4.1 WATER

PROPERTIES OF WATER AND ITS IMPORTANCE IN A CELL

- Polarity of water
- Cohesive force and adhesive force of water
- Specific heat capacity of water

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 attracted towards oxygen which is more electronegative (δ–).
- This polarity produces hydrogen bonds and allows water to act as a universal solvent
- The universal solvent properties of water allow solutes such as glucose and electrolytes to be transported through the plasma membranes into cells for biochemical reactions.

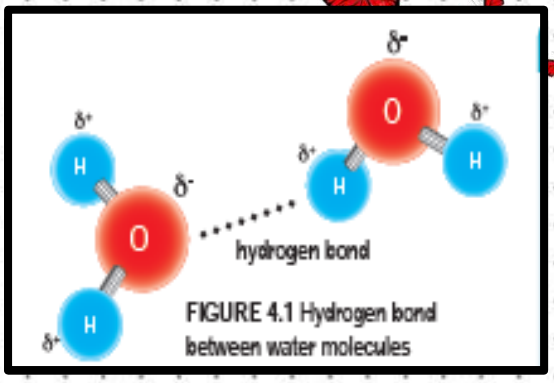
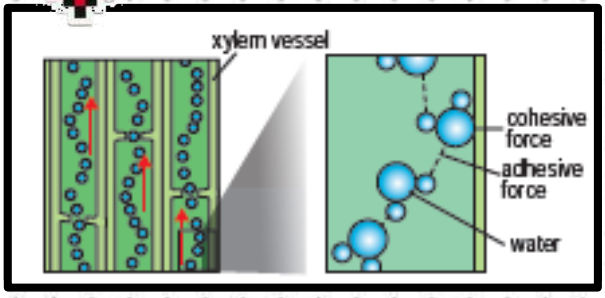


FIGURE 4.1 Hydrogen bond between water molecules

COHESIVE FORCE AND ADHESIVE FORCE OF WATER



- Water molecules are attached to each other through a cohesive force.
- At the same time, water molecules are also attached to other surfaces through adhesive force.
- 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 kJ kg^{-1} $°C^{-1}$.
- This means that 4.2 kJ of heat energy is required to raise the temperature of one kilogram of water by 1°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

4.2 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 Carbohydrates are important as a source of energy and the basic structure of some organisms.
- Carbohydrates are organic compounds consisting of the elements carbon (C), hydrogen (H) and oxygen (O) in the ratio 1:2:1 and with the chemical formula $(CH_2O)_n$

- monosaccharides (simple sugars)
- disaccharides
- polysaccharides (complex sugars)

Types of carbohydrates

MONOSACCHARIDES

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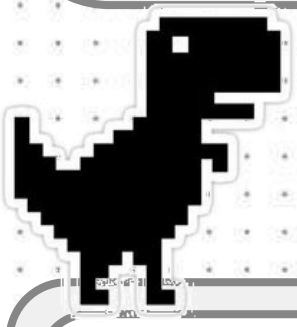
- Monosaccharides are carbohydrate monomers, which are the simplest carbohydrate units.
- Monosaccharides can combine to form polymers through a condensation reaction.
- Most monosaccharides taste sweet, can form crystals and dissolve in water.

EXAMPLES OF MONOSACCHARIDES

- Glucose is a sugar found in plants such as rice and wheat as well as fruits such as grapes.
- Glucose is the most commonly found monosaccharide and most polysaccharides are formed from this sugar.
- Fructose is the sugar found in honey and sweet fruits.
- Galactose is found in milk

- Monosaccharide has the reducing power, which is the ability to [illegible] hydrogen (or electron) to other compounds
- This is called the reducing process.
- When the 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 not soluble in water.
- All monosaccharides give this reaction and it is known as reducing sugars.



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DISACCHARIDES

- Disaccharide molecules are formed when two simple sugar molecules (monosaccharides) combine through condensation to form a disaccharide unit.
- This process involves the removal of a water molecule.

