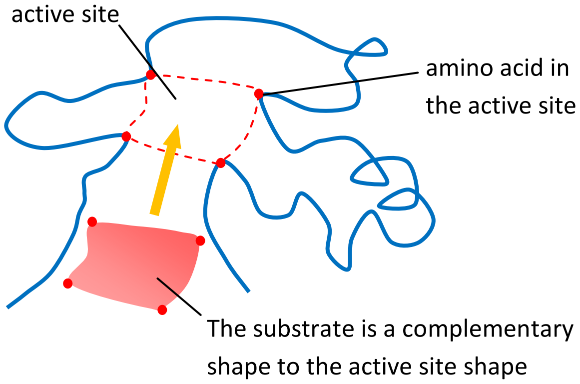
3.8 Enzyme Action

An introduction to enzyme structure and function

An **enzyme** is a protein. Each and every enzyme is a *globular protein* with a specific *tertiary structure* (see 3.4 Amino Acids and Proteins). They are **catalysts** – substances which speed up chemical reactions, but do not get used up in the process.

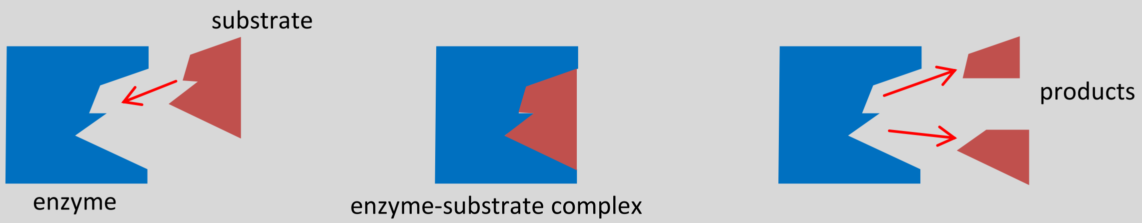
A single enzyme is quite a large molecule. The whole primary, secondary and tertiary structures are involved in giving an enzyme its specific shape. That special shape is needed to provide a certain shape for the **active site**. This is the area of an enzyme where the catalytic activity occurs, and is a 'pocket' or cleft in the enzyme's 3D structure.



Although there are hundreds, if not thousands, of amino acids found in a single enzyme, very few are responsible for maintaining the shape of the active site, usually less than ten, as shown in the diagram.

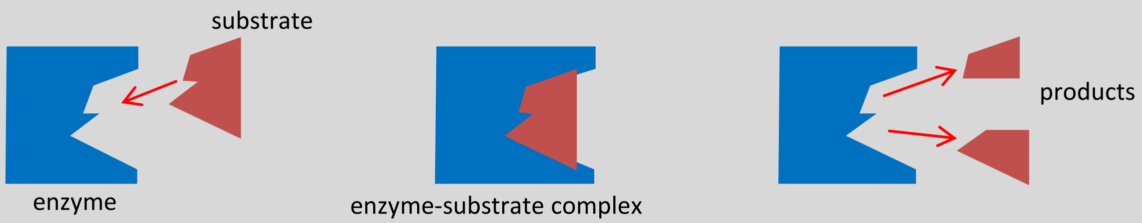
There is only one **substrate** which is specific enough to fit an enzyme. So each enzyme can catalyse a reaction involving only one type of substrate. Different enzymes use different substrates. The substrate will be shaped in a way which is *complementary* to the shape of the active site. The **lock and key theory** of enzymes states that the substrate is a "key" and the enzyme's active site a "lock" which can only be triggered by that one key that fits.

Lock and Key Theory



This is the generally-accepted model which suggests that only one substrate "the key" will fit one and only one active site belonging to an enzyme, "the lock". When the key is inside the lock, the reaction takes place with the substrate held inside the enzyme, and the result is the products released

Induced-Fit Hypothesis



A more recent explanation to the fitting of enzymes is the **induced-fit hypothesis**. This hypothesis still states that one substrate fits one active site, this is scientific fact. But this hypothesis suggests that the enzyme molecule *slightly* changes shape when it collides with substrate, making the active site fit more closely around the substrate molecule. The substrate is held in place, and the reaction takes place in the **enzyme-substrate complex**. The products made no longer fit the active site, so they are released, and this enables the enzyme to redo the whole process by taking in another substrate molecule

