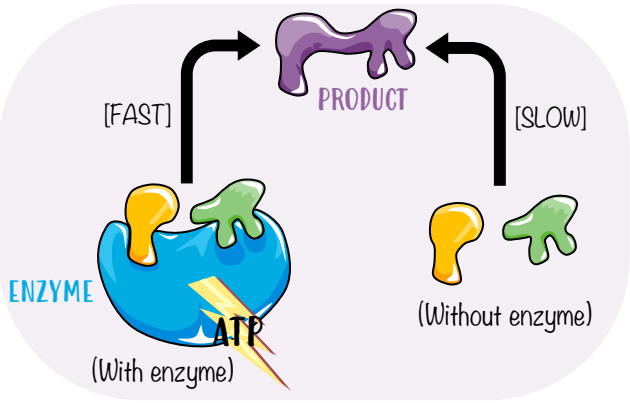
Enzymes

An enzyme is a biological CATALYST

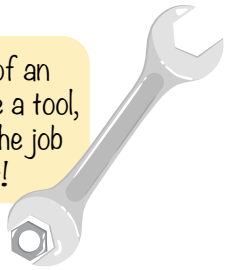
A substance that speeds up a reaction by **LOWERING THE ACTIVATION ENERGY*** (occurring in living things) that may otherwise take forever to happen.

*see page 2

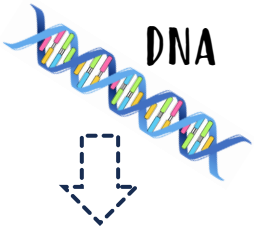


NOTE!

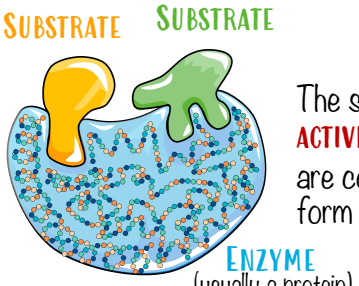
You can think of an enzyme acting like a tool, helping you get the job done faster!



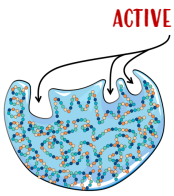
How do ENZYMES work? (overview)



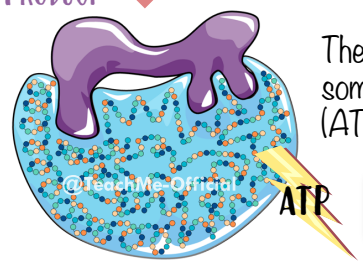
DNA codes for enzymes (even their very specific 3D structure)



The substrates (reactants) bind to the **ACTIVE SITES** (very specific shape) as they are complementary to each other, to form an **ENZYME-SUBSTRATE COMPLEX**



FAST



The product quickly gets formed – sometimes by the use of **ENERGY** (ATP)

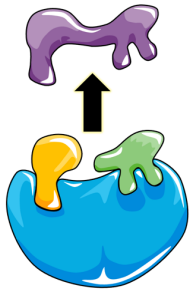
$$E + S \Rightarrow ES \Rightarrow E + P$$

MODELS OF ENZYME ACTION

2 theories

OLD: LOCK & KEY MODEL

1890s (Emil Fischer)



OLD theory – enzymes (the lock) and substrates (the key) fit together specifically due to their complementary shapes.

NEW: INDUCED FIT MODEL

NEW & ACCEPTED theory – enzymes and substrates undergo conformational changes upon binding, leading to a more complementary fit: like a glove on your hand.

MECHANISM OF ENZYME ACTION (INDUCED FIT)

1. The surface of the substrate contacts the active sites of the enzyme
2. Interaction between enzyme and the substrate requires a slight conformational change.
3. A temporary complex (enzyme-substrate complex) forms. The conformational change causes stress on the bonds in the substrate (destabilized) favoring a reaction.
4. Activation energy is lowered, and the substrate is altered by the rearrangement of the existing atoms
5. The transformed substrate (the product), is released from the active site.
6. The unchanged enzyme is then free to combine with other substrate molecules

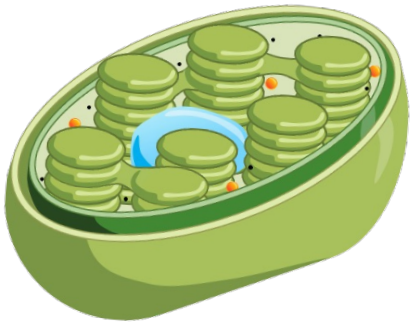
Enzymes

Catabolism vs. Anabolism

When a larger molecule (macromolecule) is broken down into smaller sub-parts (monomers). Forms ATP.

