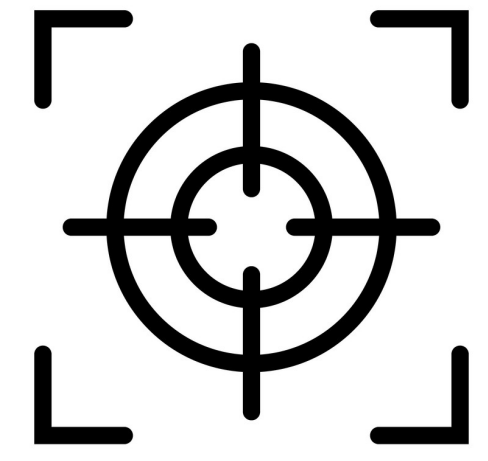


# Topic 3: Biological Molecules

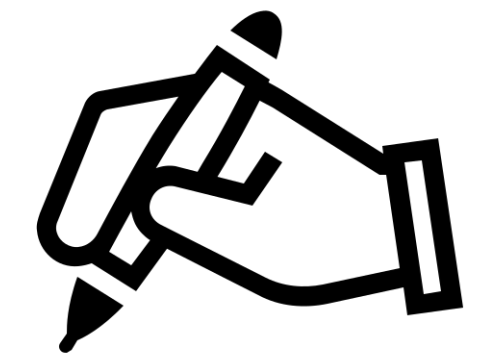


# Chapter Analysis



## **FOCUS**

- Heavily linked to Digestion chapter



## **EXAM**

- Usually tested in both MCQ and paper 2 section A



## **WEIGHTAGE**

- Constitute to around 4% in Paper 2 in the past 5 years
- Enzyme has higher weightage

# Role of Water

## Animals

- required for chemical reaction such as hydrolysis of food molecules
- key component for tissue and bodily fluid
- regulation of body temperature through sweat
- allow blood to transport substances



## Plants

- reactant for photosynthesis
- provides physical support to the plant in the form of turgor pressure.
- allow dissolved mineral salts to be transported from roots to other part of plants
- allow sugars to be transported from leaves to other parts of the plant.

