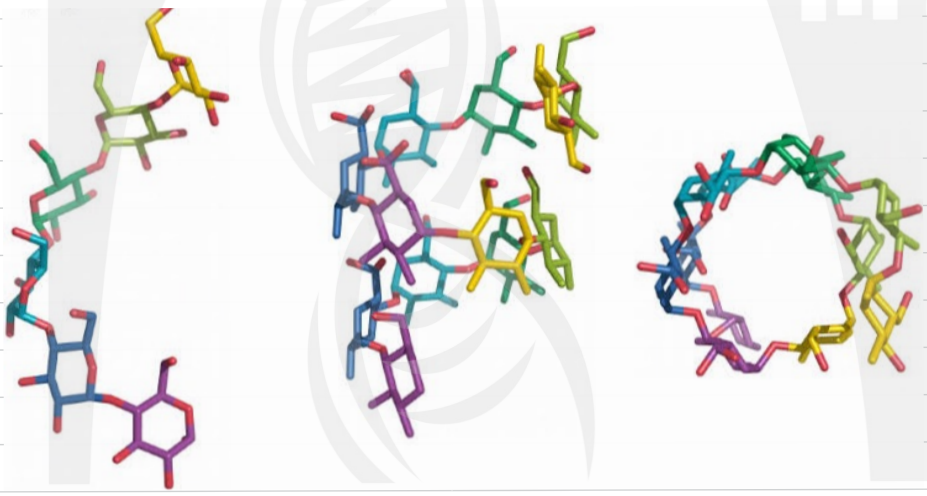
# Metabolism

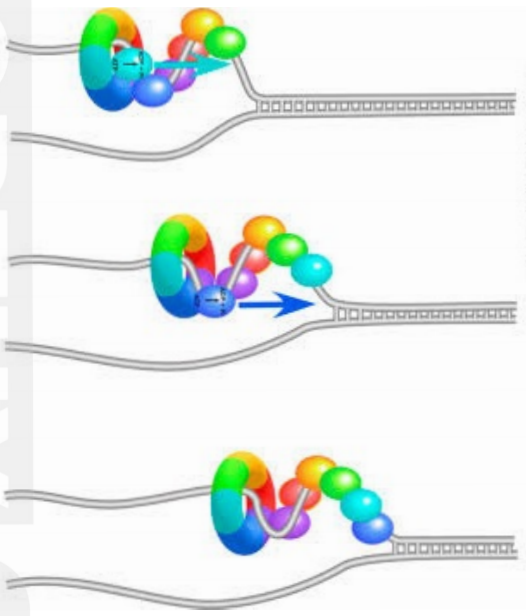
## Learning outcomes

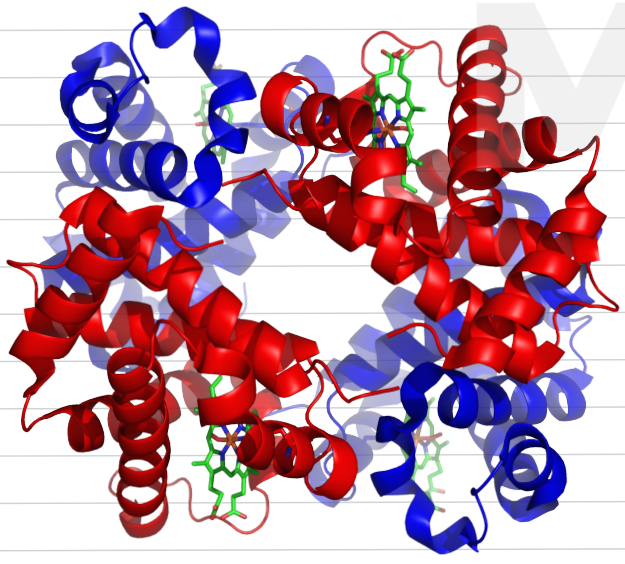
- [x] Understand how biomolecules can combine anabolically into polymers or breakdown catabolically into monomers
- [x] Name all four major biomolecules including their respective monomers and polymers
- [x] Understand what is required for a chemical reaction to occur
- [x] Understand the induced-fit model of enzyme activity
- [x] Understand how enzymes increase the rate of reaction with examples
- [x] Understand how enzyme activity is impacted by temperature, pH and substrate concentration