When a small sub-parts (monomers) are combined to form larger molecules (macromolecules). Use ATP.

NOTE!
Another example of catabolism includes the break down of food in our stomachs



Example: Cellular Respiration

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP_{(energy)}$$

Example: Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow[(energy)]{} C_6H_{12}O_6 + 6O_2$$

Collision Theory

(It is not enough for an enzymes substrate to enter an active site)

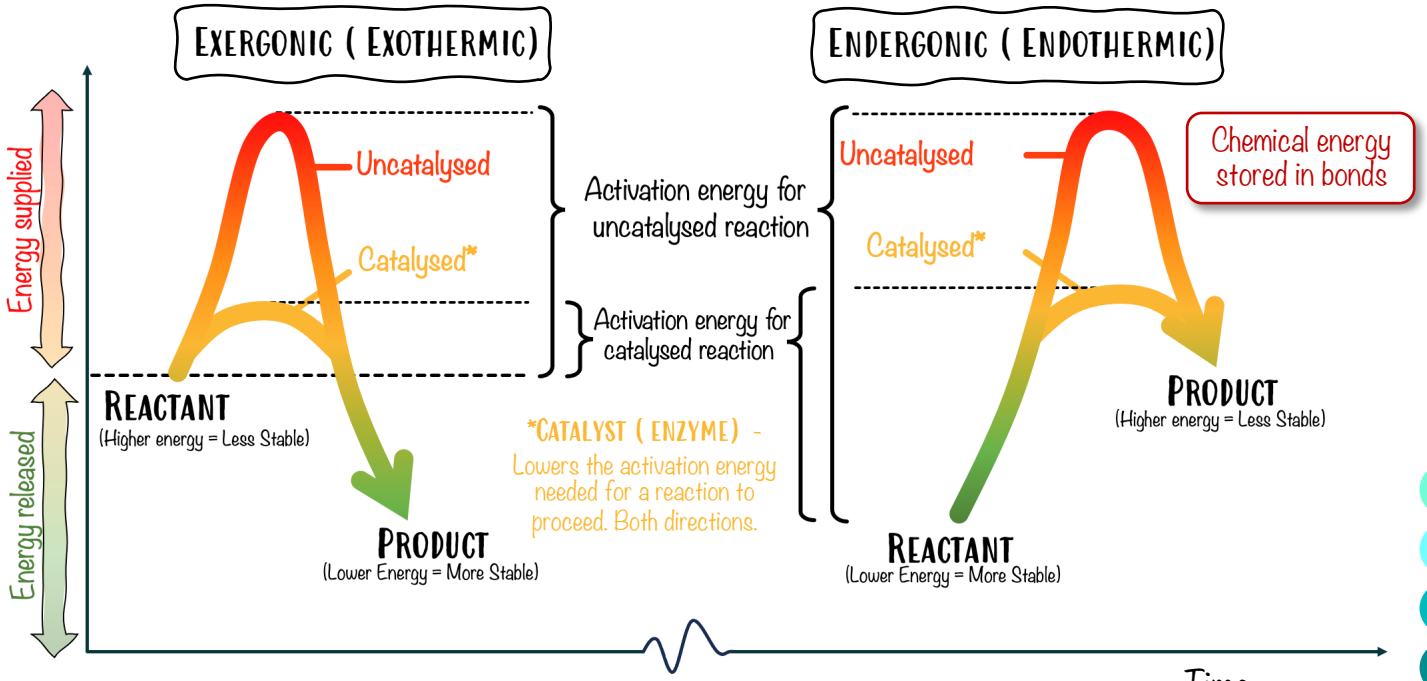
The reactants of a chemical reaction must collide with one another with **sufficient energy** (activation energy) to react. They must also collide in the **correct orientation** so that chemical bonds are affected allowing the chemical reaction to proceed.

Big Brain Tips!

Enzyme names end in "**ase**" – (lip**ase**)
Sugar names end in "**ose**" – (gluc**ose**)

Why does **lower energy** mean **more stable?**
Think about this in terms of a person with a lot of energy – more unstable. Person with low energy is calmer – more predicable, more stable.