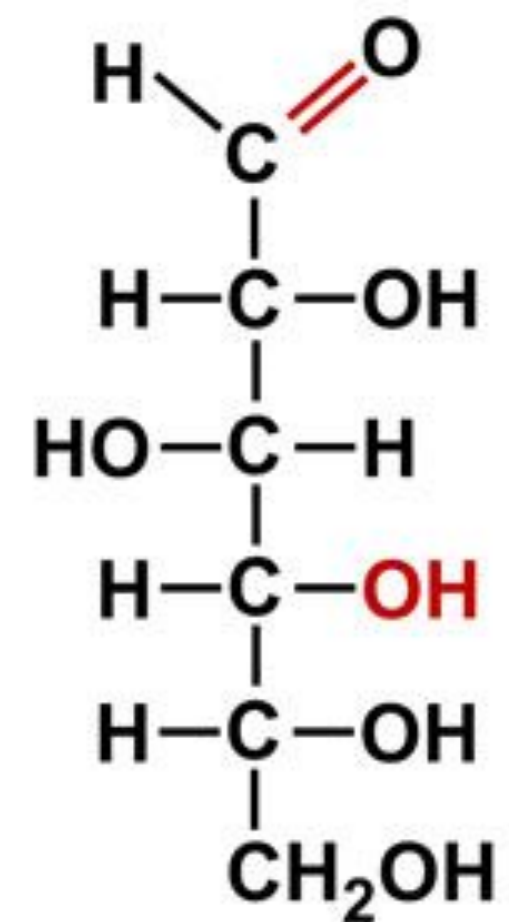
Key Concept

# Carbohydrate Food Test

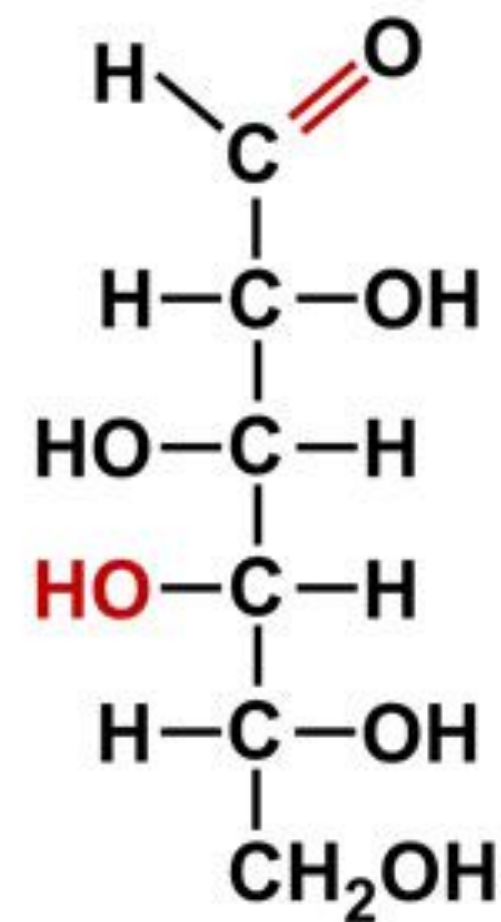


# Carbohydrate

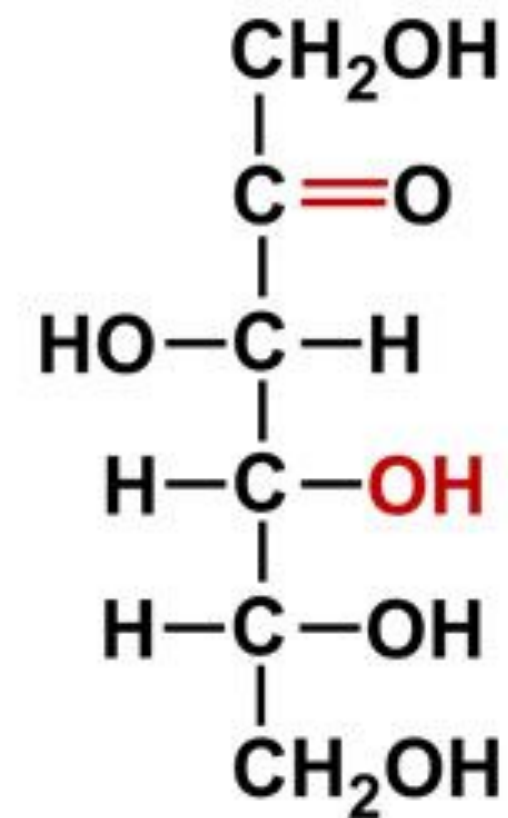
## Monosaccharides



*Glucose*



*Galactose*



*Fructose*

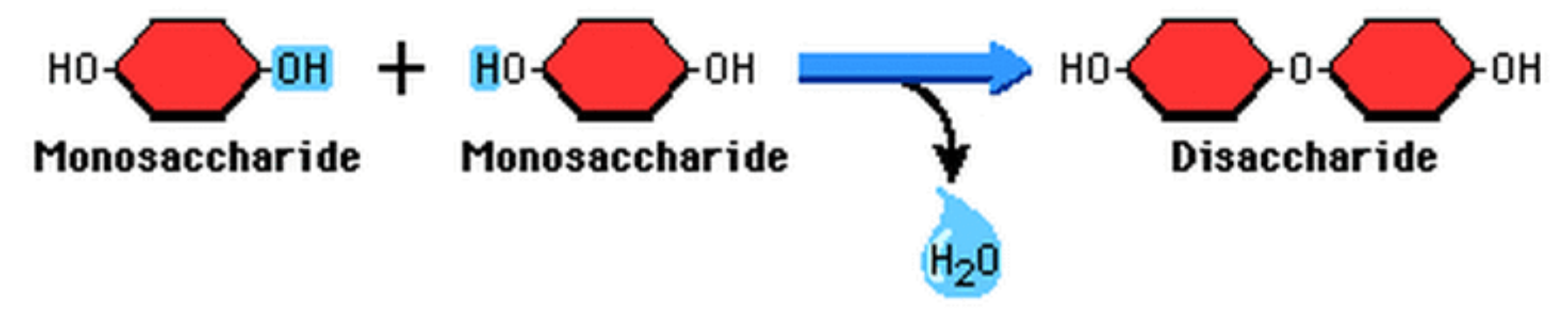
- **Carbohydrates** are organic molecules made up of the elements **carbon, hydrogen and oxygen**.
- Formula:  **$C_nH_{2n}O_n$**
- 3 broad types of carbohydrate: monosaccharides, disaccharides and polysaccharides

### Monosaccharides

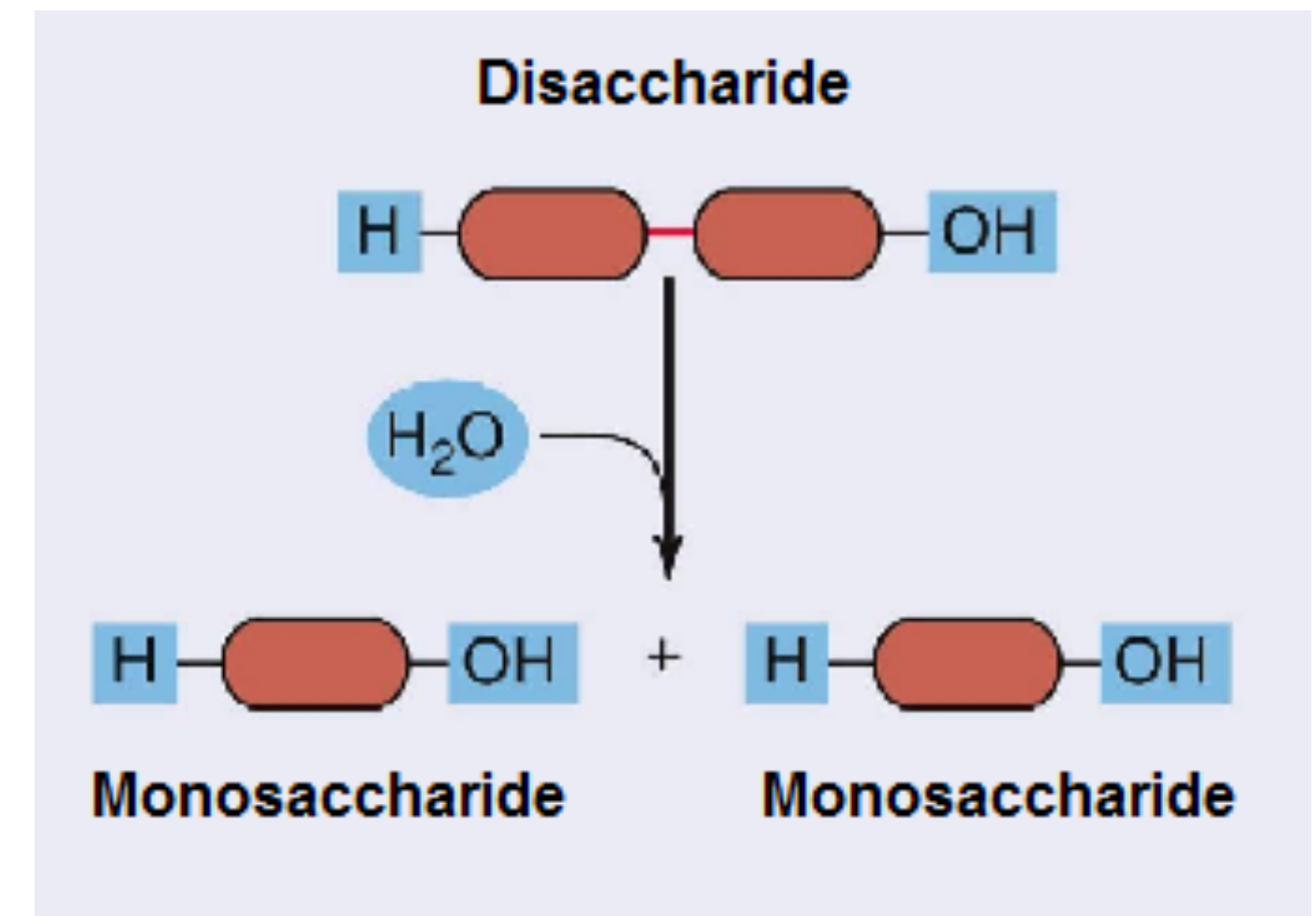
- Smallest unit of carbohydrate
- Formula:  $C_6H_{12}O_6$
- Eg glucose (found in both plants and animal), fructose (found in plants), galactose (milk sugar)

# Carbohydrate

## Disaccharides



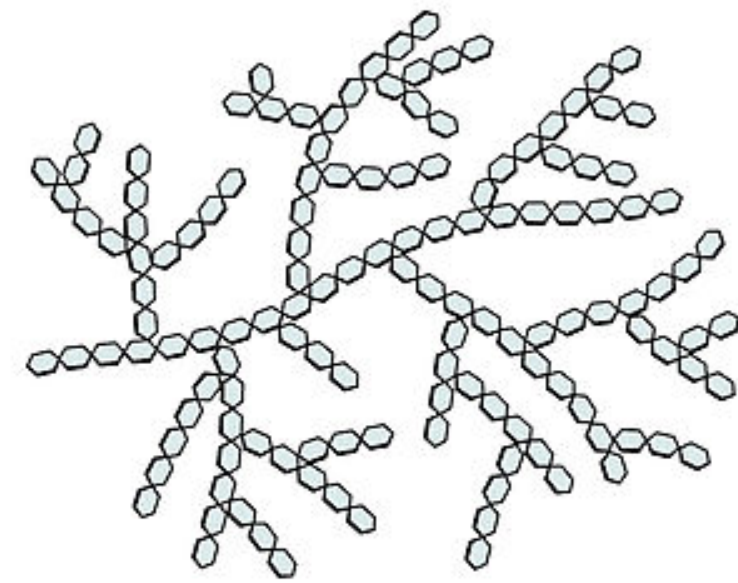
- Two monosaccharides undergo **condensation reaction** to form a disaccharides, with **removal of a water molecule**
- Disaccharides can be broken down to component monosaccharides by **hydrolysis reaction** in which a **water molecule is added**.
- **Enzyme** is needed for both condensation reaction and hydrolysis reaction.
- Formula: C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>