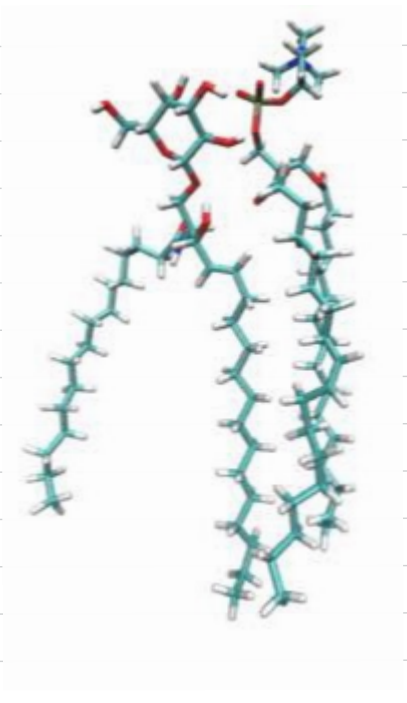
## Key terms

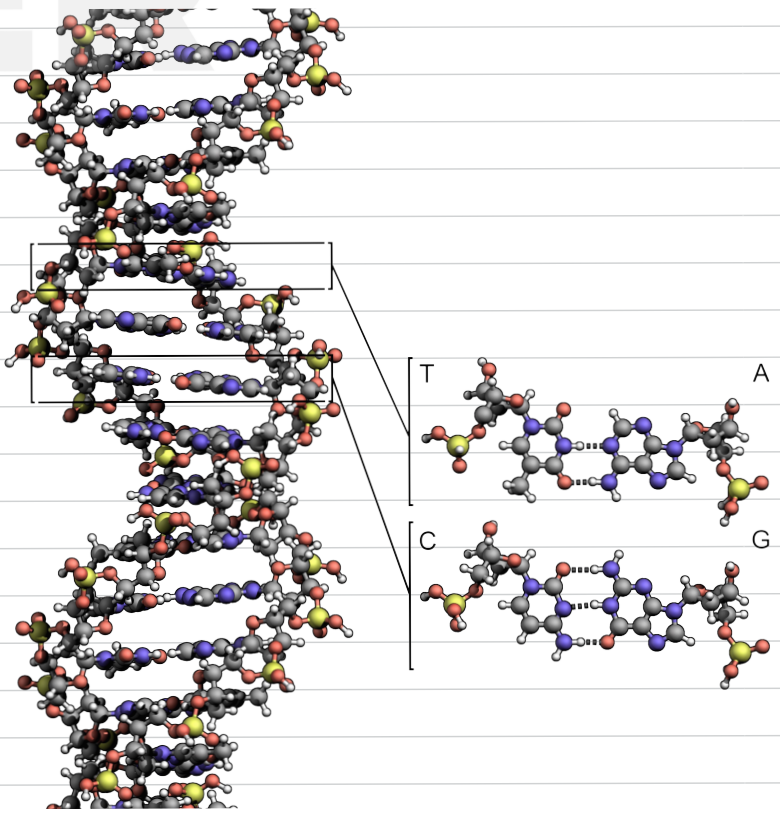
- Biomolecules
- Monomers
- Polymers
- Anabolism
- Catabolism
- Activation energy
  Enzymes
- Substrate
- metabolism
- denature

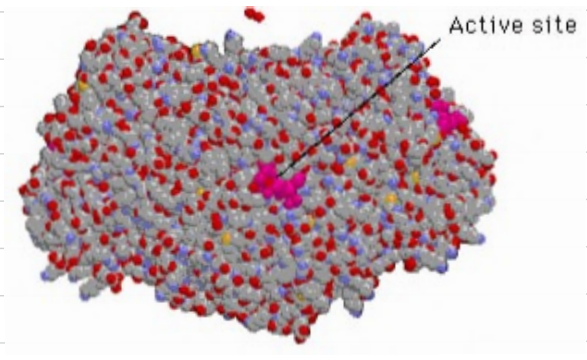










# Biomolecules

**Biomolecules** are those molecules found in living systems which are essential to living processes.

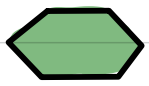
↳ All biomolecules are <u>carbon</u>-based and also contain hydrogen and oxygen → aka "organic"

