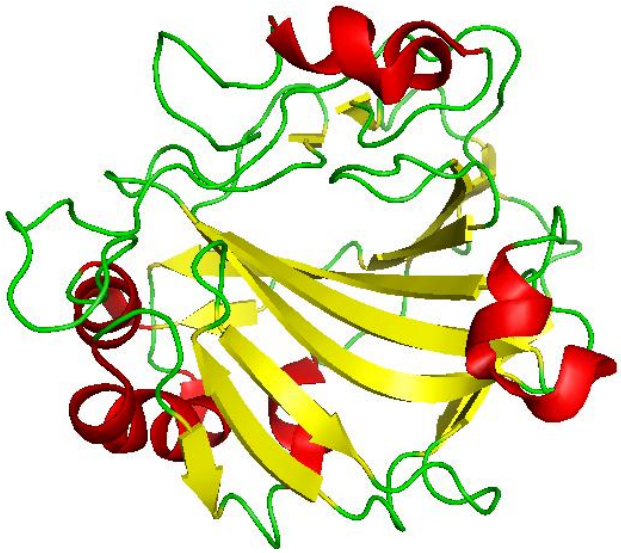
TB4 - Enzymes as Biological Catalysts

A considerable chunk of the field of chemistry is focussed on developing new and innovative chemical catalysts. This is becoming increasingly important to save time, money and resources. Despite this continuous drive to develop new catalysts, some of the most effective, specific, and cheapest are **biological catalysts**, such as **enzymes**.

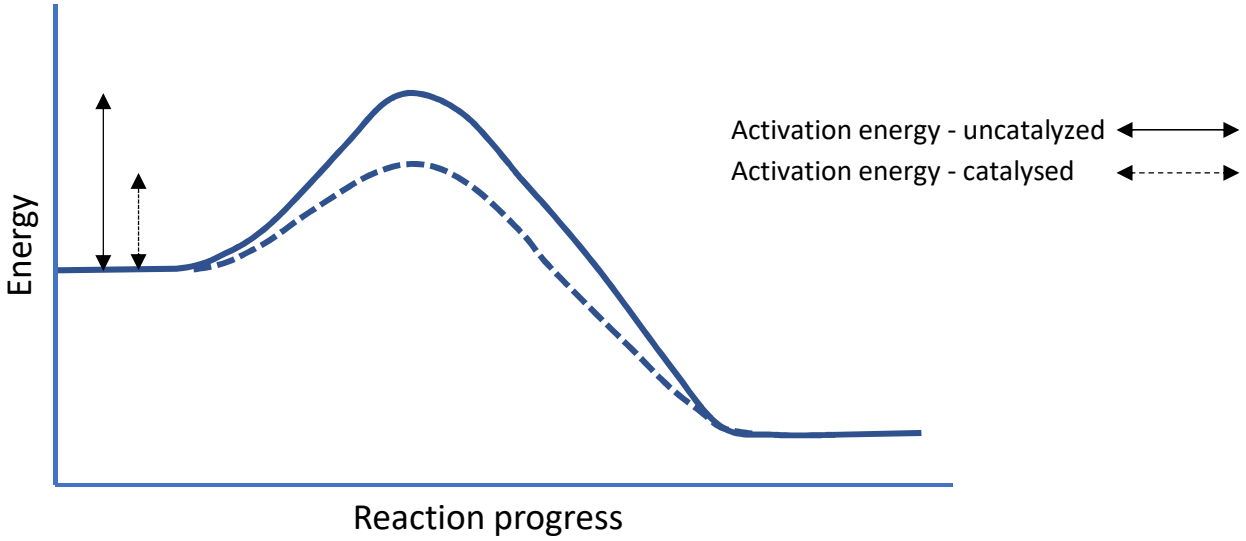


4yx4_Carbonic_Anhydrase_Inhibitor
The fastest human enzyme.

Not only are enzymes highly specific, due to their unique active sites, but they have evolved over millennia to result in specialised and highly effective catalysts. Enzymes each have specific roles in the body and they have developed to be incredibly **efficient molecular machines**. For example, the enzyme carbonic anhydrase, converts carbon dioxide, CO_2, in the blood into carbonic acid, H_2CO_3. Each enzyme manages to perform this reaction up to a **million times per second**.

HOW DO CATALYSTS WORK?

Catalysts work by providing a **different reaction pathway** which has a **lower activation energy**. Not only does this mean that the reaction can occur **faster**, but it needs **less energy** to proceed. This is especially important for reactions which typically require high temperatures to proceed. Scientists can take advantage of this by using biological enzymes in chemical reactions, lowering the activation energy, and making the reaction more feasible at lower temperatures.



Typical potential energy diagram for a reaction. Energy must be put into a reaction to overcome the activation energy barrier. The catalysed reaction has a lower activation energy, and therefore occurs more readily.

Produced by Adam Stubbs at Newcastle University as part of a summer outreach project.

ENZYMES AS BIOLOGICAL DETERGENTS

A well-known example of this is seen in biological detergents, such as washing powder. **Biological detergents** use enzymes which have been harvested from bacteria to help break down dirt and stains on laundry. These can contain enzymes such as amylases to break down carbohydrates, proteases for protein, and lipases to break down fats and oils.

Advantages of Biological Catalysts	Disadvantages of Biological Catalysts
Highly selective, and specific to certain reactions	Can be too specific, and it may be difficult to make it work for different substrates.
Naturally occurring, so they are already developed, and don't need any chemical modification	Their biological purposes are niche. Enzymes develop for biological necessity, so there are enzymes which break down food, but can't break down certain plastics well.
Can be harvested from organisms such as bacteria on an industrial scale	Can be difficult to extract, especially from complex organisms.
Tend to work well at biological temperatures around 40 °C. This uses less energy than many chemical catalysts.	Often decompose at very high temperatures, although some thermophilic ones work best around 100 °C.

Not only are these highly effective, but they are **highly specific** too, and the washing powders can be formulated to help clean a whole range of stains and chemicals. One of the major benefits of this approach, is that **lower temperatures** can be used when cleaning. Instead of having to wash the laundry at a high temperature like 90 °C, it is possible to use enzymes as biological catalysts, which break down the stains using a different path of lower activation energy. This means that less energy is needed to clean the laundry, and therefore it can be cleaned at a lower temperature such as 30 °C. This is clearly beneficial to the individual, because lower temperatures use **less energy**, and therefore cost less, so there is an **economic benefit**. But there is also a wider **environmental benefit**, as less energy needs to be used, so we don't need to burn as much fuel in power stations to meet the energy demand. Although this doesn't seem to make a huge different on an individual level, the impact globally when millions do this can be phenomenal.

ADVANTAGES AND DISADVANTAGES OF USING ENZYMES INDUSTRIALLY

Enzymes can be used industrially to catalyse certain reactions. However, they cannot be used for all reactions, and although they have many advantages, these need to be weighed up against the disadvantages too. All of these factors need to be considered when designing experiments using enzymes as catalysts.