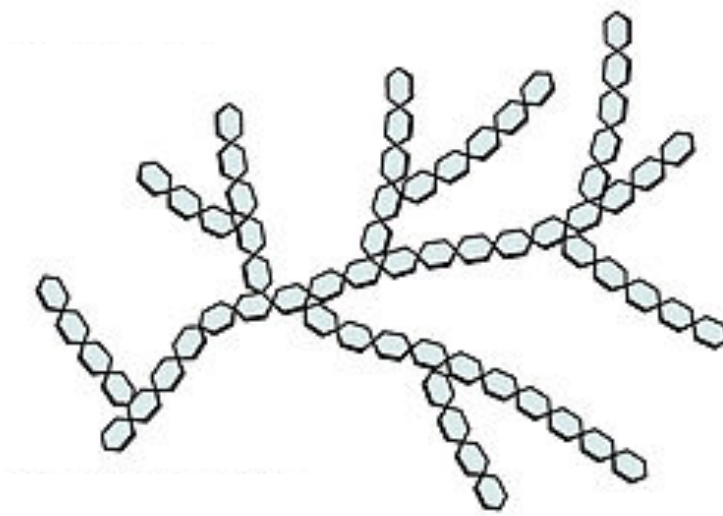
Disaccharides	Monosaccharides
Maltose	glucose + <b>glucose</b>
Sucrose	glucose + <b>fructose</b>
Lactose	glucose + <b>galactose</b>

# Carbohydrate

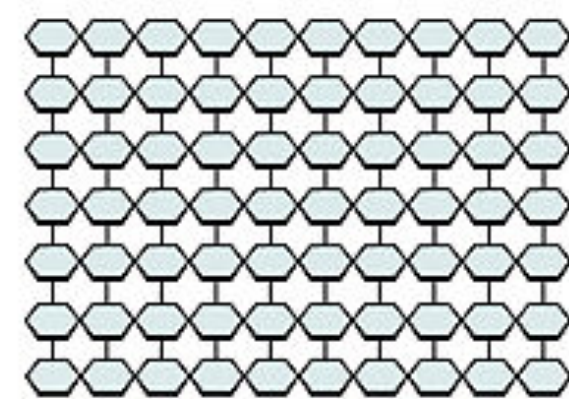
## Polysaccharides



Glycogen



Starch



Cellulose (fiber)

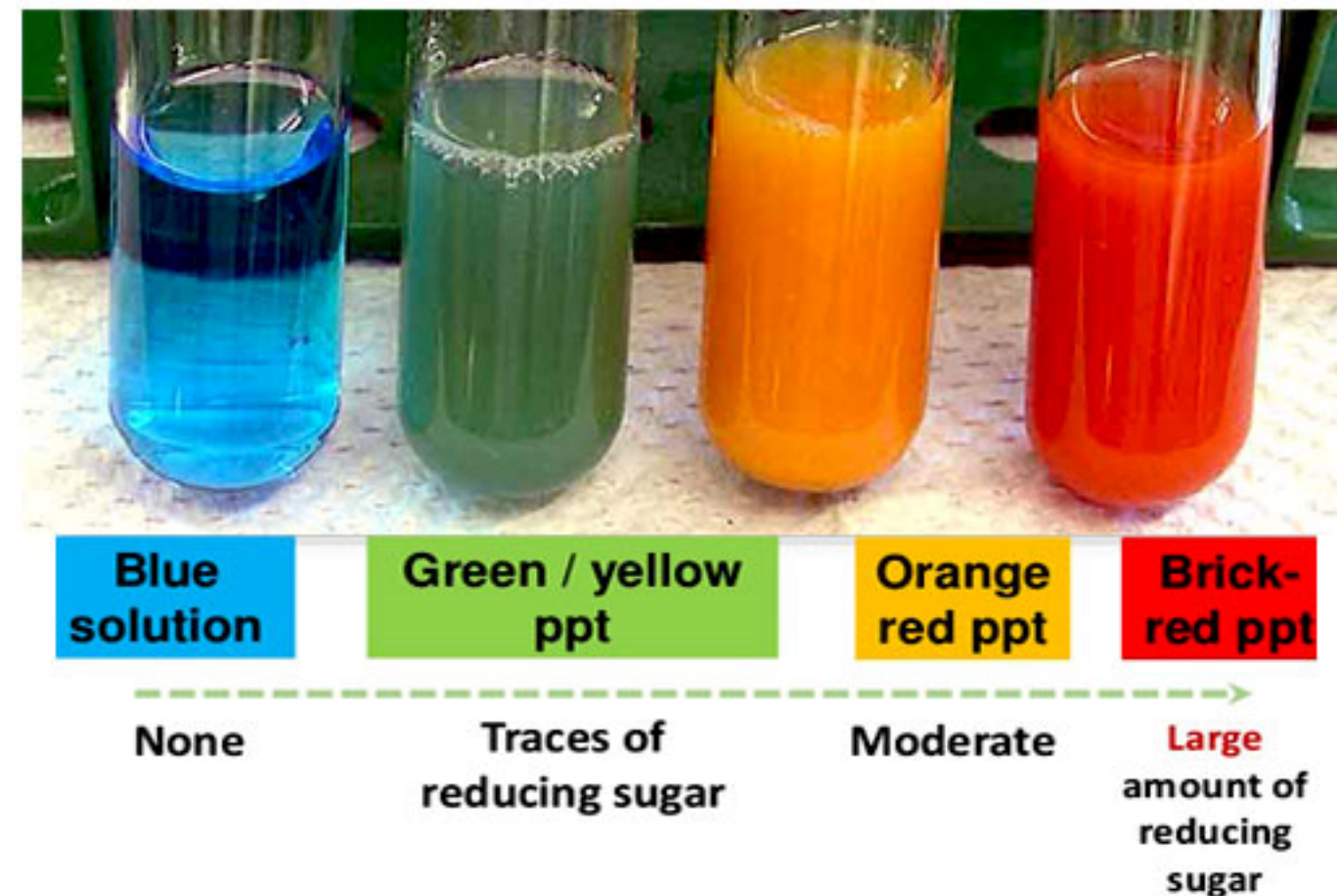
- Polysaccharides are formed when thousands of glucose molecules linked together in condensation reactions.
- Eg, glycogen, starch and cellulose

	<b>glycogen</b>	<b>starch</b>	<b>cellulose</b>
Functions	storage of carbohydrates in <b>mammals</b>	storage of carbohydrates in <b>plants</b>	The cellulose is used to make <b>cell wall in plant cells</b> from bursting or damage.
Location	found in liver and muscles of mammals	found in storage organs of plants eg potato tubers	found in plants cells

# Food test

## Benedict test

Test for reducing sugars  
(all monosaccharides  
and disaccharides  
except for sucrose)



1. Add **2cm<sup>3</sup>** of **Benedict's solution** to **2cm<sup>3</sup>** of solution to be tested.
2. Shake the mixture
3. Heat the test tube in **boiling water bath** for **5 minutes**.
4. Observe **precipitate formation** and colour changes.
5. Benedict solution is blue. Remain Blue (reducing sugar is absent) → Green (little amount) → Yellow (moderate amount) → Orange → Brick-red (most amount)

## Iodine test

Test for starch



1. Place food substance on a white tile. Solid foods may need to be chopped up to smaller pieces.
2. Add **2-3 drops of dilute iodine solution** to substance to be tested.
3. Iodine solution is yellowish brown, if it changes to blue black, starch is present. If it remains yellowish brown, starch is absent