These biomolecules exist as <u>single units</u> and can combine together to make <u>larger, more complex structures</u>

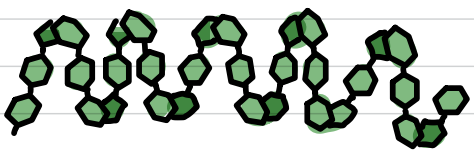
monomers → polymers

↳ 4 main types of biomolecules:

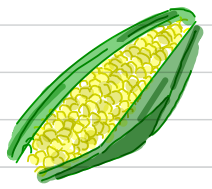
**1 Carbohydrates**



monosaccharide

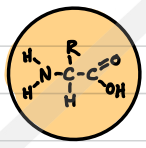


polysaccharide



ex: corn

**2 Proteins**



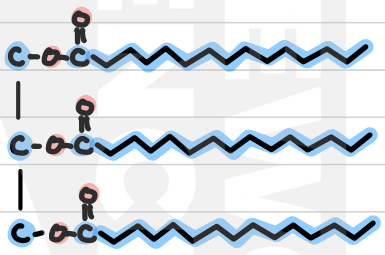
amino acid

polypeptide

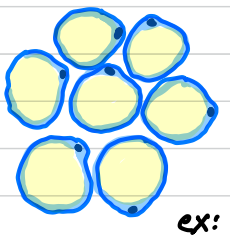
ex: ligaments

**3 Lipids**

fatty acid

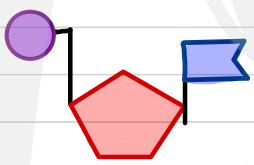


triglyceride

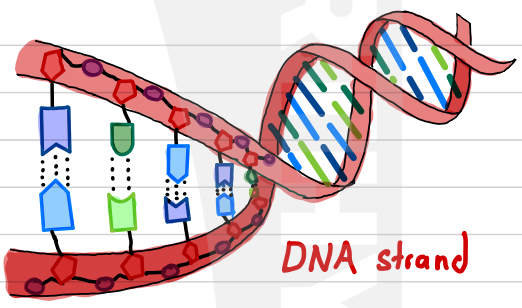


ex: fat cells

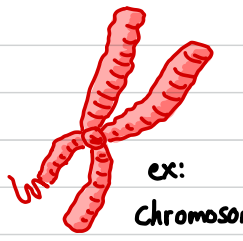
**4 Nucleic Acids**



nucleotide



DNA strand



ex: chromosomes

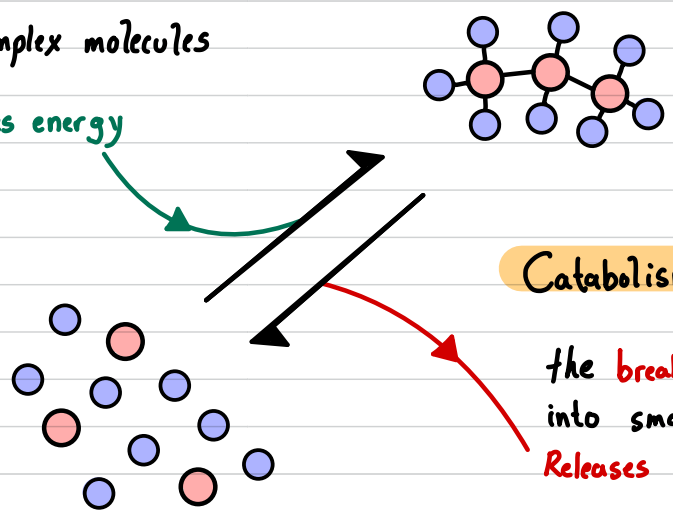
Most chemical reactions occuring in cells can be classified as either:

**Anabolism:**

the synthesis of larger, more complex molecules from smaller, simpler ones.

Requires energy

ex: photosynthesis
building muscle
building bone



**Catabolism:**

the breakdown of larger, more complex molecules into smaller, simpler ones.

