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AS Biology

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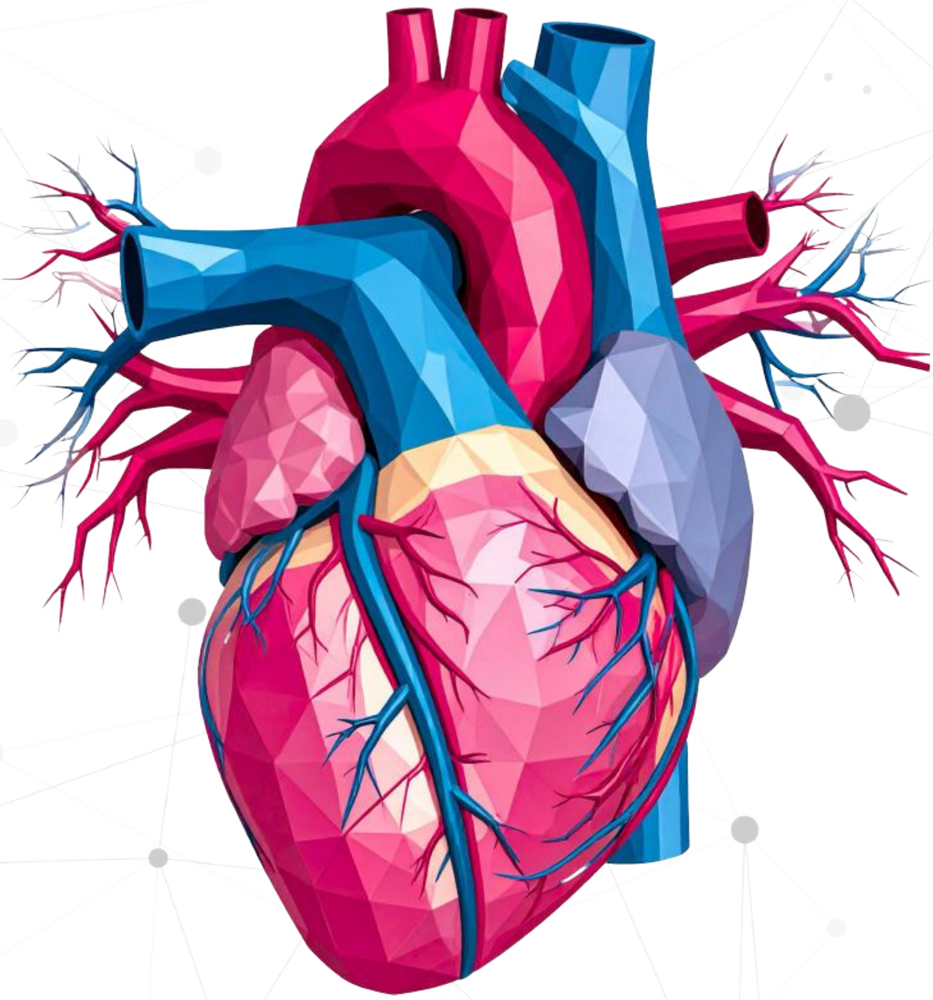

Complete Notes

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How to use this book?