Glucose + glucose —condensation→ Maltose + water

Glucose + fructose —condensation→ Sucrose + water

Glucose + galactose —condensation→ Lactose + water

- Disaccharides can also be broken down to their monosaccharide units through hydrolysis and the addition of one water molecule

Maltose + water —hydrolysis→ Glucose + glucose

Sucrose + water —hydrolysis→ Glucose + fructose

Lactose + water —hydrolysis→ Glucose + galactose

- Sucrose is found in sugar cane, sweet fruits and sugar beet

POLYSACCHARIDES

the darker
the night
the brighter
the stars

- Polysaccharides are sugar polymers consisting of monosaccharide monomers.
- Similar to disaccharides, polysaccharides are formed through the condensation process and involves hundreds of monosaccharides to form long molecular chains.
- Polysaccharides are not soluble in water due to their large molecular size.
- Polysaccharides neither taste sweet nor crystallise
- Polysaccharides can also disintegrate through hydrolysis with the help of dilute acids, boiling and enzyme action.
- Polysaccharides play various roles in organisms.

Importance of carbohydrates in cells

charcoal grey.

- As a source of energy, for example glucose
- as a food reserve, for example glycogen in animal cells and starch in plant cells
- As a support structure, for example cellulose in the plant cell wall

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Cellulose forms the main structure of the plant cell wall.

Glycogen is the main storage of polysaccharide found in muscle cells and animal liver cells.

- Starch is the main storage of polysaccharide in plants.
- Starch is also found in chloroplasts. Source: grains, potatoes and legumes..

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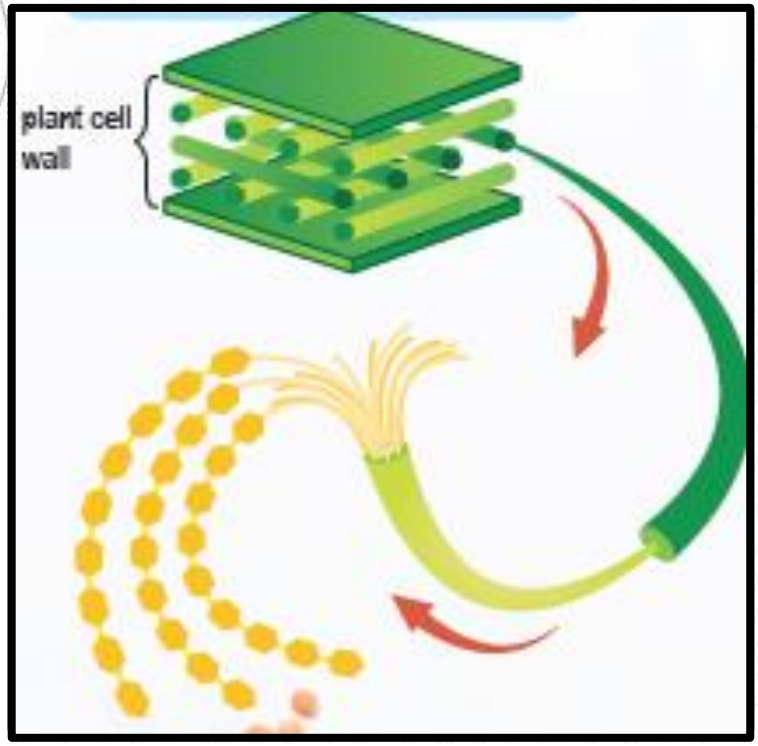

4.3 protein

- Protein is a complex compound composed of carbon, hydrogen, oxygen and nitrogen elements.
- Most proteins also contain sulphur and phosphorus. Foods rich in proteins include fish, meat, milk, beans and eggs. All proteins 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 acid molecules.
- acids are linked together through the condensation process.
- Dipeptides are composed of two amino acid molecules which are linked together by a peptide bond through the condensation process.
- In this process, one water molecule is removed.
- Further condensation can link more amino acids to form a polypeptide chain.