Releases energy

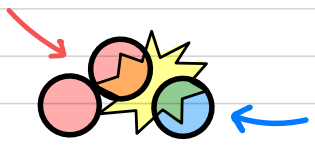
ex: cell respiration
breakdown of fats, proteins, sugars

# Reactions and Enzymes

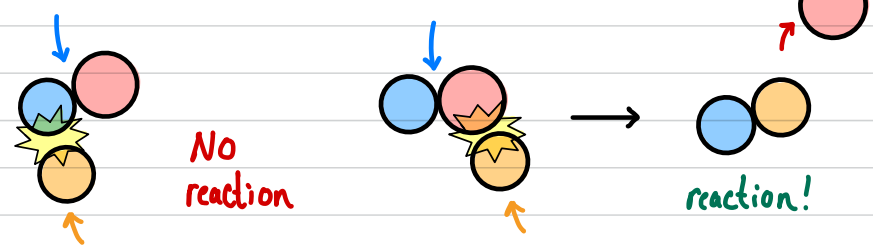
## Some notes on chemical reactions:

in order for a chemical reaction to occur:

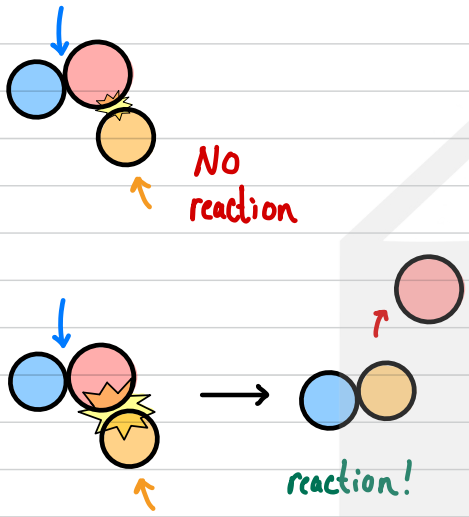
1 there must be a collision

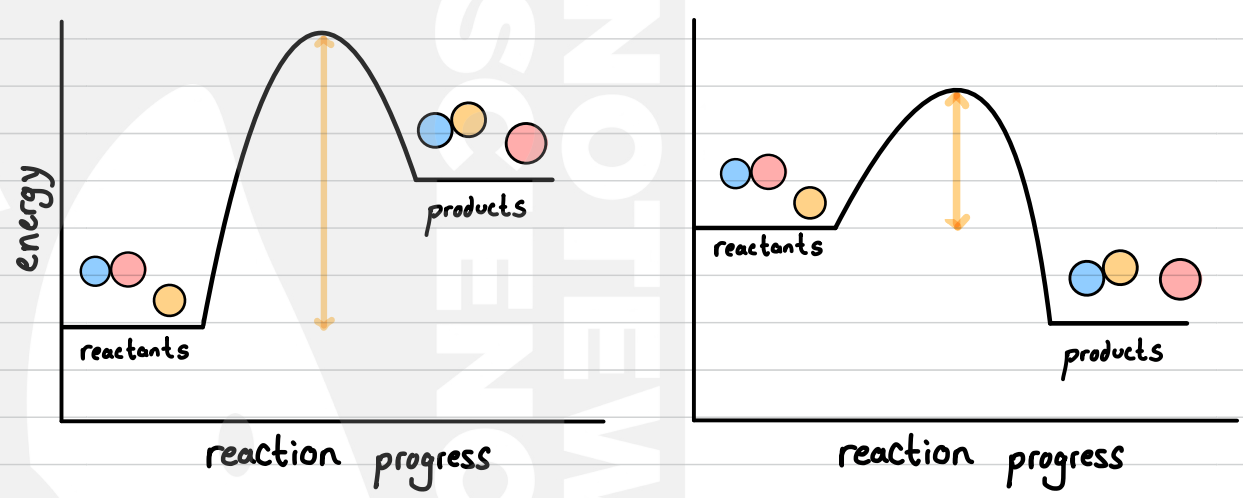


2 the collision must occur at the right location




3 the collision must occur with sufficient energy, called **activation energy:** the minimum amount of energy required for a reaction to occur

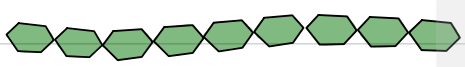



Because of these circumstances, many anabolic and catabolic reactions do not occur often

