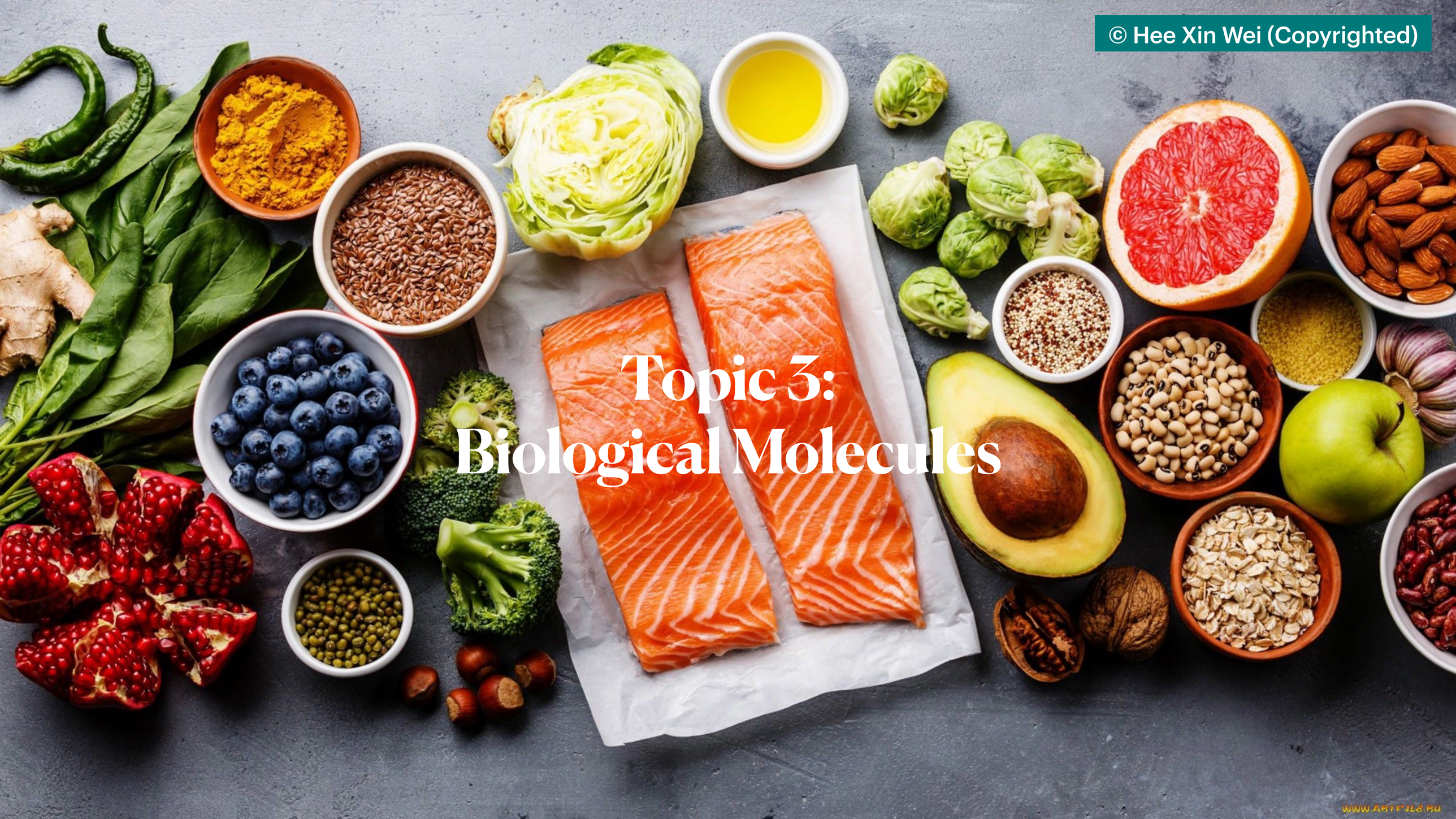
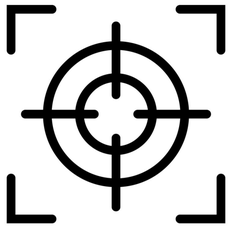


