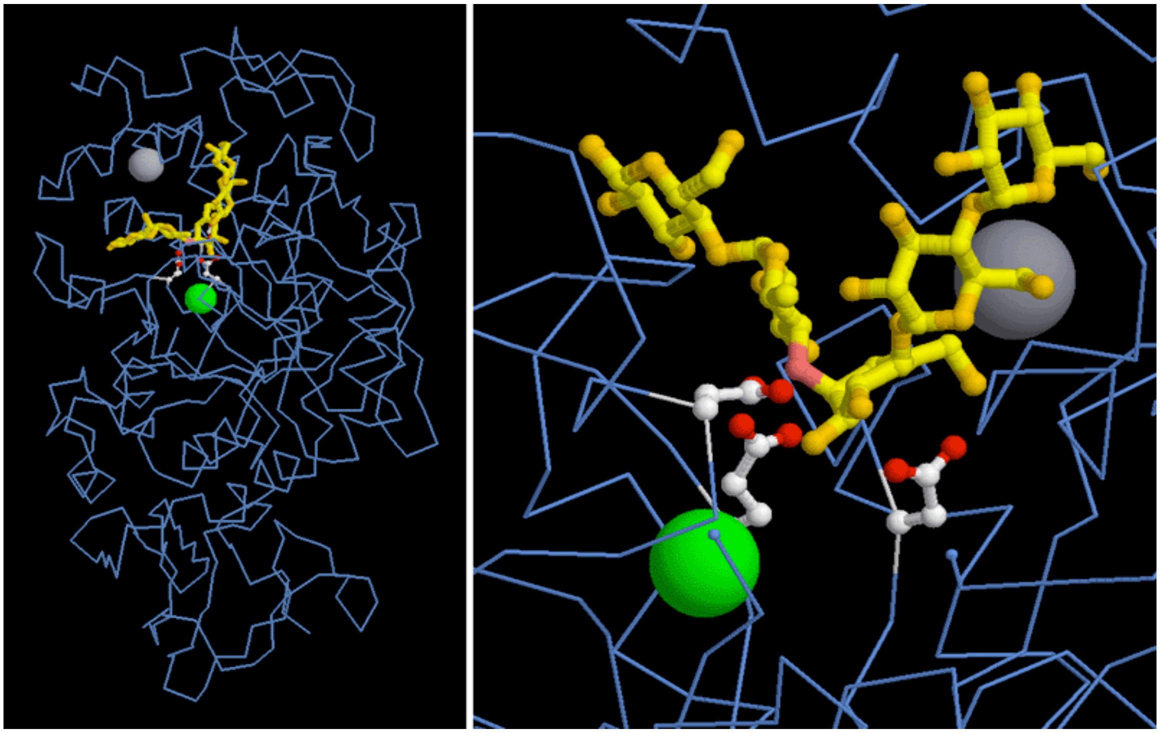
Exploring the Structure



The active site of alpha-amylase contains a trio of acidic groups (colored white and red) that do most of the work. In the amylase shown here (PDB entry 1ppi), glutamate 233, aspartate 197, and aspartate 300 work together to cleave the connection between two sugars in a starch chain. This structure contains a short chain of five sugar units (colored yellow and orange) bound in the active site. The site of cleavage is shown in pink. A calcium ion, shown as the large gray sphere, is found nearby where it stabilizes the structure of the enzyme. A chloride ion, shown as a green sphere, is bound underneath the active site in many amylases, where it may assist the reaction.

This picture was created with RasMol.