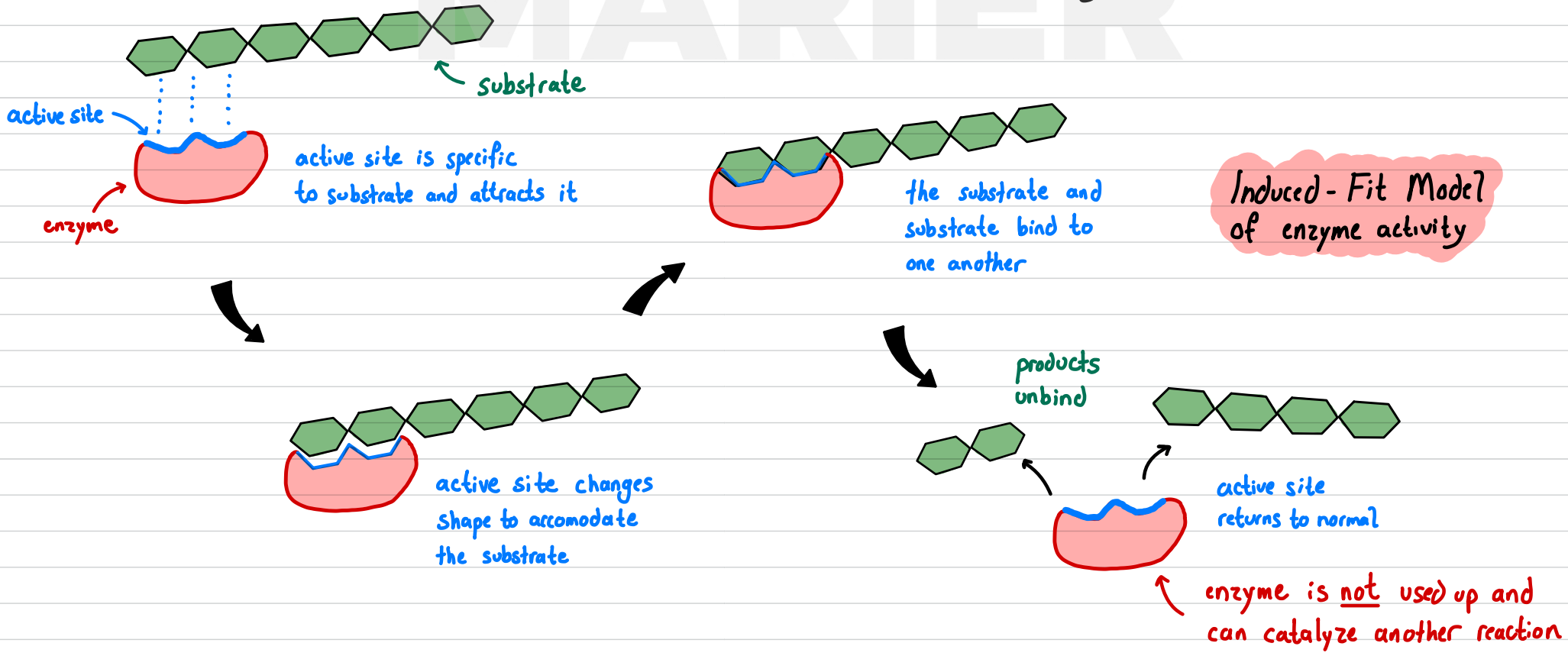
So, how do organisms survive? Enzymes!