Use the syllabus **checklist** at the end of the book

Build your answers around the **key terms**

Learn the **Practical details** for every unit

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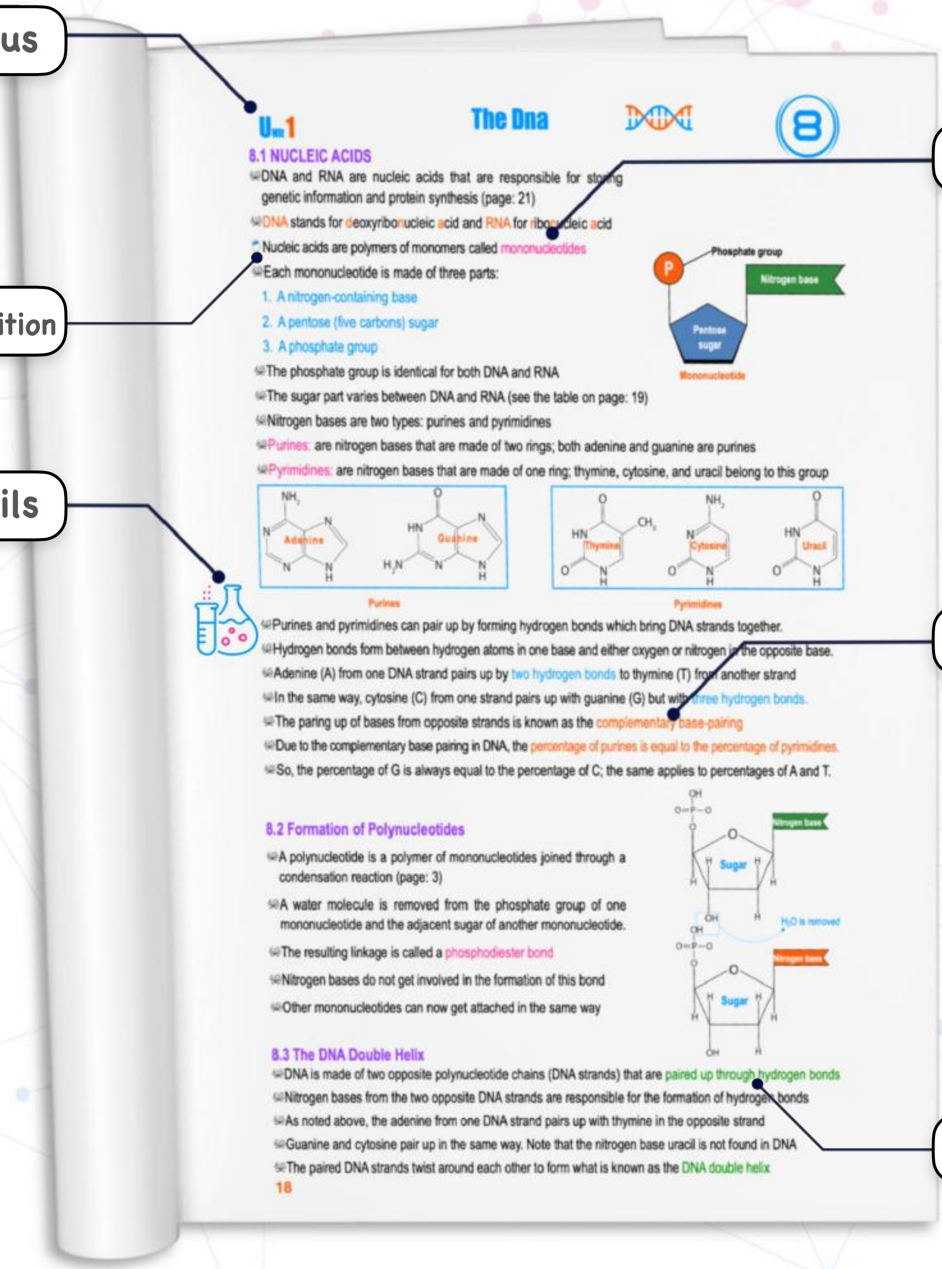

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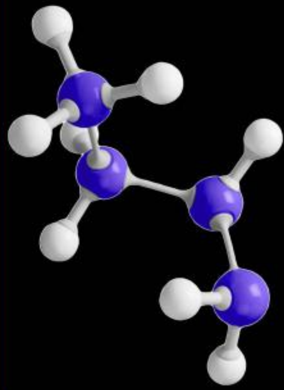