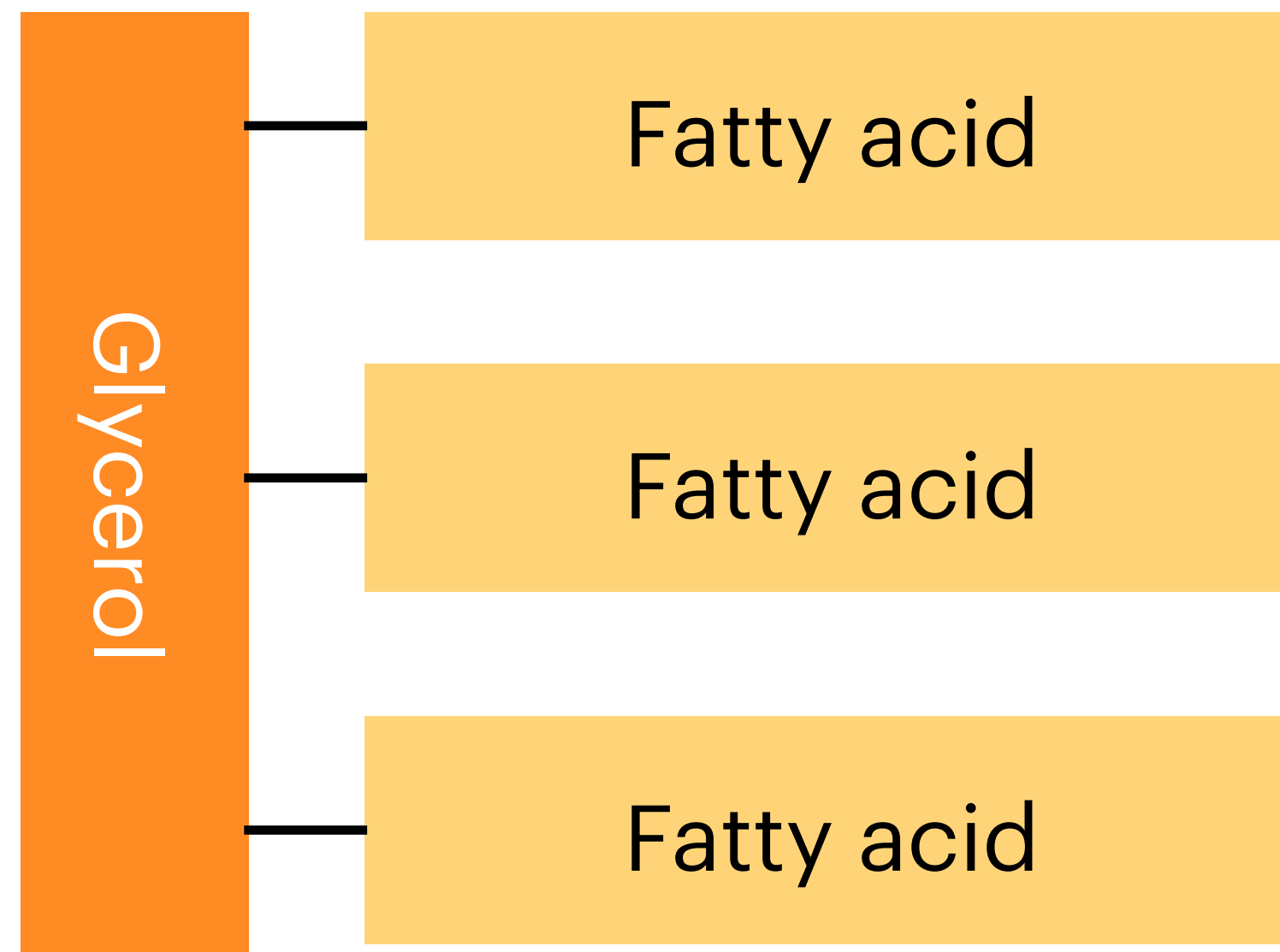
**Key Concept**

# Fats

## Food Test



# Fats



- Made up of carbon, hydrogen and oxygen.
- No fixed formula, the ratio of hydrogen to oxygen is much higher in fats than in carbohydrates
- One fat molecule contains 1 glycerol to 3 fatty acids, joined together via condensation reaction
- Three molecules of water is needed to breakdown fat molecules into glycerol and fatty acids

## **FUNCTIONS**

- Fats are **storage molecules** that can store a large amount of energy. **Each gram of fat** supplies the body with about **9 calories**, more than 4 calories by carbohydrate and protein. Therefore, Hibernating animals store fats as food reserve in cold seasons.
- They are also an important **component of cell membranes** and myelin sheath in nerve cells.
- Fats are used to make **steroids** and certain **hormones**.
- Fats stored as **adipose tissue** are also used as **insulating** material to prevent the loss of **body heat**.
- Fat is a **solvent for fat-soluble vitamins**.
- Fat serves protective functions by **cushioning vital organs** such as kidney.
- Large animals in cold seas have very thick layers of adipose tissues that **gives buoyancy** to aquatic animal. Also provide heat insulation to these animals.

# Food test

## Ethanol emulsion test

Test for fats



1. Add **2cm<sup>3</sup> of ethanol** to the substance in a dry test tube.
2. **Shake** the mixture thoroughly.
3. Add 2cm<sup>3</sup> of water to mixture.
4. If fats are present, a white emulsion will be observed.