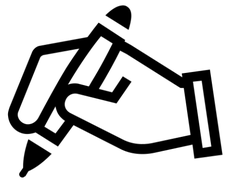
Topic 3: Biological Molecules

Chapter Analysis



FOCUS

- Heavily linked to Digestion chapter



EXAM

- Usually tested in both MCQ and structured questions
- tested in section B twice in the past 5 years

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

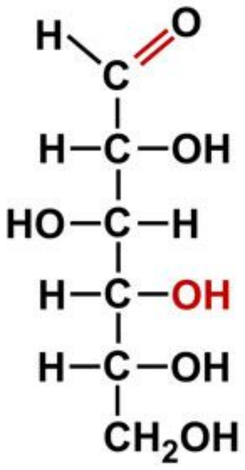
- reactant for photosynthesis
- provides physical support to the plant in the form of turgor pressure.
- allow dissolved mineral salts to be transported from roots to other part of plants
- allow sugars to be transported from leaves to other parts of the plant.

Key Concept

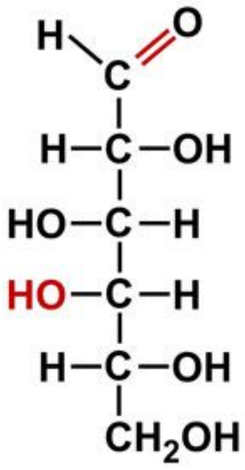
Carbohydrate Food Test

Carbohydrate

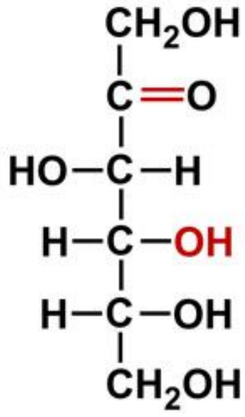
Monosaccharides



Glucose



Galactose



Fructose

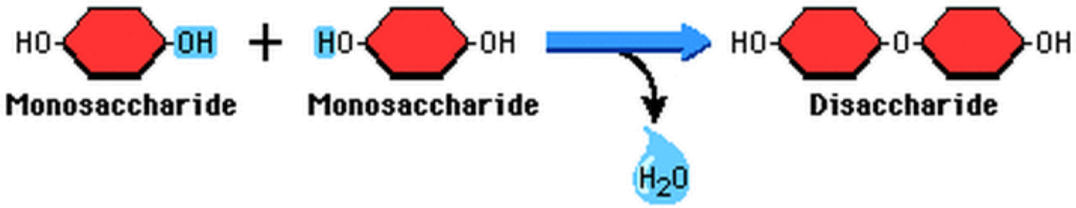
- **Carbohydrates** are organic molecules made up of the elements **carbon, hydrogen and oxygen**.
- Formula: $\mathbf{C_nH_{2n}O_n}$
- 3 broad types of carbohydrate: monosaccharides, disaccharides and polysaccharides

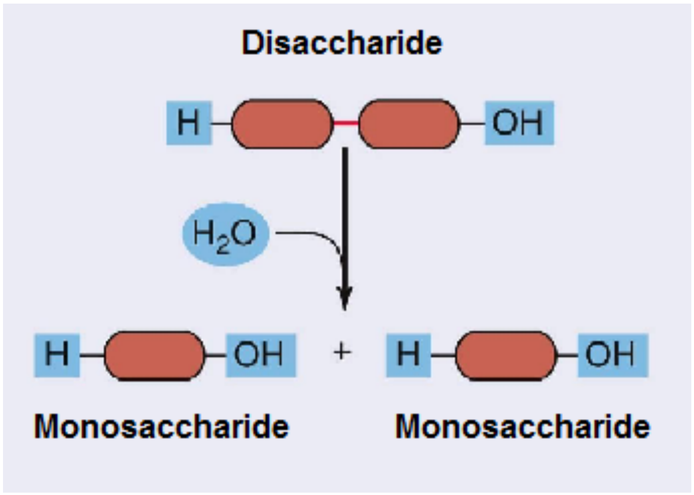
Monosaccharides

- 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



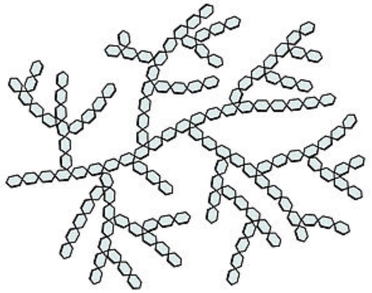


- Two monosaccharides undergo **condensation reaction** to form a disaccharides, with **removal of a water molecule**
- Disaccharides can be broken down to component monosaccharides by **hydrolysis reaction** in which a **water molecule is added.**
- **Enzyme** is needed for both condensation reaction and hydrolysis reaction.
- Formula: $C_{12}H_{22}O_{11}$