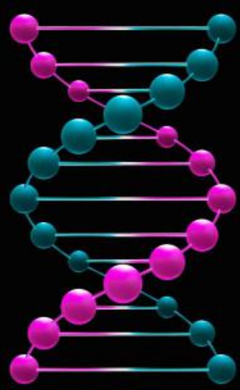

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Unit 1

Water

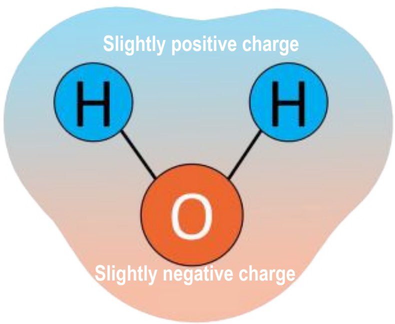
1

1.1 The Dipolar Nature Of Water

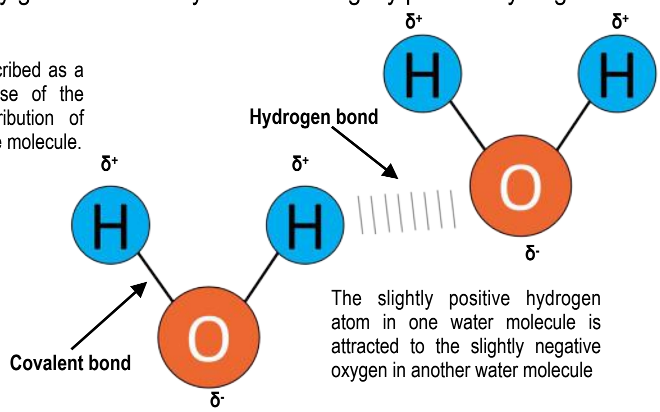
- The water molecule is made of two hydrogen atom linked by an oxygen atom by two covalent bonds
- The shared electrons in the covalent bonds are quite closer to the oxygen atom than the two hydrogen atoms
- As a result, the oxygen is slightly (partially) negative, while the two hydrogens become slightly positive
- These opposite partial charges on each side of the water molecule turn the water molecule into a dipole
- Dipole: refers to the separation of opposite charges within the water molecule

1.2 Hydrogen Bonds

- Water molecules are attracted to each other due to their dipolar nature
- The partially negative (δ-) oxygen atom in one water molecule is attracted to a partially positive (δ+) hydrogen atom in a neighbouring water molecule. These attractions are known as hydrogen bonds
- Hydrogen bonds are weak attraction forces; however, they do affect the properties of different molecules
- Other than water molecules, hydrogen bonds do also exist in DNA, proteins, starch and many other molecules
- Hydrogen bonds must include hydrogen atoms (δ+) attracted to either oxygen or nitrogen atoms in another molecule
- The reason why hydrogen bonds only exist between these specific atoms is that both nitrogen and oxygen atoms tend to be slightly negative (δ-), and they get attracted very well to the slightly positive hydrogen atoms



Water is described as a dipole because of the unequal distribution of charges in the molecule.



The slightly positive hydrogen atom in one water molecule is attracted to the slightly negative oxygen in another water molecule

1.3 Importance Of Water In Transport

- The dipolar nature of water and its ability to form hydrogen bonds explain all the unique properties of water:

a. Water is the transport medium in all organisms (such as blood), and this can be attributed to these properties:
   1. Water is a good solvent for charged (like salts) and polar molecules (like glucose)
   2. Water is a liquid over a large temperature range which can be explained by two characteristics:
      i. Water has a high latent heat of evaporation: a large amount of heat energy is needed for water molecules to turn from the liquid state to the gas state
      ii. Water has a high specific heat capacity: lots of heat energy is needed to raise the temperature of the water. This means that the temperature in water remains relatively stable despite the significant changes in the temperature of the surrounding environment

b. Water is necessary for the breaking down (hydrolysis, page 3) of covalent bonds during digestion

c. Water assists the mass flow of fluids: mass flow is the movement of fluids in one direction down a pressure gradient (from high to low pressure). The circulation of blood is a good example of mass flow (page: 25)

   Two essential properties of water help mass flow happen:

   i. Water is cohesive: water molecules stick to each other due to hydrogen bonds
   ii. Water is adhesive: hydrogen bonds allow water to get attracted to the vessels where it is flowing through