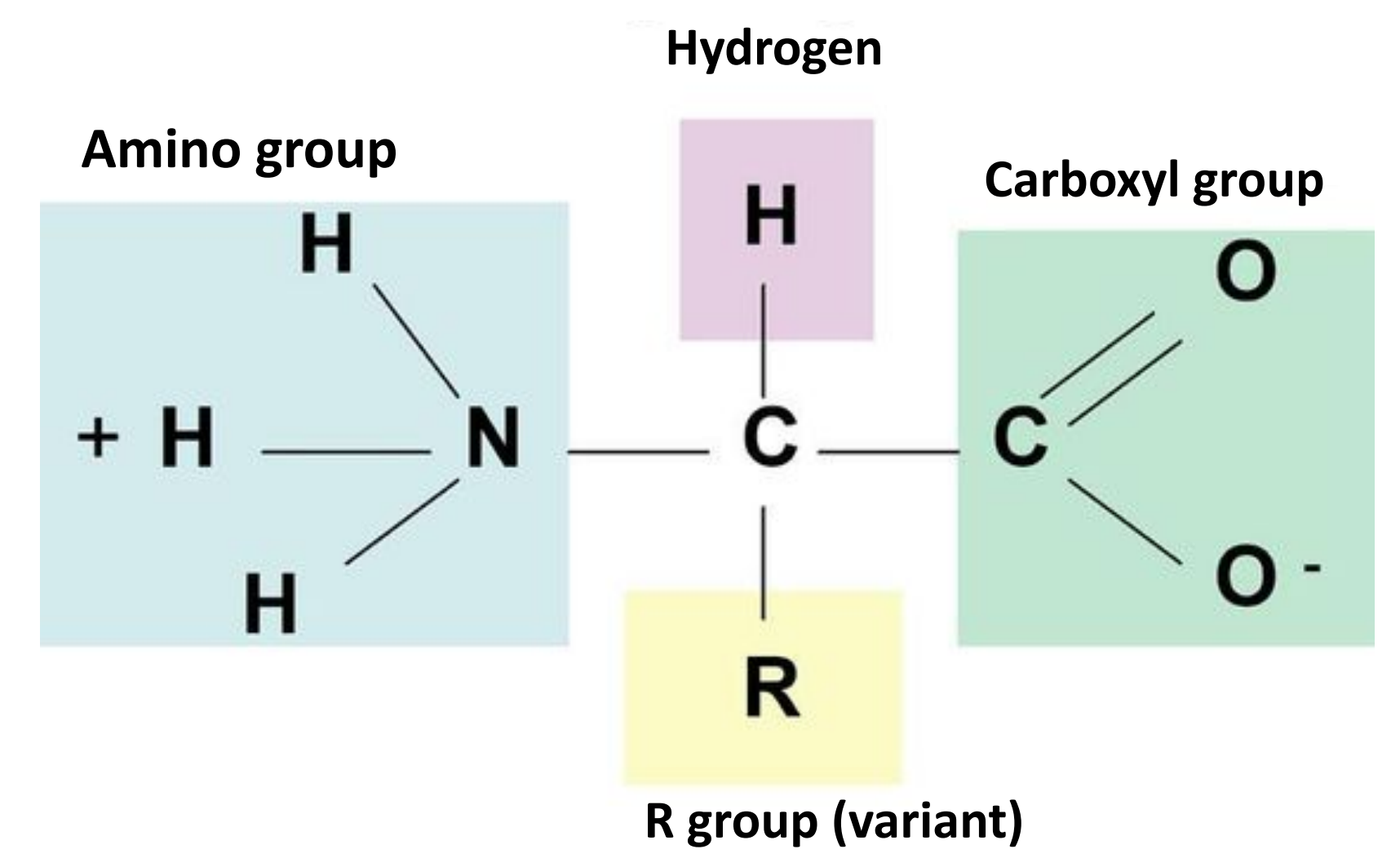
Key Concept

# Protein Food Test

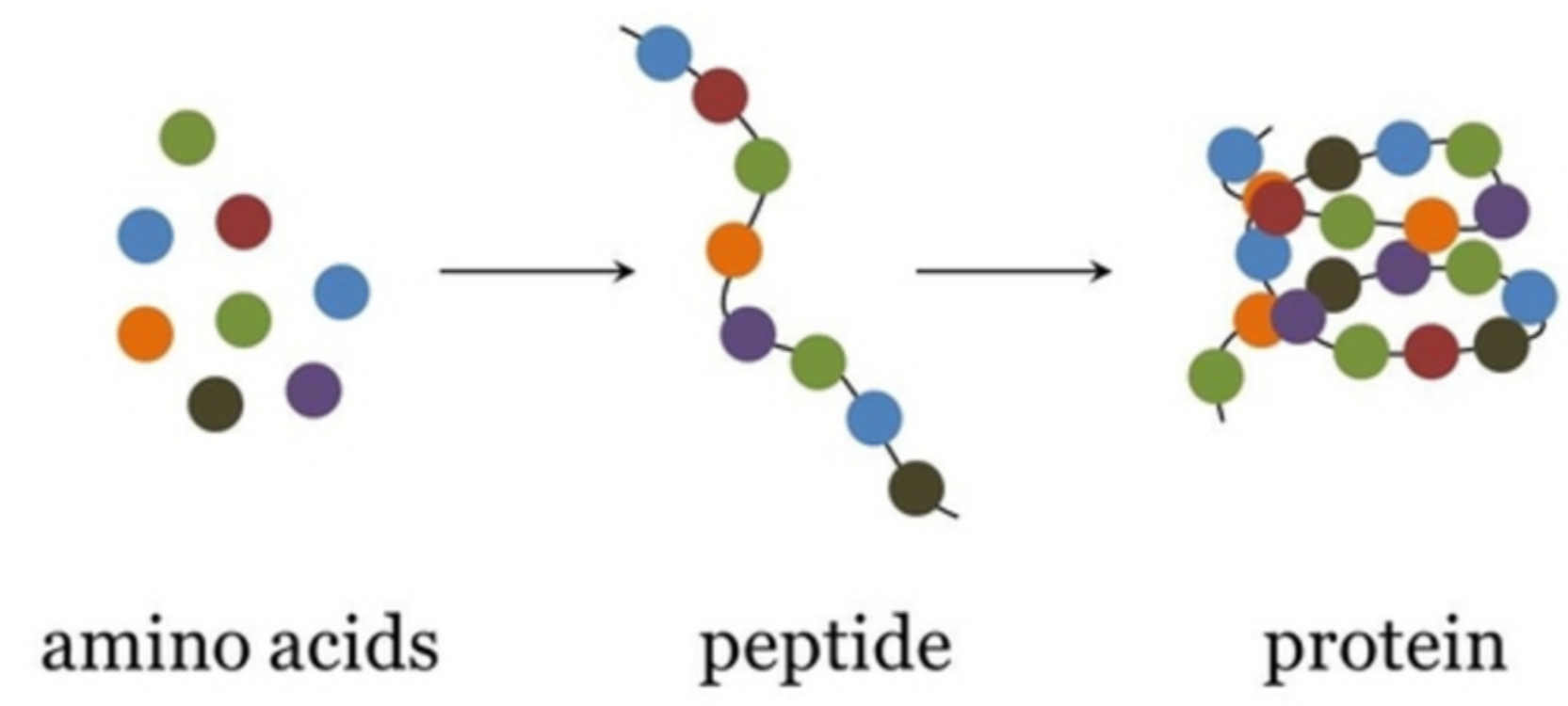


# Proteins

- Organic molecules made up of carbon, hydrogen, oxygen and **nitrogen** and sometimes sulphur
- Smallest unit of proteins is amino acids.
- An amino acid is a molecule with the general structure:



- R group is the characteristic of an amino acid, 20 different R groups, thus there are 20 different naturally-occurring amino acids