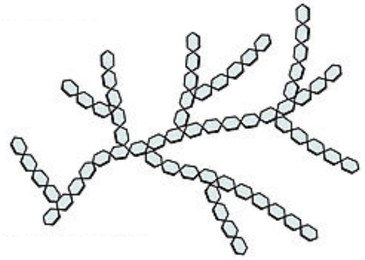
Disaccharides	Monosaccharides
Maltose	glucose + **glucose**
Sucrose	glucose + **fructose**
Lactose	glucose + **galactose**

Carbohydrate

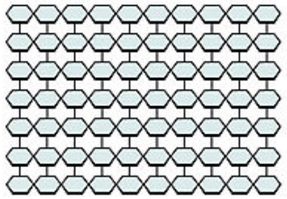
Polysaccharides



Glycogen



Starch

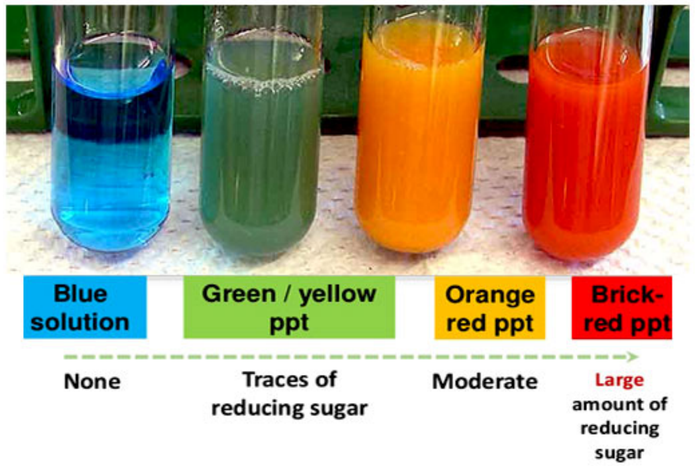


Cellulose (fiber)

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

	glycogen	starch	cellulose
Functions	storage of carbohydrates in **mammals**	storage of carbohydrates in **plants**	The cellulose is used to make **cell wall in plant cells** 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

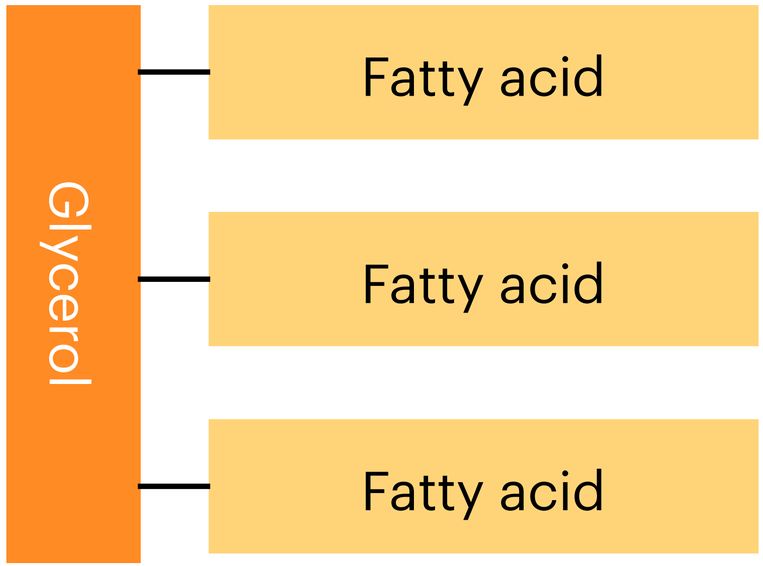
Food test

Benedict test Test for reducing sugars (all monosaccharides and disaccharides except for sucrose)  	1. Add **2cm³** of **Benedict's solution** to **2cm³** 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

FUCTIONS

(a) 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.

(b) They are also an important **component of cell membranes** and myelin sheath in nerve cells.