**Enzymes:** Biological catalysts which increase the rate of chemical reactions. They are types of proteins.

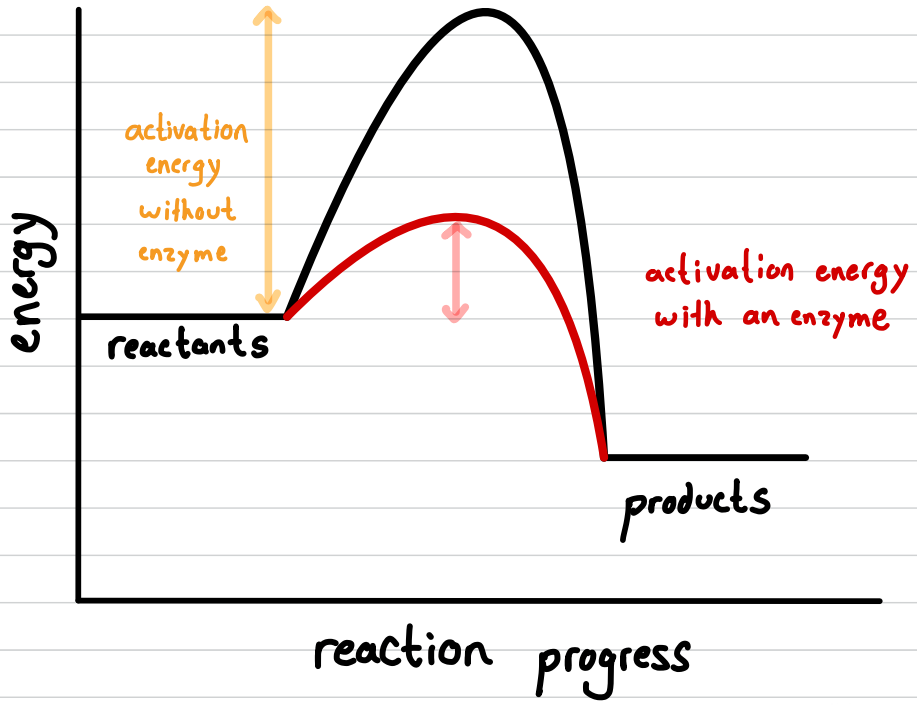


the reaction needed to break down this polymer normally takes a long time so a specific enzyme can be used to speed up this breakdown

↳ an enzyme works on a specific **substrate** due to the shape of its active site. This site will change shape to accomodate substrate



# Factors affecting Enzymes




## How do enzymes work?

↳ enzymes make it easier for chemical reactions to take place

How?

They lower the activation energy!

By not requiring as much energy, reactions occur far more often, thus increasing rate of reaction

**Metabolism:** the web of all the enzyme-catalyzed reactions in an organism

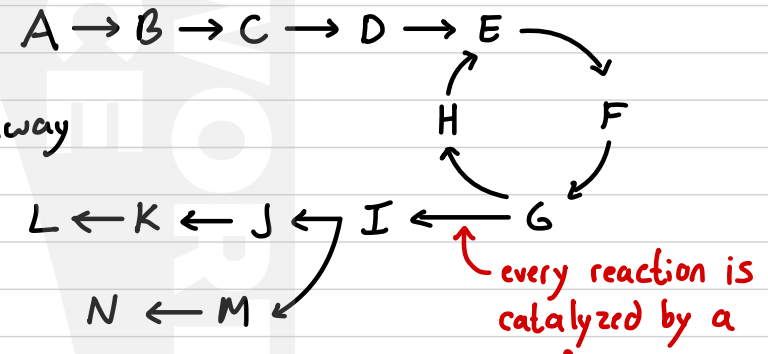
↳ most chemical reactions do not occur as a single step, $A \longrightarrow B$

why? There is too much energy involved and too difficult to control

ex: cell respiration $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ if this occured in one step it would be combustion!

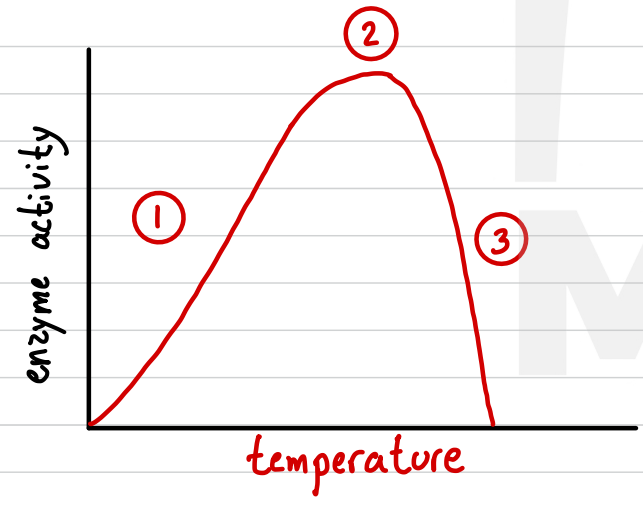
instead, $C_6H_{12}O_6$ is broken down into many intermediates by enzymes where the energy released can be utilized and controlled