Amino acid + amino acid —condensation→ Dipeptide + water

Dipeptide + water —hydrolysis→ Amino acid + amino acid

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- Each dipeptide can be broken down into an amino acid through hydrolysis. There are about 20 types of amino acids present naturally.
- Various types of polypeptide molecules can be formed from the 20 types of amino acids.
- This is because each type of protein differs in terms of the amino acid sequence in its polypeptide chain.

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IMPORTANCE OF PROTEINS IN A CELL

- Proteins are used to build new cells, repair damaged tissues and for the synthesis of enzymes, hormones, antibodies and haemoglobin
- Proteins also form building blocks such as keratin in the skin, collagen in bones and myosin in muscle tissues
- The breakdown of proteins or polypeptides by digestive enzymes gives us the energy to carry out our daily activities
- PPolypeptides can disintegrate into amino acids.
- This amino acid is then used again to build the protein molecules needed by the body

4.4 LIPIDS

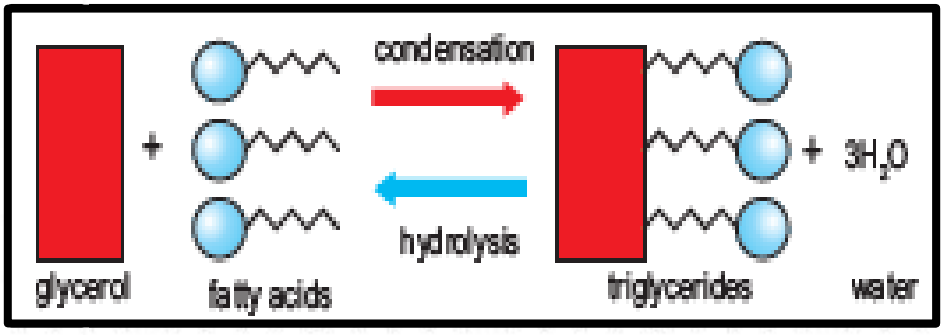
- Lipids are naturally occurring hydrophobic compounds found in plant and animal tissues
- Like carbohydrates, lipid is made up of carbon, hydrogen and oxygen elements but with a much higher ratio of hydrogen atoms to oxygen atoms.
- Lipids are insoluble in water but soluble in other organic solvents, for example, alcohol, ether and chloroform.

TYPES OF LIPIDS

fats, waxes, phospholipids and steroids.

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, namely saturated fatty acids and unsaturated fatty acids

SIMILARITIES

Both consist of carbon, hydrogen and oxygen elements.

Both contain glycerol and fatty acids.

Both contain nonpolar molecules.

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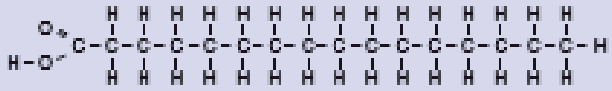
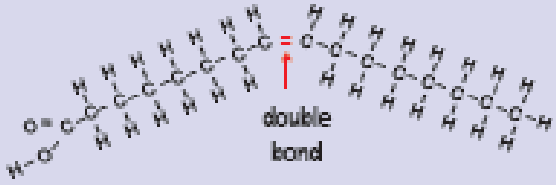
TABLE 4.2 Comparison between saturated fats and unsaturated fats

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.
Source: butter and animal fat	Source: olive and fish oil

WAX

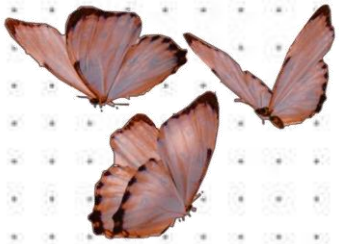
- Wax contains one molecule of alcohol that combines with another molecule of fatty acid and is waterproof.

PHOSPHOLIPID

- Phospholipids are a major component of plasma membranes and are made up of one molecule of glycerol that combines with two molecules of fatty acid and one group of phosphate.