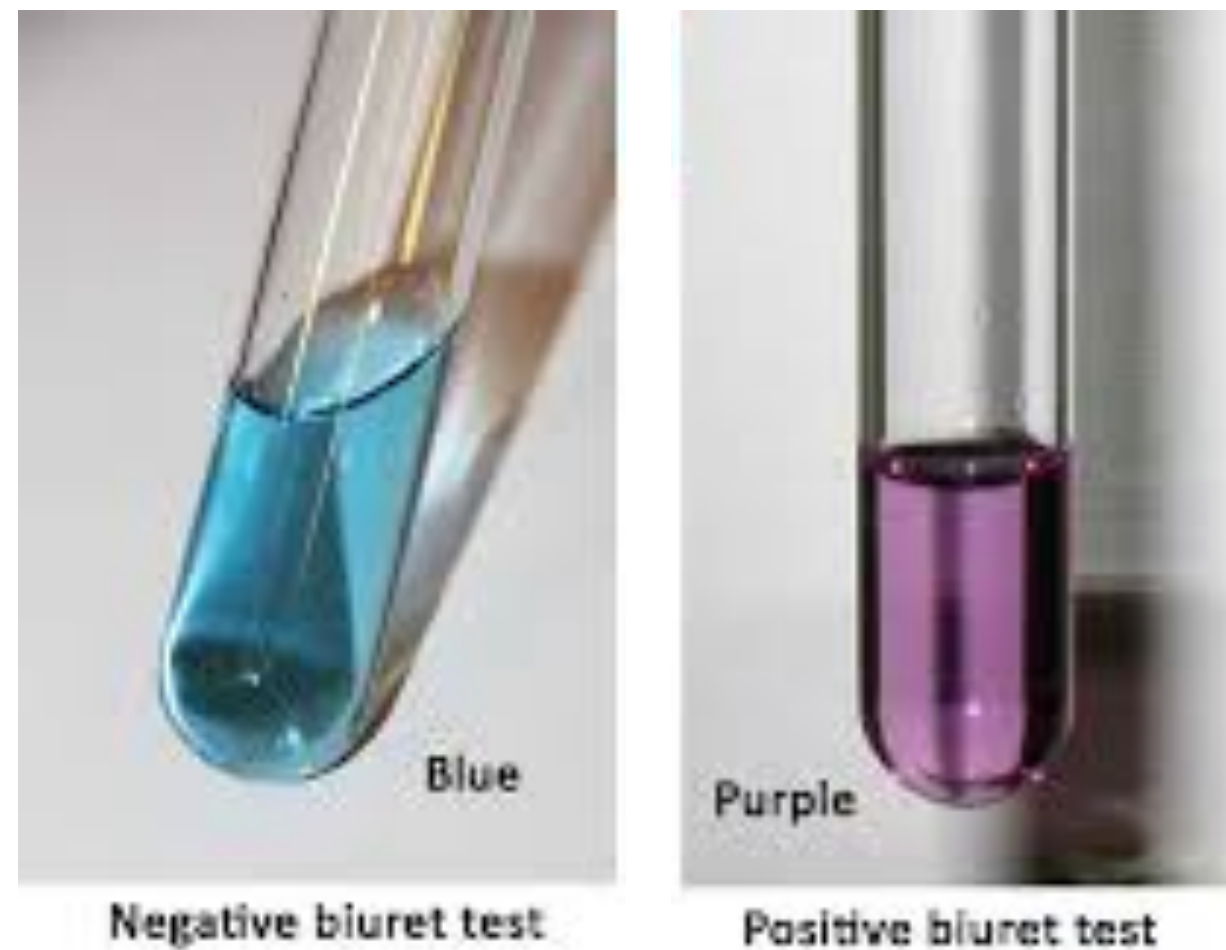
## PROTEIN FORMATION

- Amino acids join together to form a polypeptide through **condensation reaction** with the removal of water molecules, forming **peptide bond in between each amino acids**.
- Proteins are made of one or more polypeptide chains twisted, folded and coiled into a **unique 3-dimensional structure**, held together by **hydrogen bonds, ionic interactions and van der Waals interactions**

# Food test

## Biuret test

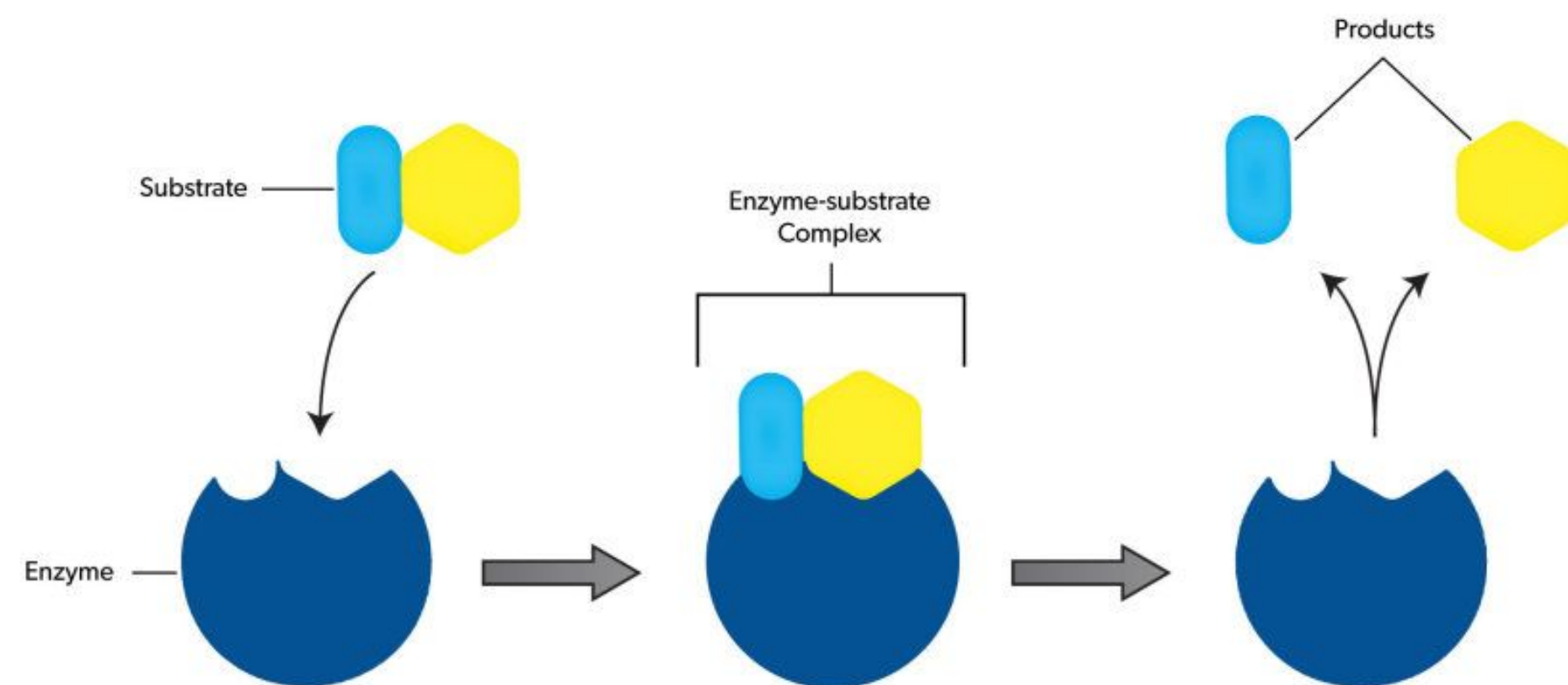
Test for proteins



1. Add **2cm<sup>3</sup>** of **sodium hydroxide** solution to 2cm<sup>3</sup> food solution.
2. Shake thoroughly.
3. Add **1% copper (II) sulfate solution, drop by drop**, shaking after every drop. Allow the mixture to stand for 5 minutes.
4. Copper (II) sulfate is blue, remains blue → protein is absent.  
Solution changes from blue to violet → protein is present