↳ Metabolic pathway




Nearly all chemical reactions are enzyme-controlled and dependent

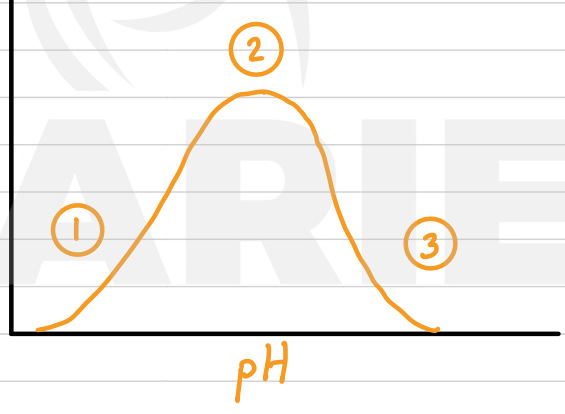
Like all reactions, enzyme activity is impacted by different factors:




① as temp ↑s, collisions are more frequent and stronger

② optimal temperature

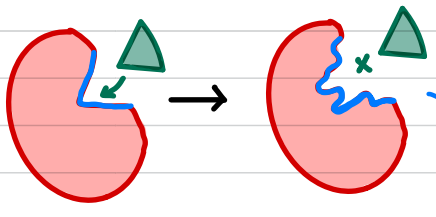
③ enzyme starts to **denature:** its shape permenantly changes

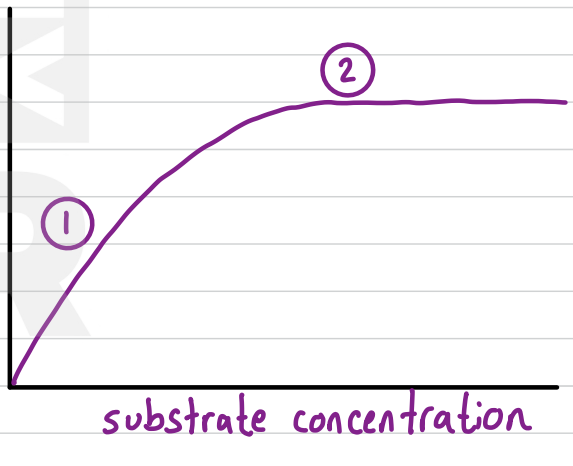



① too acidic → denature

② optimal pH

③ too alkaline → denature




① as more substrates are available, more enzymes can catalyze

② enzymes are at capacity, adding more enzymes won't matter as they are all used up

# Assessment Tasks

Answer the following questions:

1. For each biomolecule (carbs, proteins, lipids, nucleic acids) provide 1 example of an animal and 1 example of a plant source of food from which they can be obtained.
2. Which biomolecule (carbs, proteins or lipids) should comprise the majority of a diet. Why?
3. Both anabolism and catabolism are essential processes for life. Explain why.
4. Using your understanding of what is required for a chemical reaction to occur, what are 2 ways (other than enzymes) that could <u>increase</u> the rate of reaction? Explain.
5. Enzymes are involved in nearly all reactions in organisms. Provide an example of an enzyme that catalyses a carbohydrate, protein, lipid and nucleic acid. For each example: provide the name of the substrate, enzyme and product
   explain whether the reaction is anabolic or catabolic
   where in the body this occurs
6. All enzymes have their own optimal conditions. In humans, what temperature would you predict this is? Explain.
7. Why is it so dangerous for humans to have a temperature which is too low (hypothermic) or too high (hyperthermic / fever)?