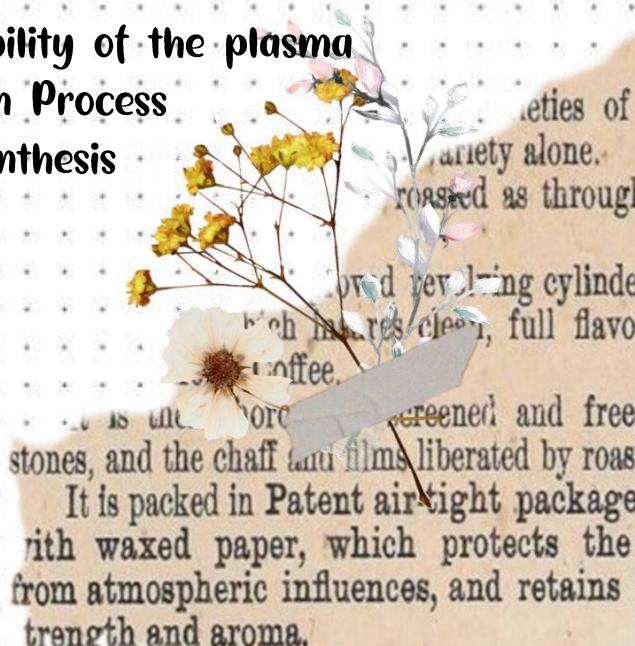
STEROIDS

- Steroids are lipids that do not contain fatty acids. Examples of steroids are cholesterol, testosterone, estrogen and progesterone.



IMPORTANCE OF LIPIDS IN CELLS

- Fats function as reserved energy for animals
- In addition, fats also function as a liner to protect internal organs and act as a heat insulator for animals.
- Waxes are an important component in cuticles that cover the epidermis of leaves and sebum secreted by our skin.
- The function of glycolipid is to ensure the stability of the plasma membrane and to help in the cell identification Process
- Cholesterol is important in steroid hormone synthesis



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4.5 NUCLEIC ACIDS

- Nucleic acids are one or two polymer chains comprising of nucleotide monomers
- Nucleic acids are formed from the elements of carbon, hydrogen, oxygen, nitrogen and phosphorus. Each nucleotide consists of a pentose sugar (5-carbon sugar), a nitrogenous base and a phosphate group that are combined together through the condensation process
- There are two types of pentose sugars, that are, ribose and deoxyribose
- The nitrogenous base consists of adenine (A) guanine (G), cytosine (C), thymine (T) and uracil (U).

TYPES OF NUCLEIC ACIDS

- deoxyribonucleic acid (DNA)
- ribonucleic acid (RNA)

- Ribonucleic acid (RNA) contains ribose sugar while deoxyribonucleic acid (DNA) contains deoxyribose sugar

DEOXYRIBONUCLEIC ACID (DNA)

