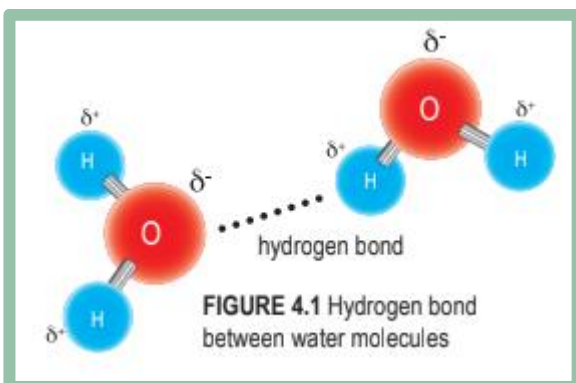


# CHAPTER 4.1 – WATER

## Properties of water and its importance in a cell

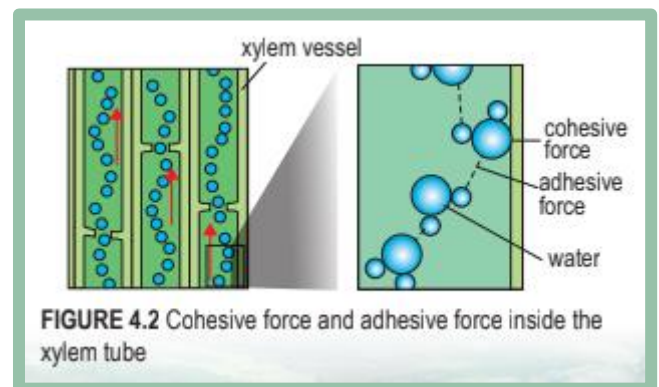
### POLARITY OF WATER

- ❖ Water is an inorganic compound consisting of the hydrogen (H) and oxygen (O) elements
- ❖ Water molecules are polar molecules because shared electrons between oxygen and hydrogen will be attached towards oxygen which is more electronegative ( $\delta^-$ )
- ❖ This polarity produces hydrogen bonds and allows water to act as a universal solvent
- ❖ The universal solvent properties of water allow solutes (glucose) and electrolytes to be transported through the plasma membranes into cells for biochemical reactions



### COHESIVE FORCE AND ADHESIVE FORCE OF WATER

- Cohesive force refers to water molecules that are attached to each other
- Adhesive force refers to water molecules that are attached to other surfaces
- Both forces produce the capillary action which allows water to enter and move along narrow spaces, such as in the xylem tube



### SPECIFIC HEAT CAPACITY OF WATER

- ✚ Water has a high specific heat capacity of  $4.2 \text{ kJ kg}^{-1} \text{ }^\circ\text{C}^{-1}$
- ✚ This means that 4.2 kJ of heat energy is required to raise the temperature of one kilogram of water by  $1^\circ\text{C}$
- ✚ Water absorbs a lot of heat energy with a small rise in temperature
- ✚ This characteristic is very important to maintain the body temperature of organisms

# CHAPTER 4.2 – CARBOHYDRATES

## Carbohydrates

- ❑ Organic compounds are **chemical compounds** that contain **carbon** elements
- ❑ Large and complex compounds form **macromolecules**
- ❑ Most macromolecules are **polymers** comprising small molecules known as **monomers** (building blocks)
- ❑ Carbohydrates, proteins and nucleic acids are **polymer molecules** of organic compounds

## Types of carbohydrates

There are three main types

- ◇ Monosaccharides (simple sugars)
- ◇ Disaccharides
- ◇ Polysaccharides (complex sugars)

### MONOSACCHARIDES

- ⊡ Carbohydrate monomers, which are the **simplest** carbohydrate units
- ⊡ Can combine to form polymers through a **condensation reaction**
- ⊡ Most taste sweet, can form crystals and dissolve in water
- ⊡ Example:
  - » Glucose
    - ✓ Sugar found in plants (**rice, wheat**) and fruits (**grapes**)
    - ✓ Most commonly found monosaccharide