# Markscheme

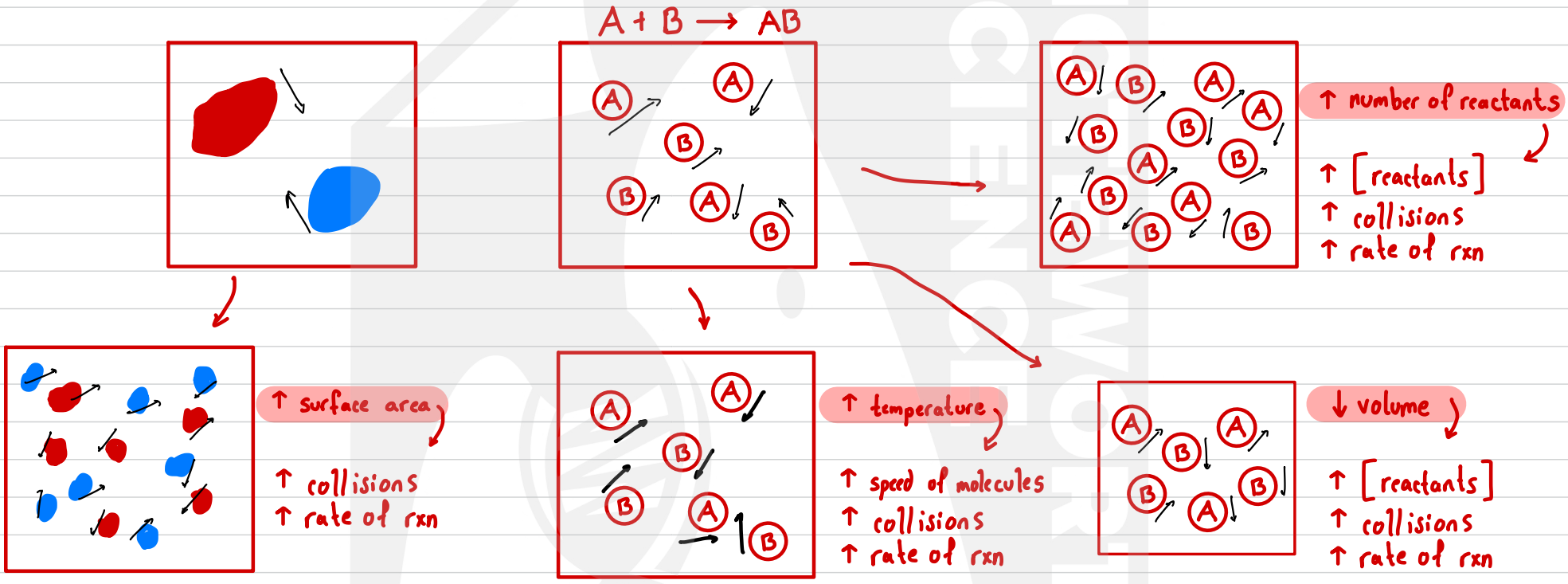
(1)

| | carbohydrates | proteins | lipids | nucleic acids |
|---|---|---|---|---|
| animals | dairy (milk) | meat, eggs, dairy | meat, dairy (milk, butter) | all foods. ↑ in: seafood, meat |
| plants | fruit, grains, potatoes, corn | legumes, beans, nuts | vegetable oils, avocados (olive, canola, etc.) | all foods. ↑ in: nuts, vegetables (spinach) |

(2) carbs should comprise majority of your diet as they are broken down the fastest and transported the easiest
↳ this makes them very efficient as a short-term energy source. Lipids + proteins are important but take longer to break down

(3) catabolism: breaks down molecules in order to acquire energy from their bonds (chemical energy). This energy is stored as ATP and used to power various processes needed for life.
anabolism: break down molecules in order to make materials for anabolic processes or other reactions
build larger molecules. The energy derivered from catabolism is used for this.
building cellular structures, growth of tissues, etc.

(4)




(5)

| | substrate | enzyme | product | |
|---|---|---|---|---|
| carbohydrate: | starch (amylose) | amylase | maltose | catabolic<br>occurs in mouth (saliva) |
| protein: | protein | trypsin | smaller polypeptide | catabolic<br>occurs in small intestine |
| lipid: | triglyceride | lipase | glycerol + fatty acids | catabolic<br>occurs in small intestine |
| nucleic acid: | nucleotides | DNA polymerase | DNA | anabolic<br>occurs in nucleus of all cells |

(6) 37°C. Normal human body temperature is 36.5 - 37.5 °C This is to ensure enzymes work optimally

(7) If too low, hypothermic, enzyme activity will be too slow - energy not obtained fast enough
If too high, hyperthermic, enzyme denature and stop working. Metabolic processes cannot occur