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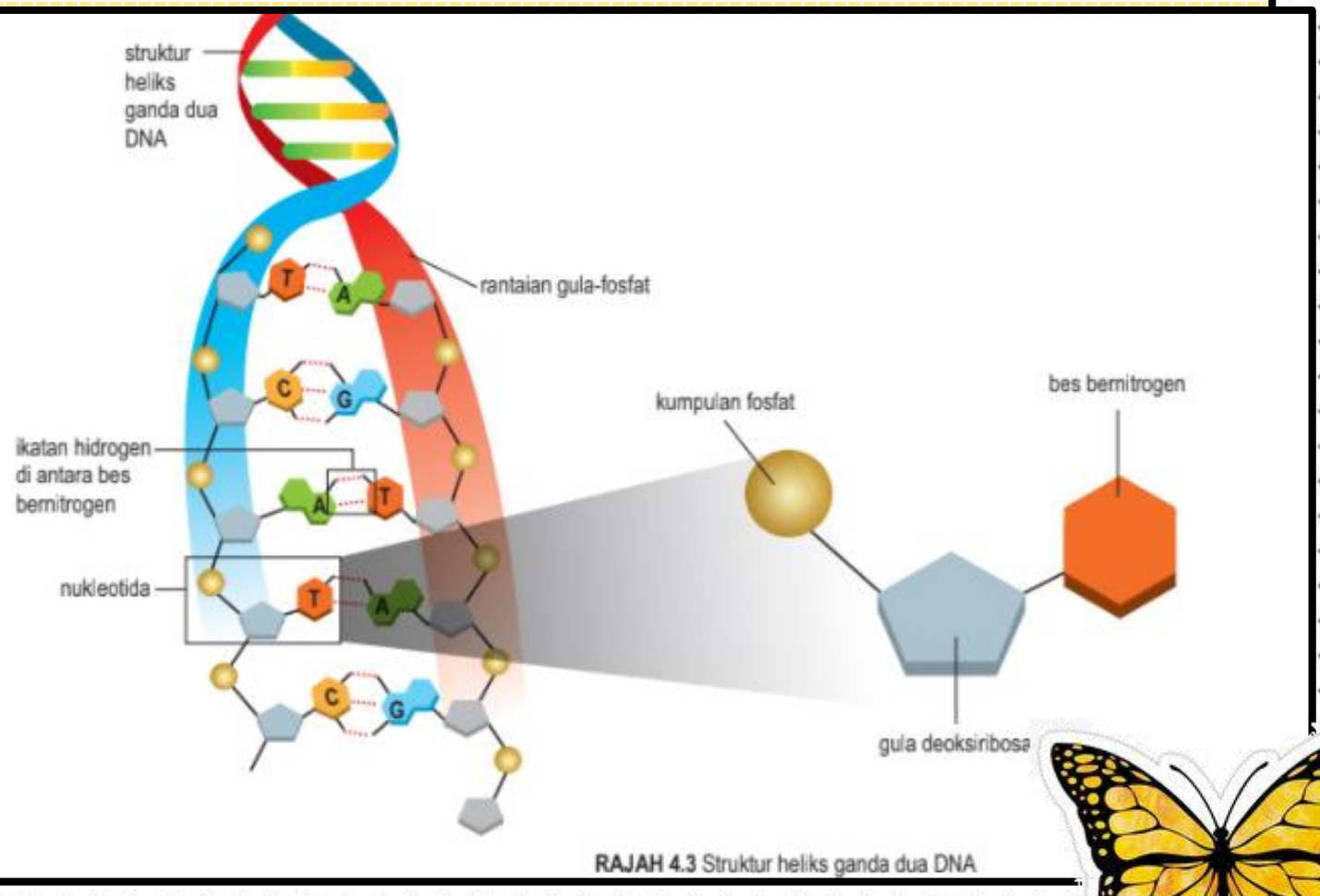
- DNA consists of two polynucleotide chains that are intertwined in opposite directions and form the double Helix
- The nitrogenous base groups on both polynucleotide chains are matched and bound together by hydrogen bonds. The nitrogenous bases for DNA are adenine (A), guanine (G), thymine (T) and cytosine (C).
- Adenine will pair with thymine while guanine will pair with cytosine..



RAJAH 4.3 Struktur heliks ganda dua DNA

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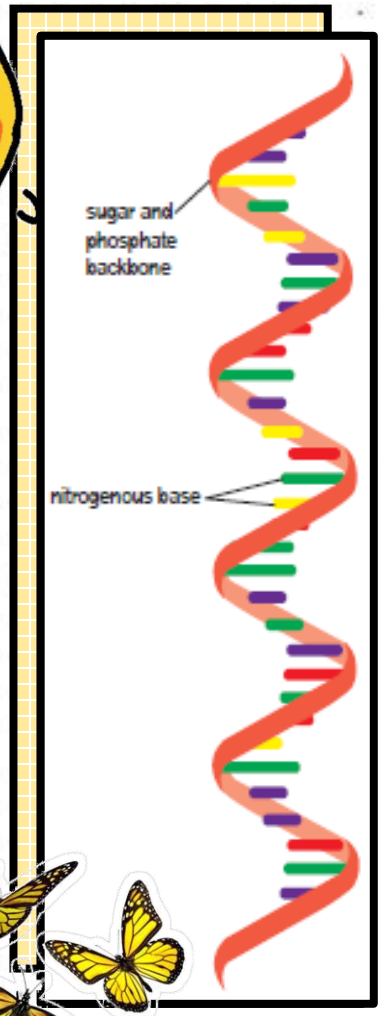
RIBONUCLEIC ACID (RNA)



- The RNA structure is a single polynucleotide chain which is shorter compared to DNA
- The nitrogenous bases for RNA are adenine, guanine, cytosine and
- uracil. Thymine in DNA is replaced by uracil in RNA. The three main types of RNA, are messenger RNA (mRNA), ribosomal RNA (rRNA) and transfer RNA (tRNA).
- three RNAs are involved in the protein synthesis process.