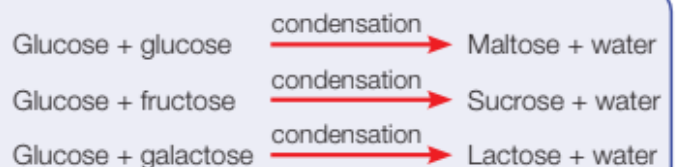
- ✓ Most polysaccharides are formed from this sugar

- » Fructose
  - ✓ Sugar found in honey and sweet fruits
- » Galactose
  - ✓ Sugar found in milk

- ⊡ Has a **reducing power**, which is the ability to **transfer hydrogen (or electron)** to the other compounds
- ⊡ When monosaccharide is heated in Benedict's solution, the monosaccharide will **reduce** the **blue copper (II) sulphate** to a **brick red precipitate of copper (I) oxide** which is **insoluble** in water
- ⊡ This process known as **reducing sugars**

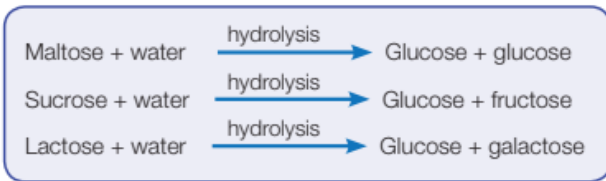
### DISACCHARIDES

- ⊕ Formed when two **simple sugar molecules** (monosaccharides) combine through **condensation** to form disaccharide units
- ⊕ Involves the **removal** of a water molecule



- ⊕ Can be **broken down** to their monosaccharide units through **hydrolysis**

- ⊕ Involves the **addition** of one water molecule



- Example:
  - Maltose
    - 1) Found in grains
    - 2) Reducing sugars
  - Lactose
    - 1) Found in milk
    - 2) Reducing sugars
  - Sucrose
    - 1) Found in sugar cane, sweet fruits and sugar beet
    - 2) Non-reducing sugars because it does not reduce copper (II) sulphate solution

### POLYSACCHARIDES

- Sugar polymers consisting of **monosaccharide monomers**
- Formed through the **condensation** process
- Involves **hundreds of monosaccharides** to form **long molecular chains**

→ \*Chitin is a type of polysaccharide that used as a surgical thread

- **Insoluble** in water due to their **large molecular size**
- **Neither** taste sweet nor crystallise
- Can be **disintegrate** through **hydrolysis** with the help of
  1. Dilute acids
  2. Boiling
  3. Enzyme action

### Importance of carbohydrates in cells

- I. As a source of **energy** (glucose)
- II. As a **food reserve** (glycogen in animal cells, starch in plant cells)
  - Starch is the **main storage** of polysaccharide in plant cells
  - Starch also **found** in chloroplasts
  - Source: grains, potatoes, legumes
  - Glycogen is the **main storage** of polysaccharide **found** in muscle cells and animal liver cells
- III. As a **support structure** (cellulose in the plant cell wall)
  - Cellulose forms the **main structure** of the plant cell wall

→ \*The advantage is that chitin will decompose after the sewn wound heals

# CHAPTER 4.3 – PROTEIN

## Protein

- Δ Protein is a **complex compound** composed of **carbon, hydrogen, oxygen and nitrogen** elements
- Δ Most of proteins contain **sulphur** and **phosphorus**
- Δ Example of protein
  - A) Fish
  - B) Meat
  - C) Milk
  - D) Beans
  - E) Eggs

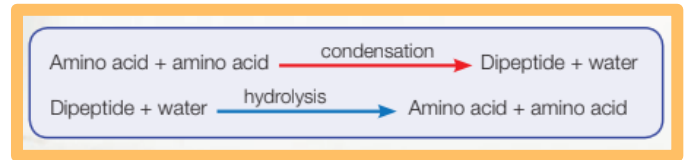
### POLYPEPTIDES

- ◇ Proteins that are composed of **one or more polymers** known as **polypeptides**
- ◇ Each polypeptide is **made up of monomers or small units** known as **amino acids**
- ◇ A polypeptide can consist of **fifty to thousands** of amino acids molecules
- ◇ Amino acids are **linked together** through the **condensation** process