## Key Concept

# Enzyme



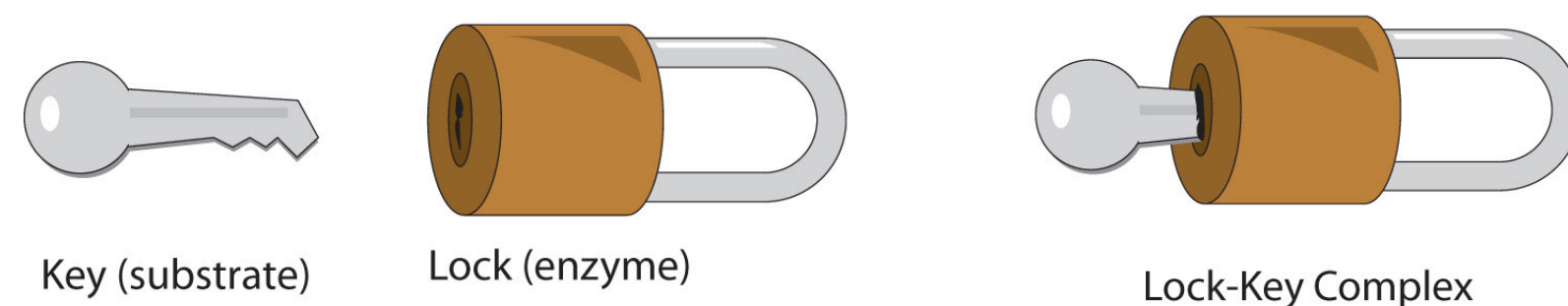
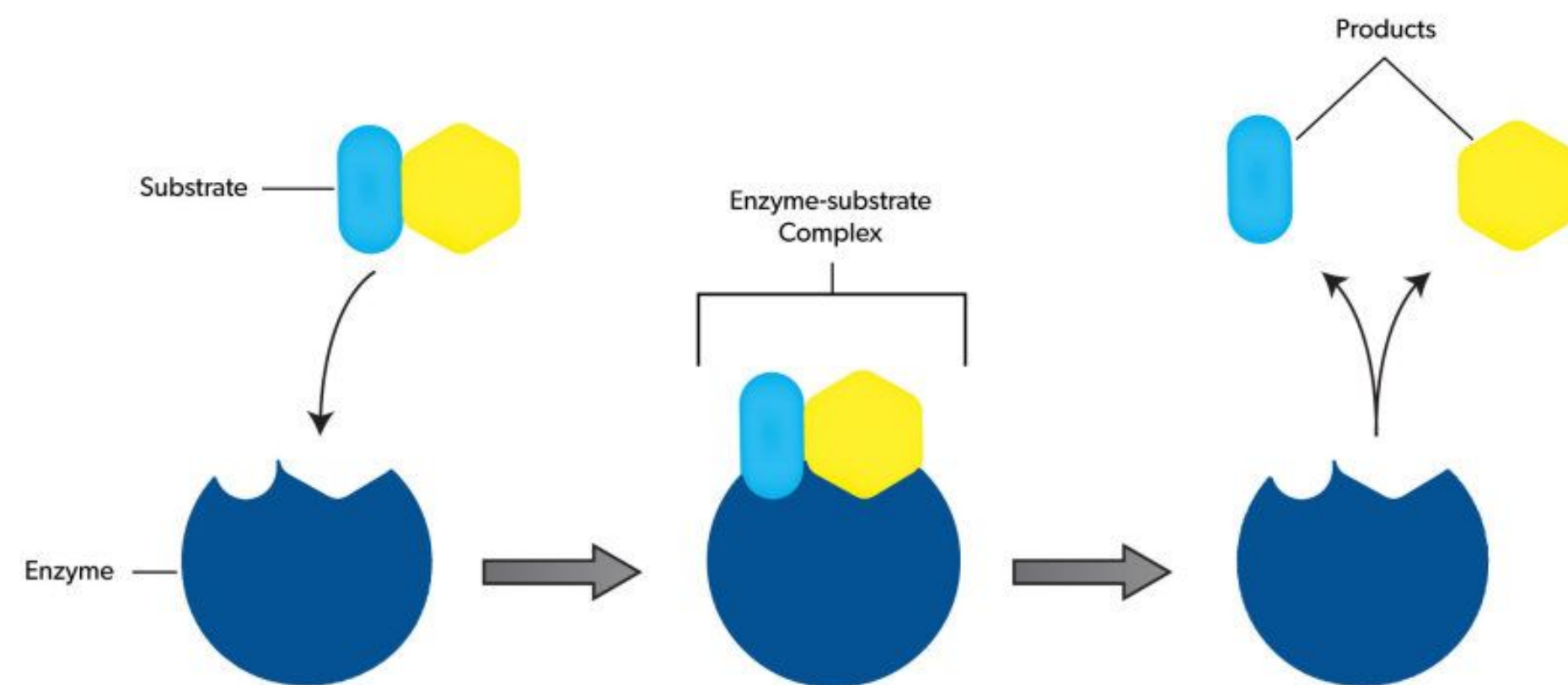
- Definition: Enzymes are **biological catalysts** that **speed up the rate of chemical reactions** by **lowering the activation energy** of a chemical reaction, **without being chemically altered** in the reaction.
- Enzymes are required in **small amounts** because they remain **chemically unchanged** in the reactions they catalyse and can be **reused**.
- The active site of an enzyme has a specific shape into which the substrate(s) fit exactly. The shape of the substrate is complementary to the shape of the active site of the enzyme.

# Enzyme

## Lock and key hypothesis

### 'LOCK AND KEY' HYPOTHESIS

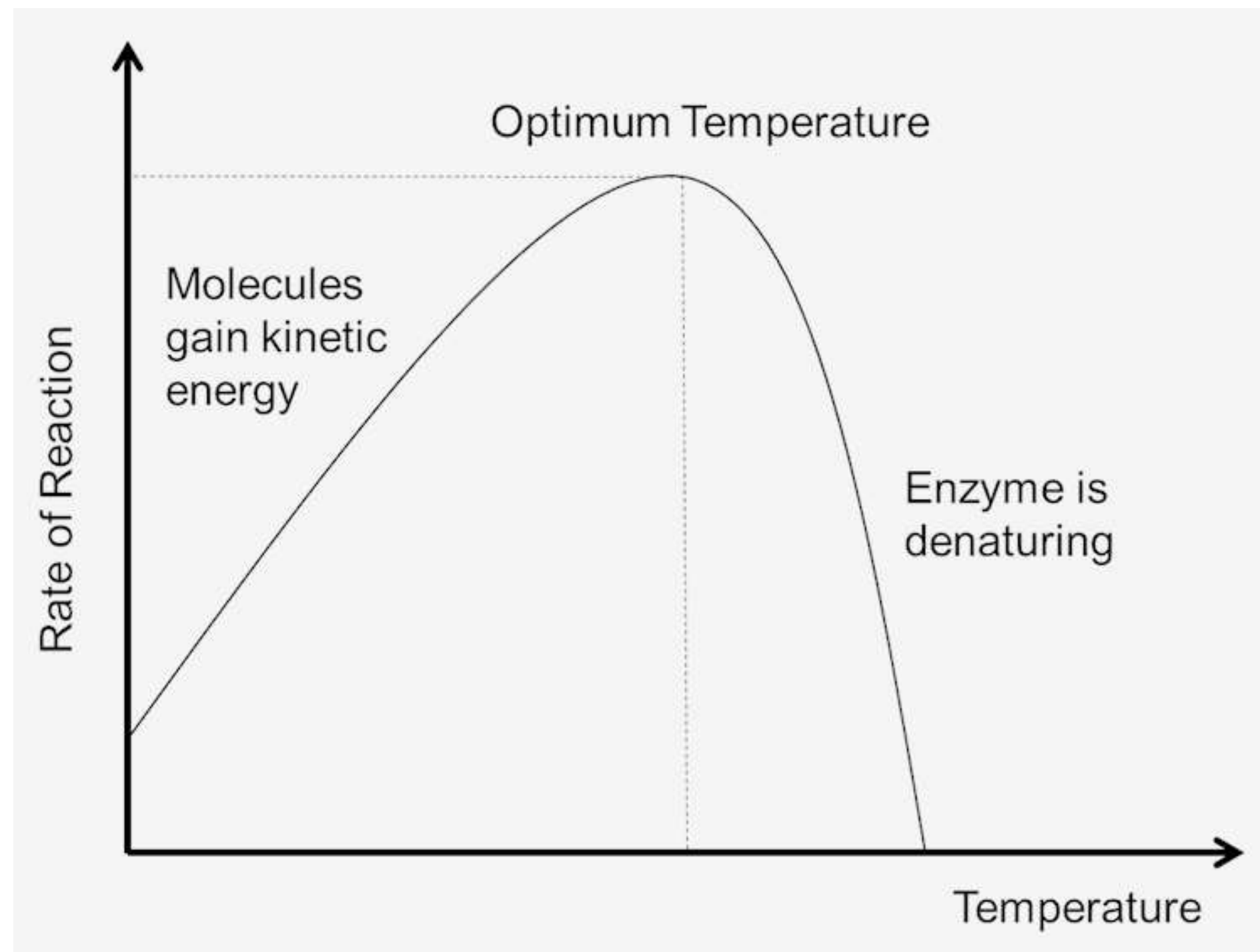
1. The **substrate** is they “**key**”, while the **enzyme** is the “**lock**”
2. Only substrate that is **complementary in shape to the active site** of the enzyme can fit into the active site.
3. The substrate **binds to the active site** of the enzyme, forming an **enzyme-substrate complex**.
4. The formation of enzyme-substrate complex **lowers the activation energy of the chemical reaction** as enzyme molecule holds the substrate molecule(s) in an arrangement that forces them together in the correct orientation.
5. The enzyme then **catalyse the reaction at its active sites** to convert the substrate into product molecules
6. The **product(s) dissociate from the enzyme**, and the **unchanged enzyme** is free to **catalyse another reaction**.





