UNIT 2 Molecules and Membranes

Timing This unit comprises approximately 20% of the learning material in AS Biology, and about 10% of the learning material in a complete Biology A Level learning programme.

Recommended Prior Knowledge Students will need some background knowledge in chemistry before embarking on this Unit. They should understand the terms 'atom', 'molecule' 'electron' and 'ion'. They should also have a basic understanding of covalent and ionic bonding, and of molecular and structural formulae. They should be able to write and understand simple chemical equations. Some knowledge of energy changes (potential energy and bond energy) would be helpful. They should understand the kinetic theory, and be able to use it to explain diffusion in solutions.

Context This Unit could be studied either before or after Unit 1, Cells and Cell Division. It provides essential material that students will constantly refer to when studying all future Units in their AS course. An understanding of the structure, roles and behaviour of biological molecules is fundamental to an understanding of all physiological processes, as well as genetics and some aspects of ecology.
>
Outline The Unit begins with the properties and roles of water in relation to living organisms; this introduces the concepts of hydrogen bonding and solubility, which will be needed in order to understand the properties of biological molecules. Three of the main groups of biological molecules - carbohydrates, fats and proteins - are studied, with an emphasis on relating their molecular structures to their properties and functions in living organisms. This leads on to an understanding of the structure and functions of biological membranes.
There are good opportunities within this Unit for students to develop their practical skills relating to Assessment Objectives in Group C (Experimental skills and investigations) including the design and evaluation of their own investigations. Try to ensure that each student works alone and under time pressure on some occasions, as this will help to prepare for the practical examination(s).

Note: the structure and function of polynucleotides (DNA and RNA) is covered in a later Unit.

Reinforcement and formative assessment It is recommended that, towards the end of the time allocated to the unit, time be taken to permit reinforcement of the learning that has occurred. This might take the form of structured revision and questions, perhaps making use of online question banks such as http://www.learncie.org.uk/ or http://exam.net/public/misc/pub_home.asp .

Formative assessment could take the form of student self-marked minitests, taking just 10 or 15 minutes for students to do and then mark for themselves, perhaps using questions from the banks above – discussing the correct answers as a whole class. At the end of the unit, there should be a much larger formative assessment test, using appropriate past-examination and similar style questions, taking a lesson to do, and a lesson to provide feedback after marking by the teacher., taking a lesson to do, and a lesson to provide feedback after marking by the teacher.

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
		Before beginning this Unit, it is recommended that you check the background knowledge of students, as described in 'Recommended Prior Knowledge' at the beginning of this Unit.	http://old.jccc.net/~pdecell/chemistry/chemtext.html is an excellent online basic chemistry tutorial designed for biologists	*Advanced Biology*, Jones and Jones, CUP, has an Appendix covering the basic chemistry required for this Unit.

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
B(i)	describe and explain the roles of water in living organisms and as an environment for organisms **Learning Activities** – question and answer session / whole class discussion – looking up key terms in the index of a variety of Biology books – brief written and diagrammatic explanation of polar/non-polar and hydrogen bonding and its importance	The way in which you deal with this topic should be tailored to the background of your students. Those with a strong chemistry background are likely to have little trouble with understanding the concepts involved, while others may find this very difficult and will need a slow and steady approach that keeps things as simple as possible. It is a good idea to make cross-references to other areas of biology, such as cell biology, during this section so that students gain a wide perspective on the roles of the biochemicals they study in this Section/Unit. You should aim to give students a sound but simple description of hydrogen bonding, and use this to explain why water has a relatively high boiling point, high specific heat capacity, high surface tension and high latent heat of vaporisation. Its solvent properties should also be discussed - this will help to explain the solubility or otherwise of the biological molecules to be dealt with later in this Unit. Each of these properties can be related to the roles of water within living organisms and as an environment for them.	http://people.pwf.cam.ac.uk/mjas2/Documents/BYB_Water.pdf has information about the range of functions of water in a text document http://www.farmweb.au.com/h2o/h2life.html has an interesting series of articles and other extension materials suitable for interested students	The properties of water are fully described and explained in *Biological Sciences*, ed Soper, CUP and in *Advanced Biology*, Jones and Jones, CUP. *Biology*, Jones. Fosbery, Taylor and Gregory, gives a briefer treatment of this topic. *Biofactsheet 30: The biological importance of water* *Biofactsheet 78: Chemical bonding in biological molecules*

		A discussion on hydrogen bonding could be extended to highlight its important in protein structure and DNA. Emphasise role of water as important solvent in biological systems - introduce concept of ‘polar’ and ‘non-polar’ here.		