### DIPEPTIDES

- » Dipeptides are composed of **two amino acid molecules** which are **linked together** by a **peptide bond** through the condensation process
- » Involves the **removal** of water molecule
- » Further condensation can link more amino acids to form a polypeptide chain

- » Each dipeptide can be **broken down** into an amino acid through **hydrolysis**



- » There are **20 types** of amino acids present naturally
- » Various type of polypeptide molecules can be formed from 20 types of amino acids
- » This is because each type of protein differs in terms of the amino acid sequence in its polypeptide chain

## Importance of proteins in a cell

- ✚ Build new cells
- ✚ Repair damaged tissues
- ✚ For the synthesis of enzymes, hormones, antibodies and haemoglobin
- ✚ Form building blocks, such as
  - 1) Keratin in the skin
  - 2) Collagen in bones
  - 3) Myosin in muscle tissues
- Δ The **breakdown** of proteins or polypeptides by digestive enzymes gives us the energy to carry out our daily activities
- Δ Polypeptides can **disintegrate** into amino acids then used again to build the protein molecules needed by the body

# CHAPTER 4.4 – LIPIDS

## Lipids

- ❑ Lipids are naturally occurring hydrophobic compounds found in plant and animal tissues
- ❑ Lipid is made up of carbon, hydrogen and oxygen elements with a higher ratio of hydrogen to oxygen atoms
- ❑ Lipids are insoluble in water but soluble in other organic solvents (alcohol, ether, chloroform)

## Types of lipids

There are four types

- Fats
- Waxes
- Phospholipids
- Steroids

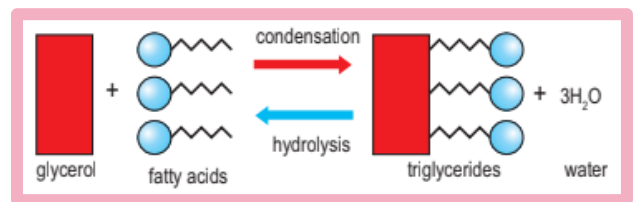
## Fats

### FATS

- Fats and oils are triglycerides
- Triglycerides are a type of ester formed from the condensation of one

glycerol molecule with three molecules of fatty acids

- Triglycerides can be hydrolysed again into fatty acids and glycerol through the reaction of hydrolysis
- Glycerols are a type of three carbon alcohol that contain three hydroxyl groups (-OH)

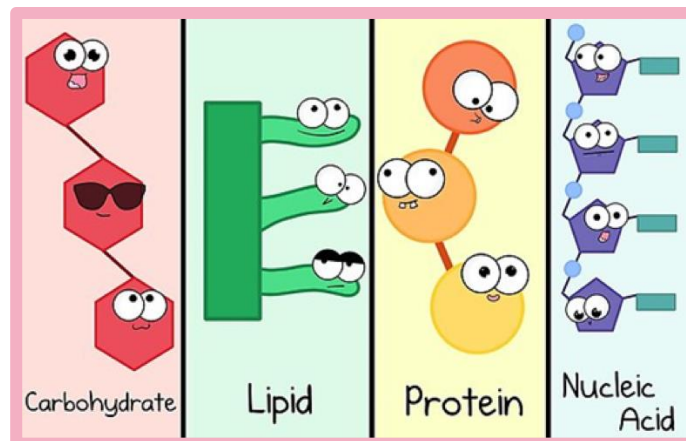


- There are two types of fatty acids
  - I Saturated fatty acids
  - II Unsaturated fatty acids

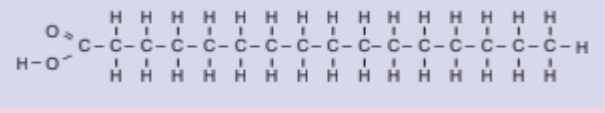
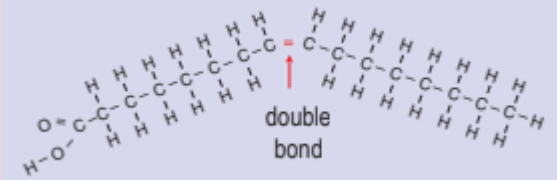
### SATURATED AND UNSATURATED FATTY ACIDS