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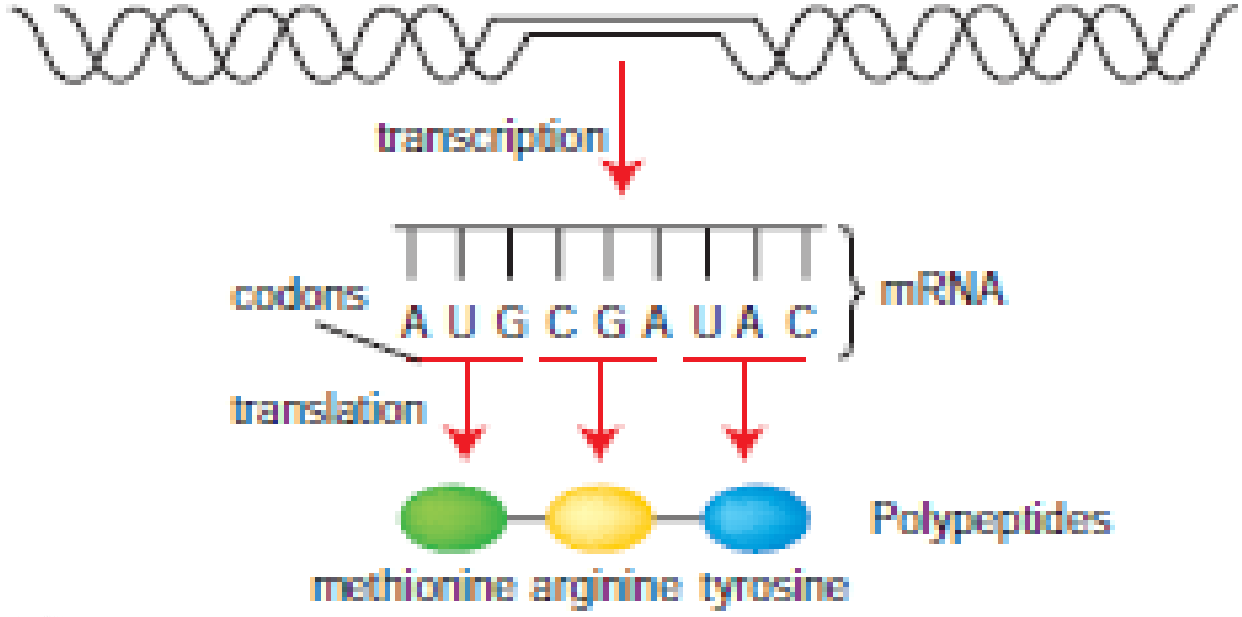
IMPORTANCE OF NUCLEIC ACIDS IN A CELL

- 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 synthesised. 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 the 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



GOOD VIBES

URE 4.5 Genetic code on mRNA is translated into protein

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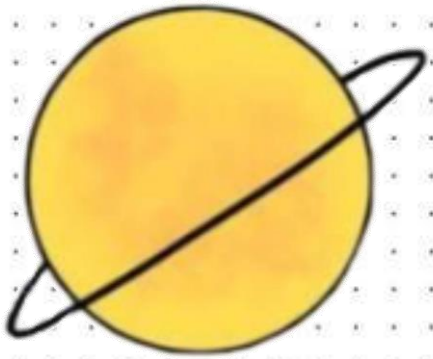
FORMATION OF CHROMOSOMES FROM DNA AND PROTEINS

- Chromosomes are formed from DNA polynucleotide chains that are wound around a protein called histone.
- Chromosomes are formed from DNA polynucleotide chains that are wound around a protein called histone.
- Nucleosomes are intertwined to form the chromosome structure.