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
B(b) (c)	describe the ring forms of alpha and beta glucose describe the formation and breakage of a glycosidic bond **Learning activities** – making and using molecular models (there are some inexpensive drinking straw based models as well as plastic sphere / bond models) – numbering the atoms on existing drawings of glucose molecules, and completing incomplete diagrams by adding OH and H groups – practising drawing α and β glucose with all the atoms, and omitting the carbon atoms, as well as diagrams summarising glycosidic bond formation (e.g. to form maltose)	All students will be familiar with the term 'carbohydrate', but are likely to know little about their molecular structure. Glucose is used here as an example of a monosaccharide; an understanding of its alpha and beta forms will be needed in order to understand polysaccharide properties later. An explanation of how a glycosidic bond forms and can be broken can lead to an understanding of the terms 'monosaccharide' and 'disaccharide' - note that these terms are not required by the syllabus, but may be useful to candidates nevertheless. This also introduces the terms 'condensation' and 'hydrolysis' for the first time. If you have access to molecular modelling materials, students may enjoy and learn from making models of glucose molecules and their combination to form maltose.	It is possible to view models of molecules on line at Botany on-line: http://www.biologie.uni-hamburg.de/b-online/e00/contents.htm	Molecular models are available from suppliers, such as Philip Harris *Biology*, Jones, Fosbery, Taylor and Gregory, like other texts, uses diagrams to illustrate these structures and processes

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
B(a)	carry out tests for reducing and non-reducing sugars (including semi-quantitative use of the Benedict's test) **Learning activities** – use Benedict's test on water, pure glucose, fructose, maltose, lactose, sucrose, protein solutions, starch suspension, and vegetable oil – use Benedict's test on a range of natural biological materials (e.g. fruits, tubers) – use Benedict's test on water, and on solutions containing sucrose, before and after hydrolysis in hot acid and neutralisation – describe the tests made and the results obtained – use qualitative Benedict's solution in a semi-quantitative way to determine the approximate concentration of glucose in some solutions by colour or by mass of precipitate	I would suggest carrying out these tests on solutions of different sugars first to identify reducing and non-reducing sugars. I would not call them 'food tests'. Students could first carry out the Benedict's test for reducing sugars on a range of food substances; this will be revision for most of them. You could then explain to them that this test does not work for sucrose (the only non-reducing sugar they will come across) and ask them to suggest how they might be able to adapt the test to test for sucrose - encourage them to draw on their knowledge of glycosidic bonds - before carrying out this test on a sucrose solution. Recommend using AR sucrose, not LR or cane sugar. You could then set them the task of determining which of three solutions contain glucose only, sucrose only and a mixture of both sugars. It is well worth giving them the opportunity to work this out for themselves. Practical work should also include determining the approximate concentration of an unknown glucose solution. Students will first need to carry out the Benedict's test (controlling all variables) on a range of solutions of known concentration, and then compare	http://jchemed.chem.wisc.edu/JCESoft/CCA/CCA5/MAIN/1ORGANIC/ORG18/TRAM18/B/MENU.HTM has illustrations of simple benedict's test, including negative test for sucrose before hydrolysis. http://www.mrothery.co.uk/module1/Mod%201%20techniques.htm gives a straightforward description of benedict's test for reducing and non-reducing sugars. http://www.mrothery.co.uk/bio_web_prac/practicals/2Food%20Tests.doc has clear protocols http://www.biotopics.co.uk/as/cho.html protocol including tests for reducing and non reducing sugars, and some points to ponder - maybe a useful starting point.	*Practical Advanced Biology*, King and Reiss, describes these techniques (though not the semi-quantitative tests). *Comprehensive Practical Biology*, includes a protocol that describes a semi-quantitative test. See also *Biological Science*, ed Soper, pub. CUP. *Advanced Biology principles and applications. Study Guide* Clegg and Mackean, and *Biology*, Jones, Fosbery, Taylor and Gregory, also describes suitable ways of carrying out these tests.

		the depth of colour or the mass of precipitate obtained when testing the unknown.		