#### ❖ Similarities

SIMILARITIES	
I	Consist of carbon, hydrogen and oxygen elements
II	Contain glycerol and fatty acids
III	Contain nonpolar molecules



## ❖ Differences

SATURATED FATS	UNSATURATED FATS
Fatty acids only have single bonds between carbon	Fatty acids have at least one double bond between carbon
	
Do not form chemical bonds with additional hydrogen atoms because all bonds between carbon atoms are saturated	Double bonds can still receive one or more additional hydrogen atoms because carbon atoms are unsaturated
Exist in solid form at room temperature	Exist in liquid form at room temperature
e.g., butter and animal fat	e.g., olive and fish oil

## Wax

- Contains **one molecule of alcohol** that **combines with another molecule fatty acid**
- Waterproof**

## Phospholipid

- A **major component** of plasma membranes
- Made up of **one molecule of glycerol** that **combines with two molecules of fatty acid** and **one group of phosphate**

## Steroids

- ✓ Lipids that do **not contain** fatty acids
- ✓ E.g.
  - Cholesterols
  - Testosterone
  - Estrogen
  - Progesterone

## Importance of lipids in cells

### ⊞ Fats

- Function as reserved energy
- Function as a liner to protect internal organs
- Act as a heat instructor

### ⊞ Waxes

- An important component in cuticles that cover the epidermis of leaves and sebum secreted by our skin

### ⊞ Phospholipid

The function of glycolipid

- To ensure the stability of the plasma membrane
- To help in the cell identification process

### ⊞ Steroids

- Cholesterols is important in steroid hormone synthesis

# CHAPTER 4.5 – NUCLEIC ACIDS

## Nucleic acid

- ⊕ Nucleic acids are one or two polymer chains comprising of nucleotide monomers
- ⊕ Formed from the elements of carbon, hydrogen, oxygen, nitrogen and phosphorus
- ⊕ Each nucleotide consists of a pentose sugar (5-carbon sugar), nitrogenous base and phosphate group that combined together through the condensation process
- ⊕ There are two types of pentose sugars
  - » Ribose
  - » Deoxyribose
- ⊕ The nitrogenous base consists of
  - Adenine (A)
  - Guanine (G)
  - Cytosine (C)
  - Thymine (T)
  - Uracil (U)

## Two types of nucleic acids

There are two types of nucleic acids

- ◇ Deoxyribonucleic acid (DNA)
- ◇ Ribonucleic acid (RNA)

### DEOXYRIBONUCLEIC ACID (DNA)

- ✓ DNA consists of two polynucleotide chains that are intertwined in opposite directions and form the double helix
- ✓ The nitrogenous base groups on both polynucleotide chains are matched and bound together by hydrogen bonds
- ✓ The nitrogenous bases for DNA
  - A) Adenine (A)
  - B) Guanine (G)
  - C) Thymine (T)
  - D) Cytosine (C)
- ✓ Adenine will pair with thymine while Guanine will pair with cytosine