(c) Fats are used to make **steroids** and certain **hormones**.

(d) Fats stored as **adipose tissue** are also used as **insulating** material to prevent the loss of **body heat**.

(e) Fat is a **solvent for fat-soluble vitamins**.

(f) Fat serves protective functions by **cushioning vital organs** such as kidney.

(g) 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

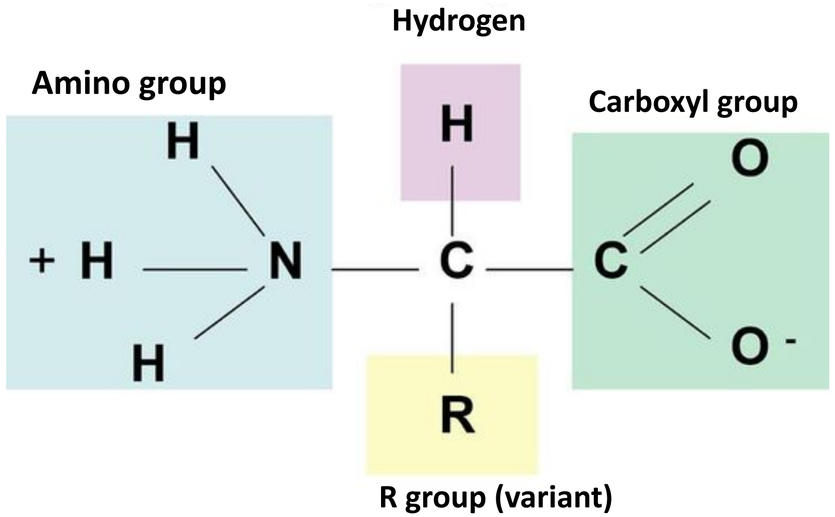
Ethanol emulsion test Test for fats 	1. Add **2cm³ of ethanol** to the substance in a dry test tube. 2. **Shake** the mixture thoroughly. 3. Add 2cm³ of water to mixture. 4. If fats are present, a white emulsion will be observed.

Key Concept

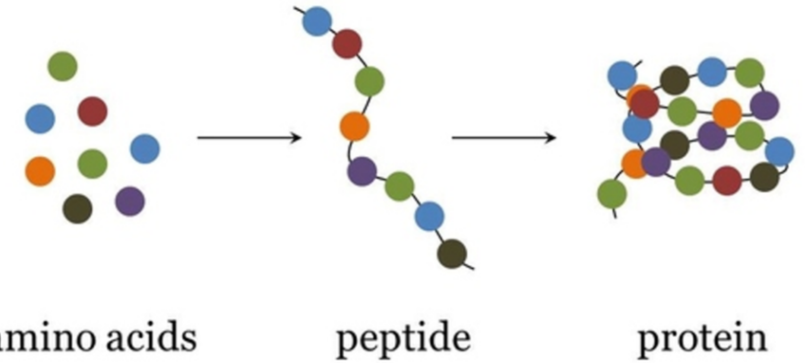
Protein Food Test

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:



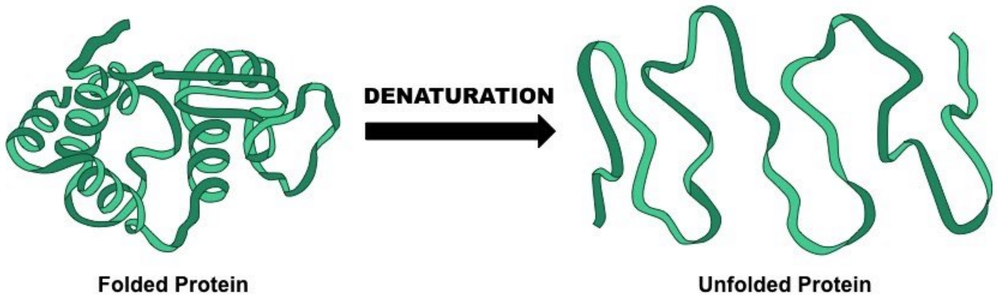
- R group is the characteristic of an amino acid, 20 different R groups, thus there are 20 different naturally-occurring amino acids



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**

Proteins



DENATURATION

- Hydrogen bonds, ionic interactions and van der Waals interactions are weak and can easily be broken by heat or by changes in pH.
- Proteins can be denatured if they are heated or placed in an environment with unsuitable pH. Denaturation occurs when these bonds are broken and it leads to a loss of function as protein 3D shape is specific to its function

FUNCTIONS

(a) Proteins are used in the **synthesis of new cells**, for **growth** and **repair** of worn-up cells.