Activation Energy – The energy necessary to destabilize the existing bonds in a substrate so that a reaction can proceed.



NOTE!
Exothermic reactions **release energy** as they occur since the product is more stable (less energy) than the reactants

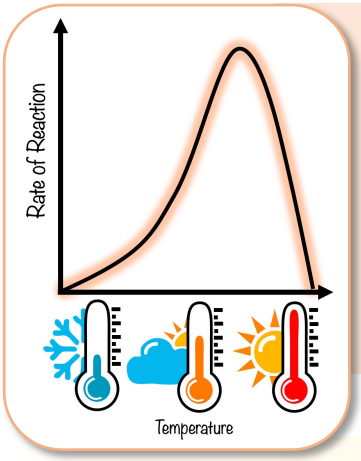
Endothermic reactions **use energy** as they occur since the product is less stable (more energy) than the reactants

Enzymes

Factors affecting rate of reaction (speed of reaction)

1 Temperature 2 pH 3 Substrate Concentration

1 Temperature



The higher the temperature, the faster the movement of the molecules (higher kinetic energy) and hence the higher odds of collision (collision theory).

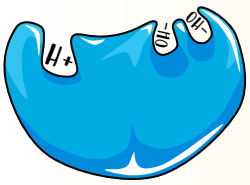
Excessively high temperatures can lead to enzyme **DENATURATION*** (alteration of protein tertiary structure) leading to enzyme malfunction & reduced rate of reaction.

"Different Enzymes have different optimal temperature"

2 pH

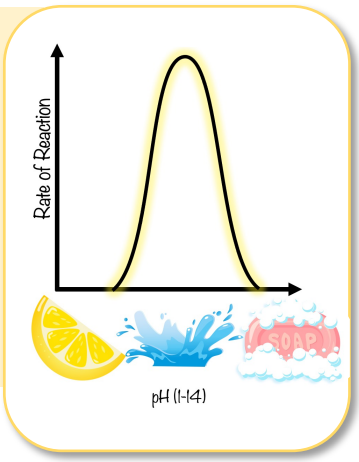
H^+ OH^-

Hydrogen (acidic) and hydroxide ions (basic) bind with the amino acids on substrate or active site. For example, stomach pH is low (acidic), so stomach enzymes work best at low pH – intestines pH is high (basic) so the intestinal enzymes will work best at higher pH.

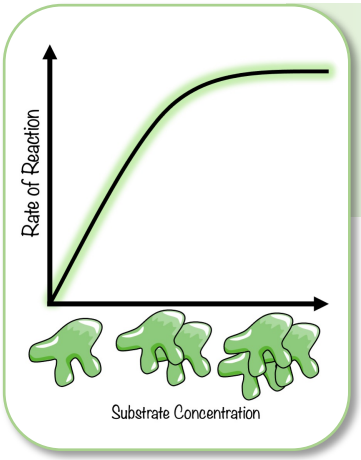


Extremes in pH can also cause **DENATURATION***

"Different Enzymes have different optimal pH"

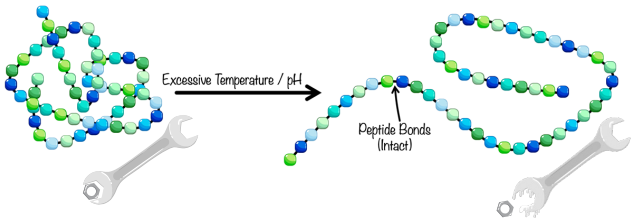


3 Substrate Concentration



Increasing the substrate concentration causes an increase in the rate of reaction until a point at which all the active sites are occupied, so increasing the concentration of substrate will not increase the rate of reaction – causes a **PLATEAU** to be formed.

* Denaturation of Enzymes (protein)



Key Point!

A **DENATURED** protein temporarily loses its function because its 3D structure has been altered by unsuitable temperature or pH

Measuring Rate

Measuring reactants — Measuring product

$$6CO_2 + 6H_2O \xrightarrow{\text{Energy}} C_6H_{12}O_6 + 6O_2$$

We can measure the rate of reaction by either measuring the reactants (being used) or by measuring the products (being formed) – depends on the specific reaction which would be more convenient

notes