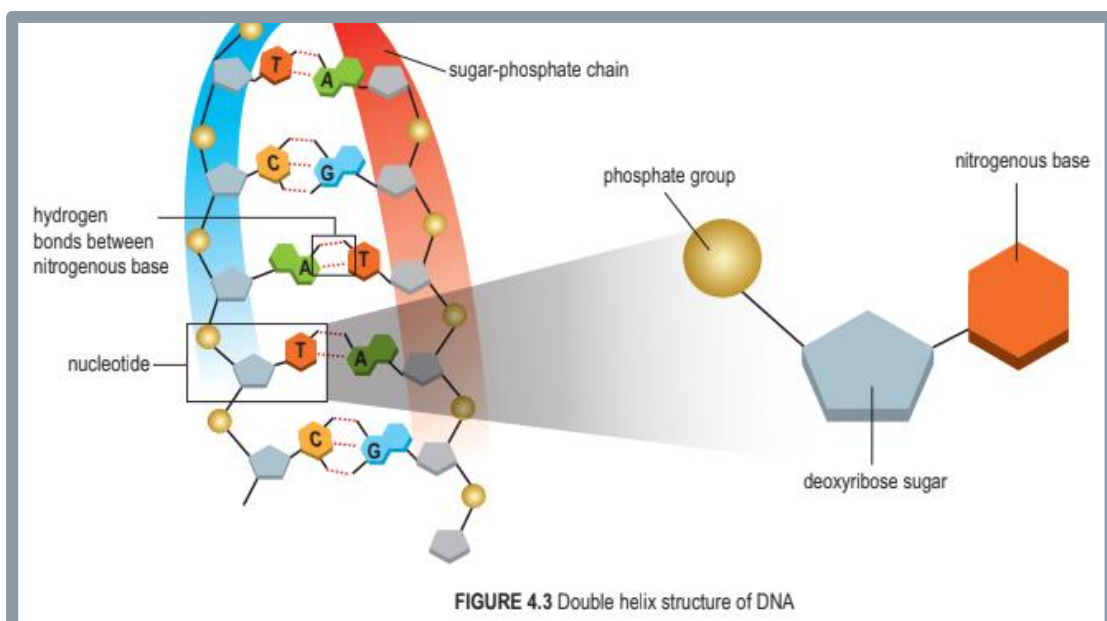
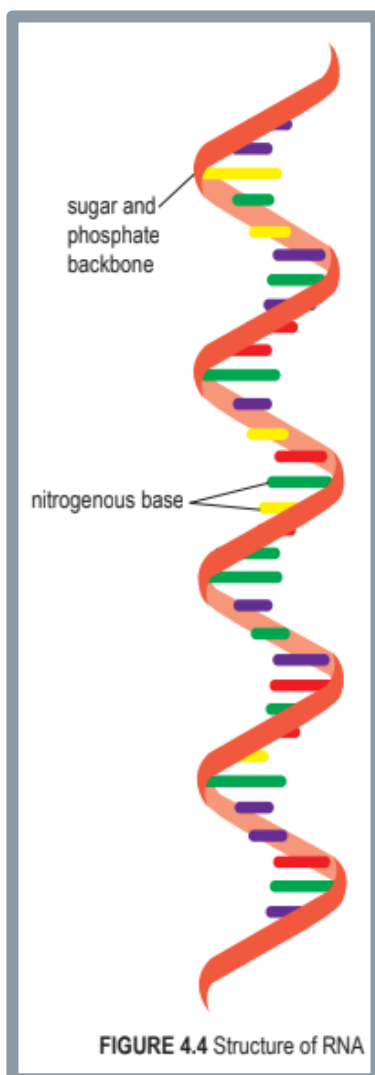


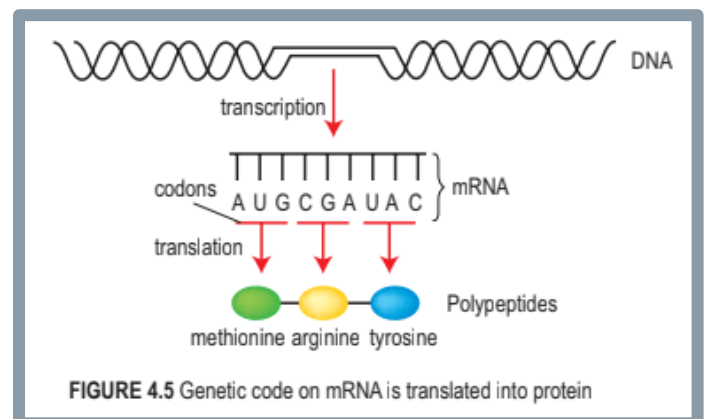
FIGURE 4.3 Double helix structure of DNA