(b) Proteins are used as biological catalyst to speed up chemical reactions, e.g. **enzymes**

(c) Proteins serve as chemical messengers, e.g. **hormones** such as insulin

(d) Proteins serve a transport function, e.g. **haemoglobin** is used to transport oxygen in red blood cells

(e) Proteins perform a structural function, e.g. **collagen** is a component of skin, bones while **keratin** is a component of hair, nails, and feathers.

(f) Proteins are used for the defense of the body, e.g. **antibodies** which recognise and combine with foreign substances such as bacteria.

Food test

Biuret test

Test for proteins

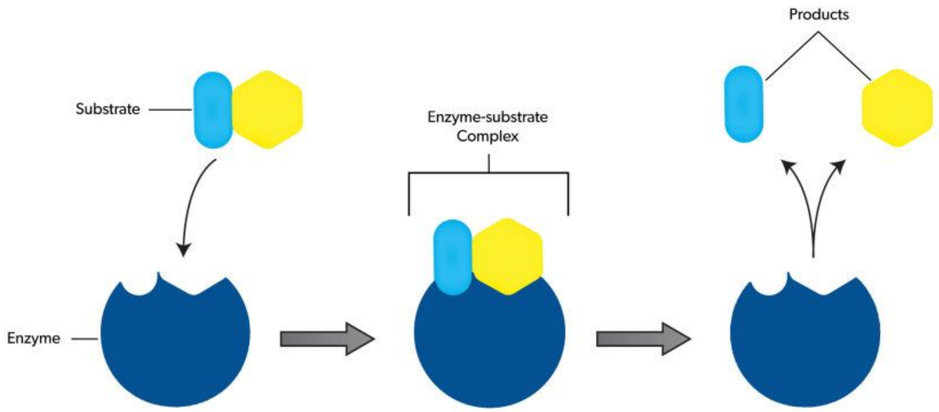
Negative biuret test

Positive biuret test

1. Add **2cm³** of **sodium hydroxide** solution to 2cm³ 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

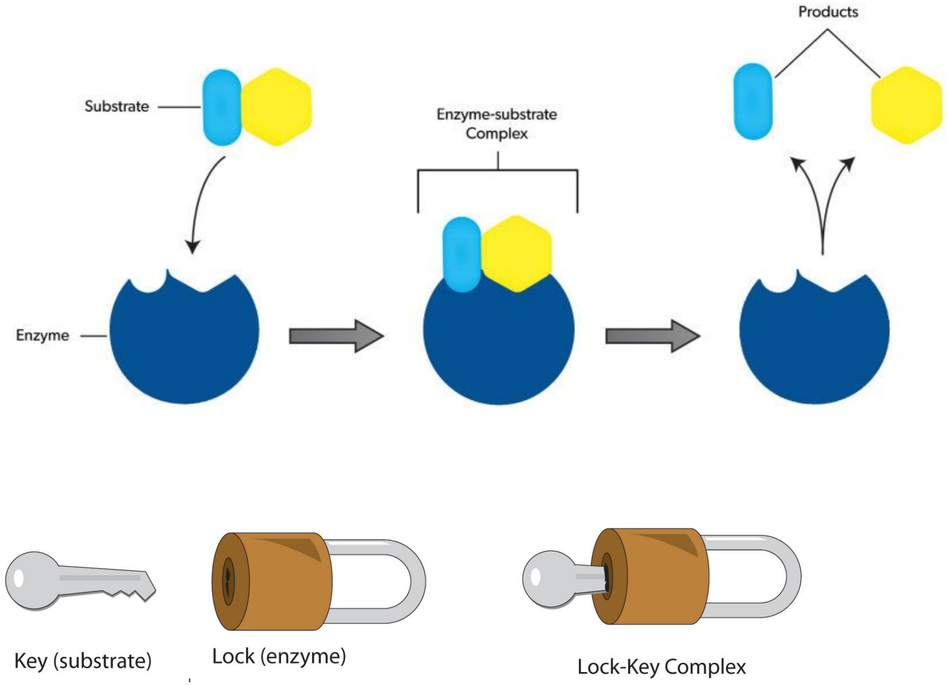