# Enzyme

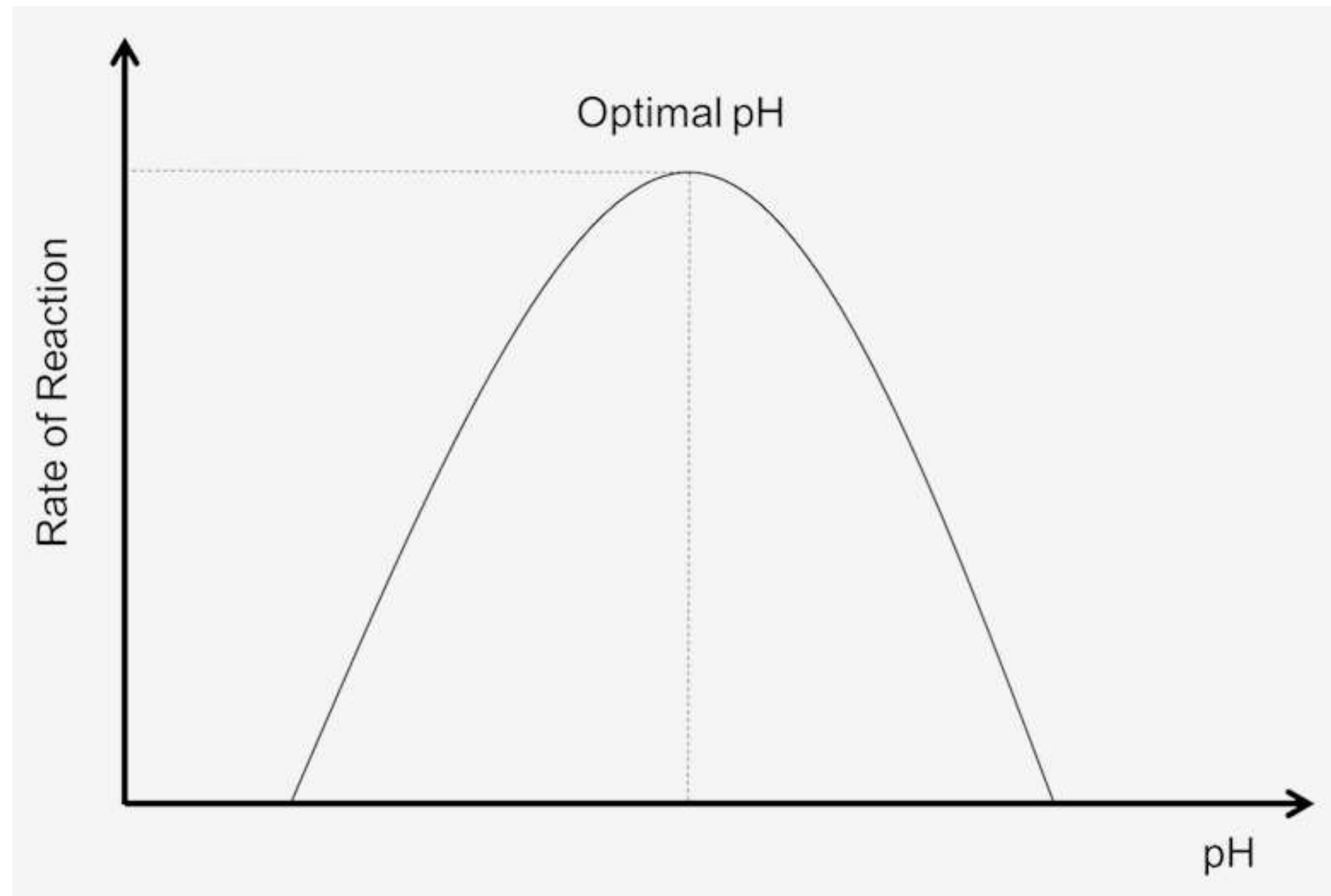
## effect of temperature



1. At low temperatures, enzymes are inactive and the rate of reaction is low. Substrate and enzyme molecules have **little kinetic energy**, hence the frequency of collision is low. In addition, most substrate molecules **do not contain sufficient energy to overcome the activation energy required** to start a reaction.
2. As temperature increases, enzyme and substrate **gain kinetic energy** and they **collide more often**, increasing the **formation of enzyme substrate complex** thus increase rate of reaction. Rate of reaction doubles with every 10°C rise in temperature.
3. Reaction rate is its **maximum** at enzyme **optimum temperature**.
4. As temperature increases beyond optimum temperature, enzyme is **denatured**. The enzyme **loses its 3D shape** and active site is unable to bind to the substrate. Rate of reaction thus decreases.
5. Denaturation is irreversible even when temperature is lowered. At extremely high temperatures, the enzyme is completely denatured and the rate of reaction drops to zero.

# Enzyme

## effect of pH



1. Enzyme activity is the **highest** at the **optimum pH** of the enzyme.
2. As the pH deviates from the optimum, enzyme activity sharply decreases. This is because the **hydrogen bonds and ionic bonds that hold the 3-dimensional structure are disrupted**. The enzyme is denatured and the **shape of the active site is altered**.
3. At extreme pH levels, the enzyme is completely denatured and the rate of reaction drops to zero. The optimum pH for each enzyme differs.

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