1.4 Solubility In Water

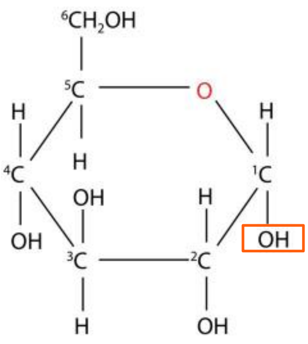
- Polar molecules can be either fully charged like ionic compounds (salts) or partially charged like sugars.
- Polar molecules dissolve well in water because water surrounds these molecules and forms bonds with them.
- Non-polar molecules are usually hydrocarbons (made up of carbon and hydrogen only). They are described as being hydrophobic. Hydrocarbons do not dissolve in water because they cannot form bonds with it.
- Size also plays an essential role in solubility; smaller molecules are more likely to dissolve than larger ones.

Carbohydrates

2

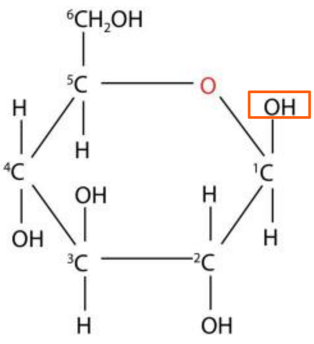
2.1 Monosaccharides

- Monosaccharides: simple sugars that are made up of one single unit
- Both monosaccharides and disaccharides are soluble in water because they can form hydrogen bonds with it
- The general formula of all monosaccharides is $C_nH_{2n}O_n$, where "*n*" is the number of carbons in the molecule
- This ratio of 1:2:1 for C:H:O is unique for all monosaccharides
- Based on the number of carbons, monosaccharides are classified into two major groups:
  a. Pentoses: monosaccharides with five carbon atoms such as ribose (see page: 17)
  b. Hexoses: monosaccharides with six carbon atoms, such as glucose
- Glucose has two forms (alpha and beta) that are different by the position of the (-OH) on carbon number 1



The OH group on carbon number 1 is pointing down

Alpha glucose



The OH group on carbon number 1 is pointing up

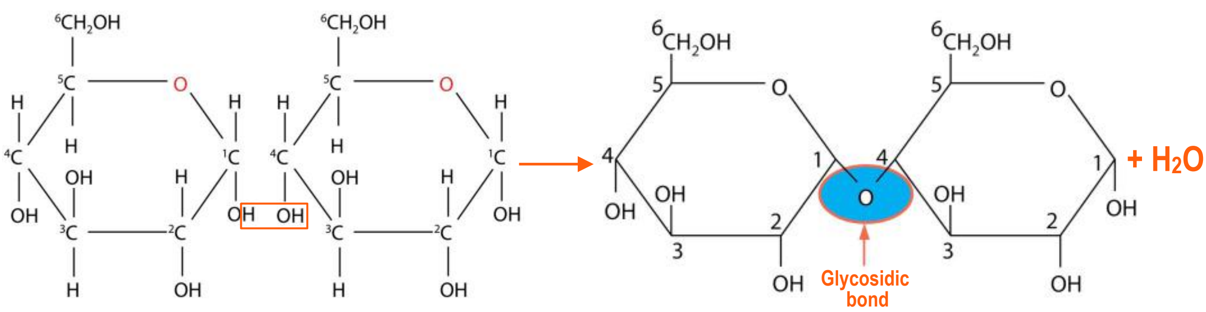
Beta glucose

- Glucose has two major functions in living organisms:
  a. It is used as a source of energy for respiration
  b. Glucose is the building block of disaccharides and polysaccharides (see below)

2.2 Disaccharides

- Disaccharides: sugars that are made of two monosaccharides joined through a condensation reaction
- Condensation: a reaction in which two molecules join by the removal of a water molecule
- Glycosidic bond: a covalent bond that forms as a result of condensation reaction in carbohydrates
- Glycosidic bonds are named based on the position of the bond (number of the carbon) and the type of glucose.
- For instance, the glucosidic bond in the diagram below is named: *alpha 1,4 glycosidic.*
- Different monosaccharides join to produce different types of disaccharides:

1. Glucose + Fructose → Sucrose (found in plants)
2. Glucose + Galactose → Lactose (present in cow's milk)
3. Glucose + Glucose → Maltose (product of starch digestion)