Enzyme



- 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

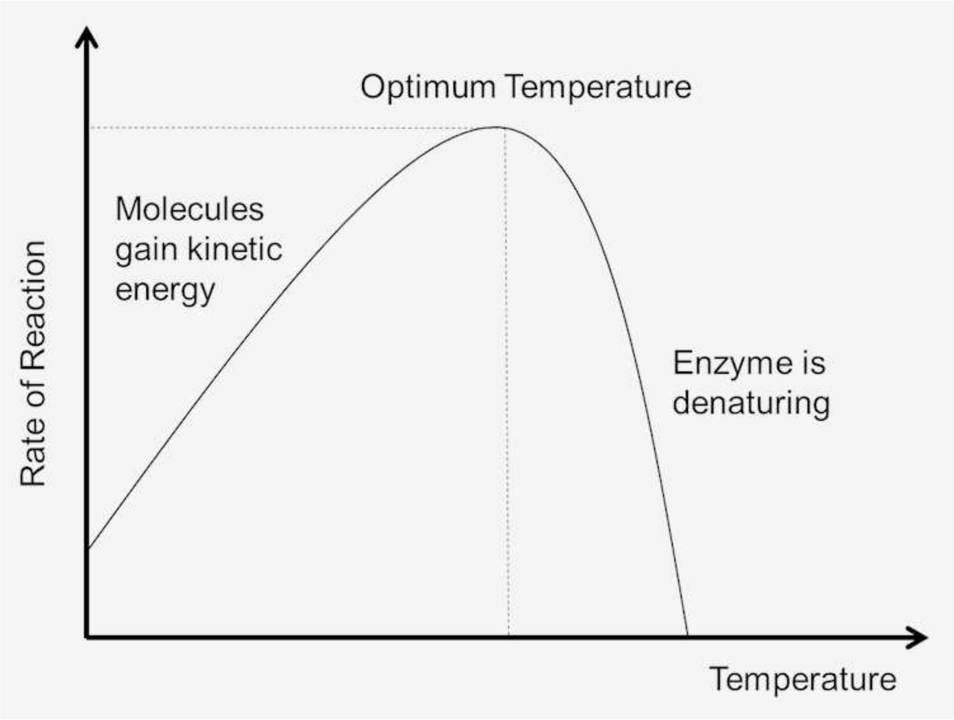


‘LOCK AND KEY’ HYPOTHESIS

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

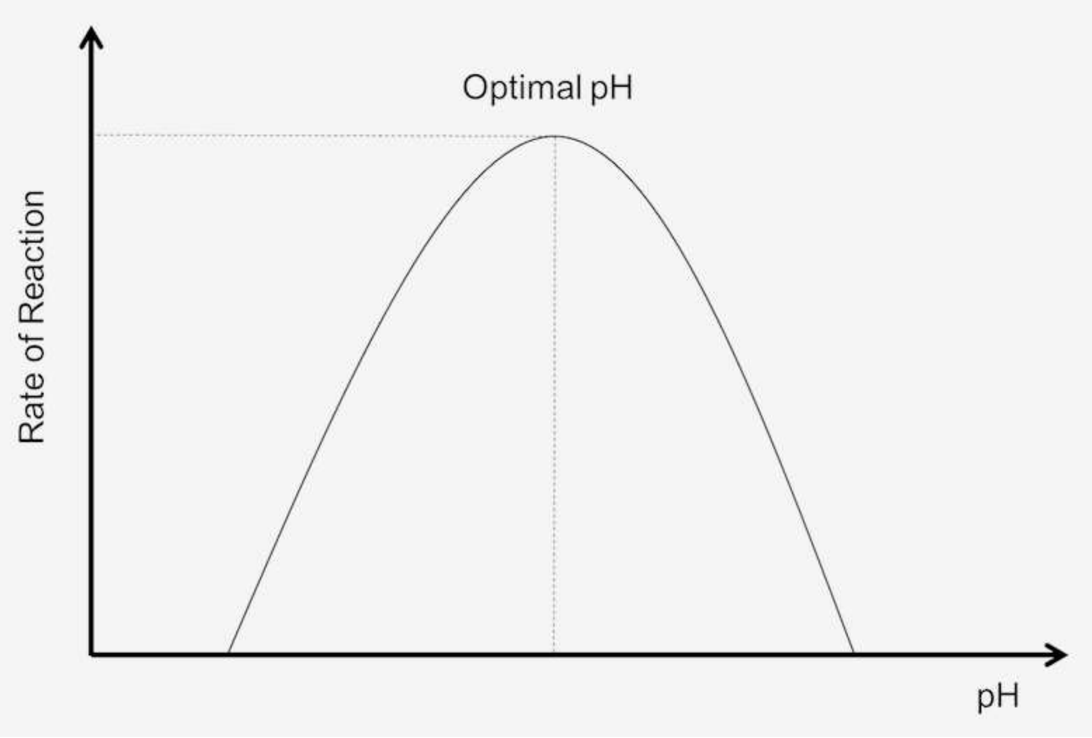
effect of temperature



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

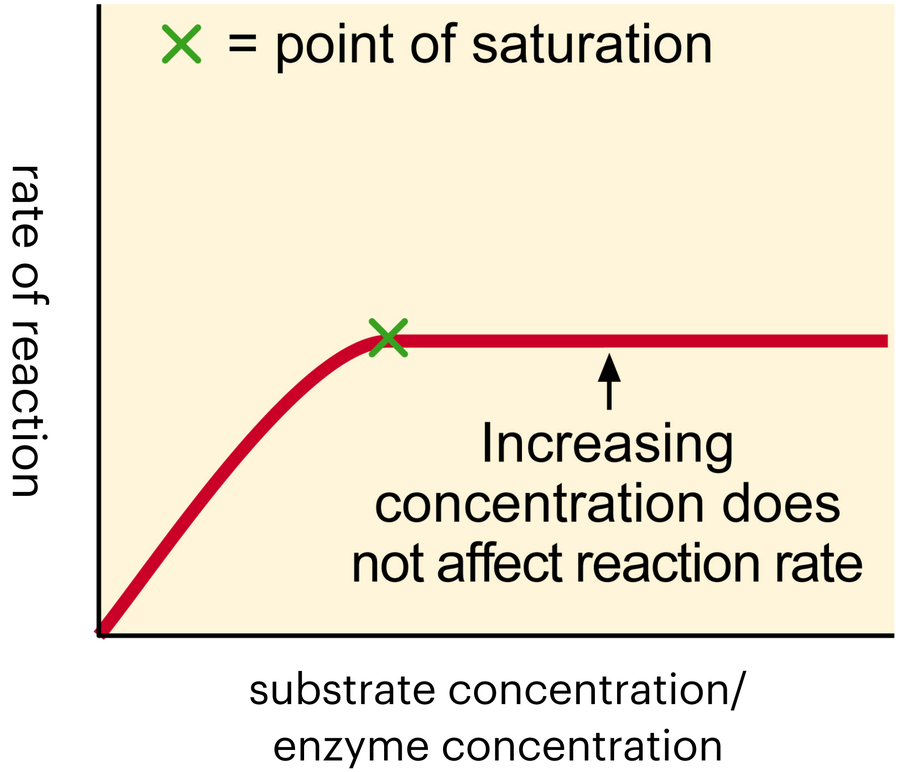
effect of pH



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.

Enzyme

effect of enzyme and substrate concentration



Enzyme concentration

- Limiting factor at low enzyme concentrations, adding more enzyme increases the rate of reaction.
- With more enzymes present, there are **more active sites for effective collisions** to take place, increasing the **formation of enzyme substrate complex.**
- The rate of reaction is directly proportional to the enzyme concentration **until all substrate have bind to enzyme active sites**
- The rate of reaction becomes **constant** and **reaches a plateau.**
- At this point, **substrate concentration becomes the limiting factor**.

Substrate concentration

- Limiting factor at low substrate concentration, adding more substrate increases the rate of reaction
- There are many available active sites for effective collisions to occur, when more substrate are present, **more enzyme substrate complex will be formed.**
- At higher substrate concentrations, increasing the amount of substrate cannot increase the rate of reaction as **active sites of enzyme molecules are saturated**
- Rate of reaction becomes **constant** and **reaches a plateau**.
- At this point, **enzyme concentration becomes the limiting factor.**

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