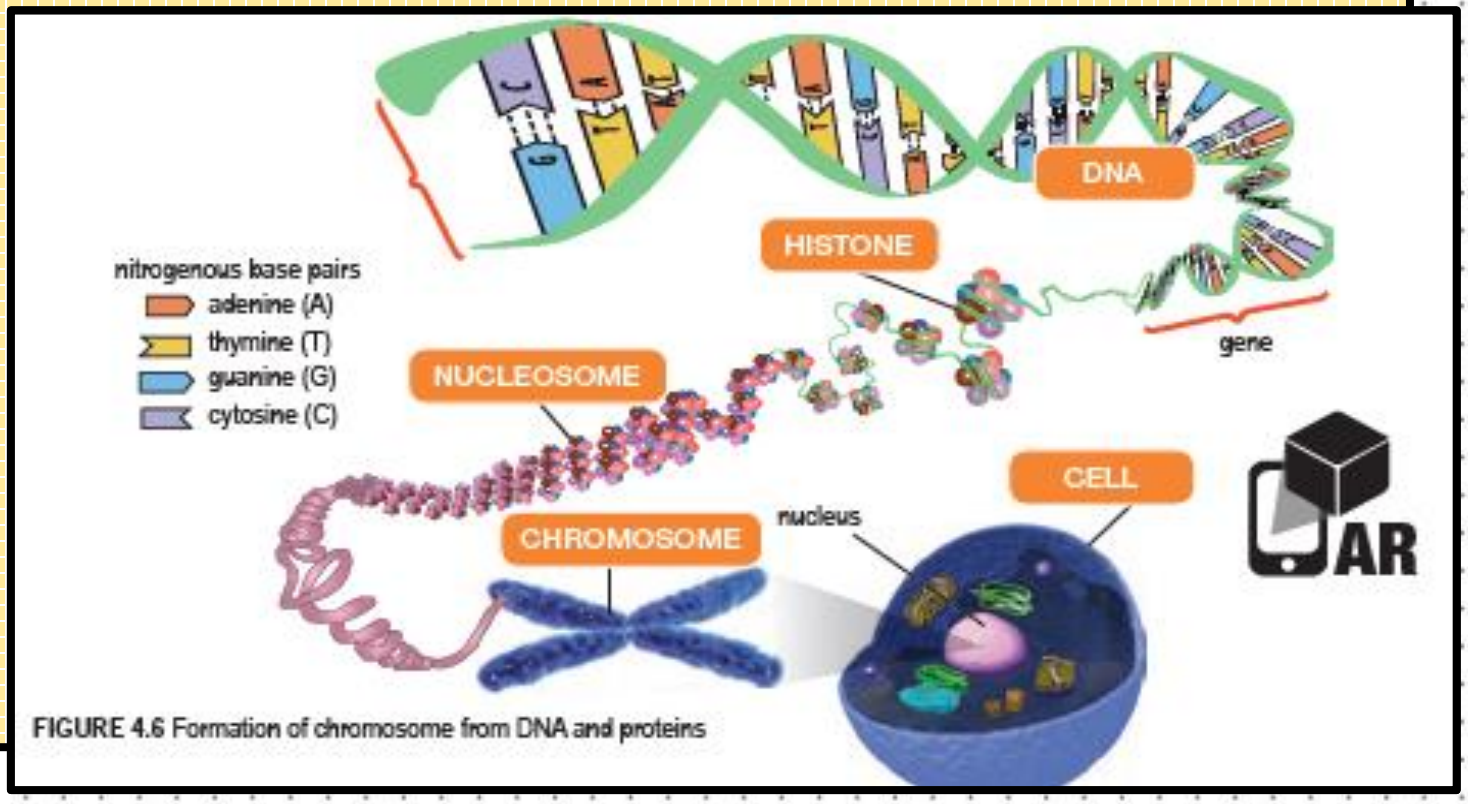


FIGURE 4.6 Formation of chromosome from DNA and proteins

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