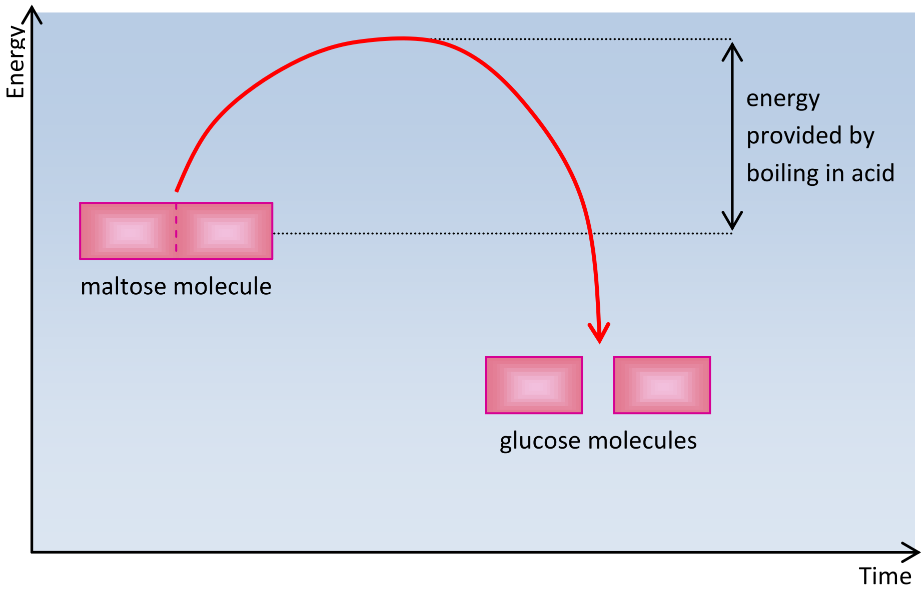
These two theories bring up the idea of *product*. In a chemical reaction, if an enzyme catalyses the reaction, *substrate* is turned into **product**. The general formula below shows this:

substrate —catalyst→ product

Take the example of the enzyme *maltase*. This is able to catalyse the conversion of maltose into glucose:

maltose —maltase→ glucose + glucose

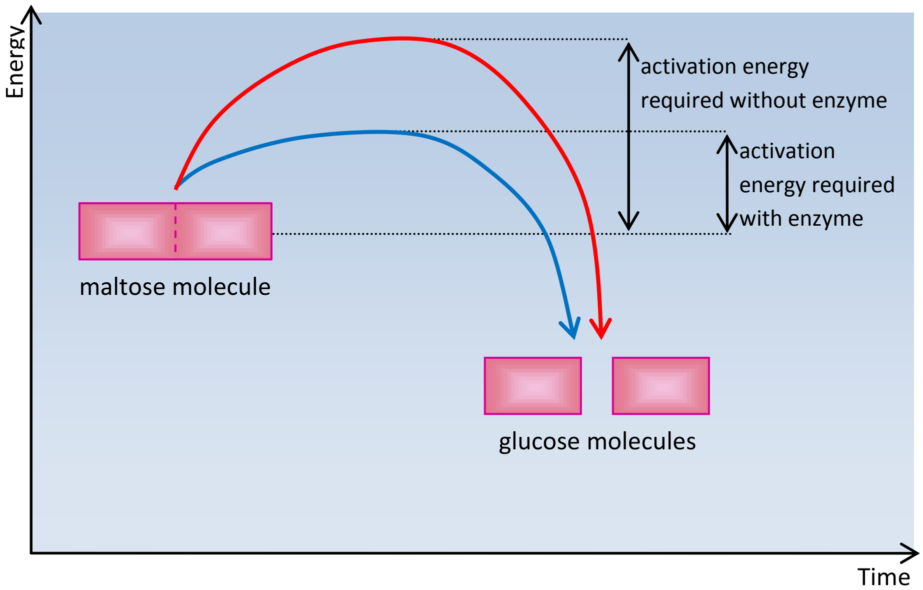
One maltose molecule is made up of two glucose molecules joined by a single **glycosidic bond** (see 3.2 Carbohydrates). If we want to break the component down back into two separate glucose molecules, we need to break that glycosidic bond up. We can boil maltose in hydrochloric acid to do this. It supplies the maltose molecules with enough energy to break the bond and collide with water molecules for the **hydrolysis** reaction to take place. This extra burst of energy required to initiate a reaction is called **activation energy**.



Many biological molecules, like maltose, are simply too stable to simply break their bonds out of thin air. These large amounts of energy are required to do so, because the bonds are strong, most of them covalent.

Boiling in hydrochloric acid provides the molecule with this energy, but it is very unlikely that cells do this naturally and even if they did, that they would survive. So how can these reactions be initiated without the need for such extremes?

A **catalyst** can be used to drive metabolic reactions. These work by enabling the same reactions more readily, because they reduce the amount of activation energy required to initiate the reaction. Enzymes are catalysts which reduce the amount of activation energy needed, so reactions can take place at lower temperatures and in a more diverse range of conditions. This is the case because the active site of the enzyme molecule can fit the substrate perfectly.



Without catalysts, the metabolic reactions which are essential to life would not be able to take place at the right amounts and at the right speeds, so they are essential substances.

It is important to remember that an enzyme is a catalyst, and that it is part of a chemical reaction, where it is used to speed up the reaction – but the enzyme does *not* get used up in the process: an enzyme can be used many times, but does eventually become less effective.