Alpha glucose + Alpha glucose → Maltose

Carbohydrate	Monosaccharides	Disaccharides
Common features	Both are soluble and made up of carbon, hydrogen and oxygen	
Number of units	One	Two
Ratio	The ratio of carbon:hydrogen: oxygen is 1:2:1	This ratio does not apply here
Glycosidic bond	Not present	Present

2.3 Condensation And Hydrolysis

Hydrolysis is the opposite chemical reaction to condensation; these reactions are different in many ways:

Reaction	Condensation	Hydrolysis
Definition	Synthesis of a large molecule by the joining of simpler molecules and the removal of water	Breaking down of a larger molecule by the addition of water
Reactant(s)	Smaller molecules (monomers)	Larger molecule (polymer)
Product(s)	Larger molecule (polymer)	Smaller molecules (monomers)
Bonds	Formed	Broken
Example	Synthesis of starch from glucose molecules	Digestion of starch to produce alpha glucose

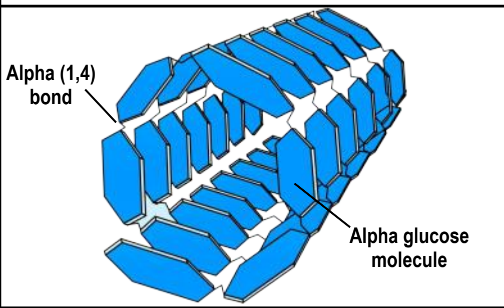
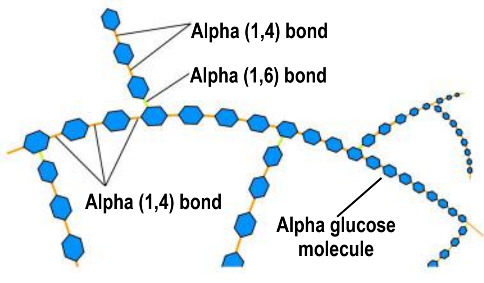
2.4 Polysaccharides

Polysaccharides: large carbohydrates (polymer) that are made up of simpler units of monosaccharides (usually glucose) joined by glycosidic bonds

Unlike monosaccharides and disaccharides, polysaccharides are insoluble in water and do not taste sweet.

There are two types of polysaccharides that need to be covered here:

1. Starch: a polymer of alpha glucose that is used as energy storage in plants; starch is a mixture of two substances: amylose and amylopectin; these two components of starch are different in many ways:

Substance	Amylose	Amylopectin
Monomer	Alpha glucose	
Shape	Coiled due to hydrogen bonds but unbranched	Branched
Bonds	Only alpha (1,4) glycosidic	Alpha (1,4) on the main chain Alpha (1,6) glycosidic at the branches
Diagram		

2. Glycogen is a polymer of alpha glucose used for energy storage in mammals; unlike starch, glycogen is made only of one part that is quite very similar to amylopectin. Glycogen is a branched molecule with chains linked by alpha 1,4 and 1,6 bonds. Glycogen is actually more branched than amylopectin.

Carbohydrate	Starch	Glycogen
Common feature	Both are alpha glucose polysaccharides that serve as energy storage	
Where is it found	In plants	In animals and some bacteria
Overall shape	Both helical (amylose) and branched (amylopectin)	Only branched
Branching	Less branched	More branched

2.5 Structure Of Polysaccharides Is Related To Their Function

The structure of starch and glycogen is largely related to their function as energy storage in many ways:

Property	How does this property relate to the function?
Compact	Amylose in starch has a helical shape which makes it compact so that more glucose molecules (and therefore more energy content) can be stored in less space inside the cell
Branched	Both amylopectin of starch and glycogen are branched which enables many glucose molecules to be broken down at the same time (hydrolysed) from several points
Insoluble	Polysaccharides do not dissolve in water, and therefore they don't affect the osmotic pressure (concentration of solutes) inside the cell (see osmosis on page: 15)
Large	Polysaccharides are too large to diffuse out of the cells