**RIBONUCLEIC ACID (RNA)**

- ✚ The RNA structure is a single polynucleotide chain which is shorter compared to DNA
- ✚ The nitrogenous bases for RNA
  - Δ Adenine (A)
  - Δ Guanine (G)
  - Δ Cytosine (C)
  - Δ Uracil (U)
- ✚ Thymine in DNA is replaced by uracil in RNA
- ✚ There are three main types of RNA
  - Messenger RNA (mRNA)
  - Ribosomal RNA (rRNA)
  - Transfer RNA (tRNA)
- ✚ These three RNAs are involved in the protein synthesis process

**Importance of nucleic acids in a cell**

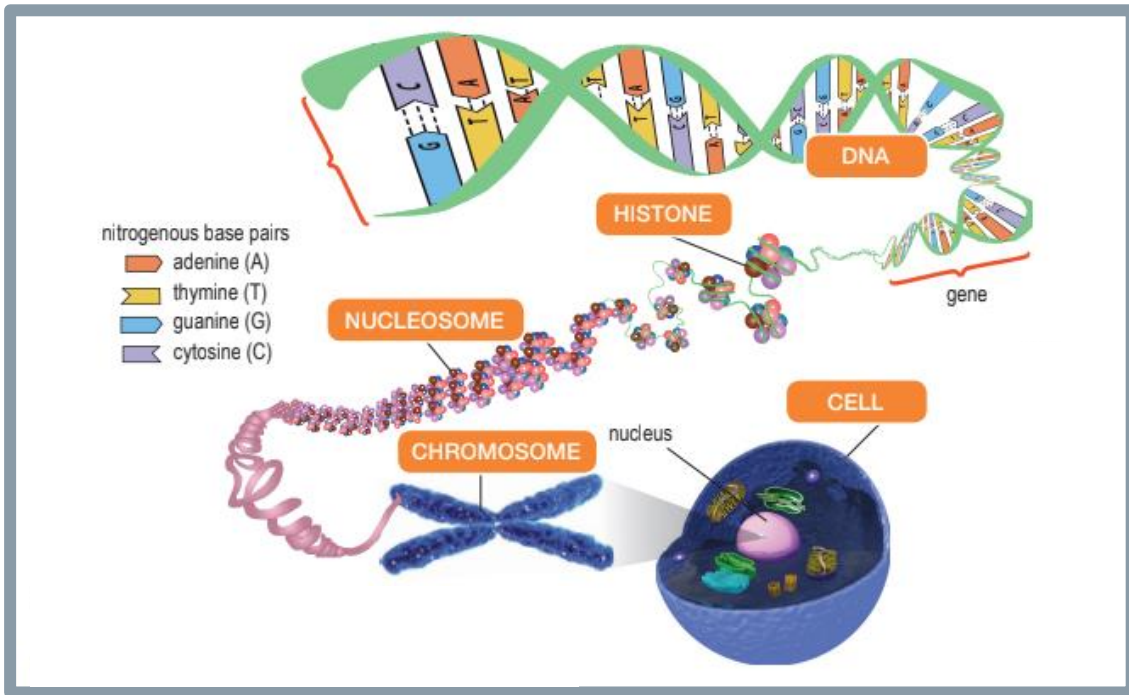
- DNA is important as a carrier of hereditary information and a determinant of characteristics in living organisms
- DNA contains genetic codes carried by nitrogenous bases (A, G, C and T) for the synthesis of polypeptides which form proteins
- The genetic code is written as a series of three bases that determine the sequence of amino acids in proteins to be synthesized
- For example
  - The AUG codon (base sequence: adenine, uracil and guanine) on mRNA is the code for methionine amino acid
- The three-base sequence in DNA is transcribed into mRNA codons which are then translated into amino acid sequence to form a single polypeptide chain
- This means that the sequence of nucleotides in DNA determines the amino acid sequence in the polypeptide chain that builds the corresponding protein



# Formation of chromosomes from DNA and proteins

- Chromosomes are formed from DNA polynucleotide chains that are wound around a protein called histone

- Histones do not carry genetic information
- DNA molecules combine with histone proteins to form nucleosomes
- Nucleosomes are intertwined to form the chromosome structure



## Summary

### CHEMICAL COMPOSITION IN A CELL