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
(d)	describe the molecular structure of starch (amylose and amylopectin), glycogen and cellulose and relate these structures to their functions in living organisms **Learning activities** – get students to handle strings of beads on wire or to join hands and pretend to be 'long, strong chains of β glucose residues' (cellulose), 'compact, energetic spirals of α glucose residues' (amylose), and 'compact, branched, amorphous, energetic shapes of α glucose residues' (amylopectin and glycogen) – the concrete experiences help to learn a difficult abstract idea – make brief written and diagrammatic explanations of the relationship between structure and function	Build on the students' understanding of hydrogen bonding, covered in B(i), to explain how these molecules are held in shape. Explain advantage of branching of amylopectin in providing large number of 'ends' to attach and detach glucose units	http://chemed.chem.purdue.edu/genchem/topicreview/bp/1biochem/carbo5.html has a comprehensive review of carbohydrate structure and function, useful as a source of extension materials http://www.calfnotes.com/pdffiles/CN102.pdf material on the structure and function of these polysaccharides in the context of calf nutrition.	Most AS and A level textbooks cover this material thoroughly. *Biofactsheet 39: Carbohydrates: revision summary* *Biology*, Jones, Fosbery, Taylor and Gregory, like other texts, uses diagrams to relate these structures to their functions

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
B(e)	describe the molecular structure of a triglyceride and a phospholipid and relate these structures to their functions in living organisms **Learning activities** – make very simple paper cut out models of triglycerides to illustrate the non-polar exposed fatty acids, and phospholipids to show the very different ends of the molecule. – the cut out phospholipids can be laid out side by side to form a bilayer (keep the paper models for use in D(a)) – examine diagrams of triglycerides, describing evidence that makes them good energy stores (lots of carbon-carbon bonds, highly reduced so energy can be released by oxidation, insoluble in water so can be localised in the organism)	The insolubility of triglycerides, and the behaviour of phospholipids when in contact with watery liquids, should be related to the absence or presence of polar groups; once again, you should refer back to the earlier work on water to help to explain this. It is suggested that you do not go into any detail about saturated and unsaturated fatty acids. You may like to describe the formation of bilayers by phospholipids at this stage, or to deal with this later, in topic D(a). Students should be able to describe a range of functions of lipids in organisms, relating each of these functions to their molecular structure.	http://ntri.tamuk.edu/cell/lipid.html has a nice illustrated review, useful as a source of material	*Biofactsheet 42: The structure and function of lipids* *Biofactsheet 74: The structure and biological functions of lipids* *Biology*, Jones, Fosbery, Taylor and Gregory, like other texts, uses diagrams to relate these structures to their functions

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
B(a)	carry out the emulsion test for lipids **Learning activities** – use the ethanol emulsion test with vegetable oil and yellow-dyed water – use the ethanol emulsion test with crushed fruits and seeds	Students may already know this test from earlier work. They can now use it to investigate the occurrence of lipids in a selection of fruits and seeds.	http://www.mrothery.co.uk/bio_web_prac/practicals/2Food%20Tests.doc has clear protocols including this one.	*Practical Advanced Biology*, King and Reiss, and *Comprehensive Practical Biology* Siddiqui and *Biology*, Jones, Fosbery, Taylor and Gregory include suitable tests.

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
B(f) (g) (h)	describe the structure of an amino acid and the formation and breakage of a peptide bond; explain the meaning of the terms *primary structure*, *secondary structure*, *tertiary structure* and *quaternary structure* of proteins and describe the types of bonding (hydrogen, ionic, disulphide and hydrophobic interactions) that hold the molecule in shape; describe the molecular structure of haemoglobin as an example of a globular protein, and of collagen as an example of a fibrous protein and relate these structures to their functions **Learning activities** – examine diagrams of typical amino acid and simple amino acids, to identify the R group and the part common to them all, as well as the amine group and carboxylic acid group – draw simple diagrams of the structure of a typical amino acid, and to show condensation and hydrolysis of peptide bonds – question and answer / whole group discussion followed by written and diagrammatic explanation of protein structure	Students do not need to know the structures of different amino acids, but they do need to understand that the R (residual) group can take many different forms. There is no need to go into any detail at all about how individual amino acids behave in solution; the behaviour of terminal amine and carboxyl groups in a protein molecule is of little importance compared with the behaviour of the R groups. You could teach the various levels of protein structure with reference to haemoglobin. Its globular shape and solubility (which can be related to the positions of polar R groups on the outside of the coiled molecule) are typical of metabolically active proteins. The structure and function of collagen can be contrasted with this. Note: students often think that to have quaternary structure proteins must be composed of 4 polypeptides.	http://www.bbc.co.uk/education/asguru/biology/02biologicalmolecules/01proteins/index.shtml The BBC AS Guru web site has interactive animations of the formation and breakage of peptide bonds.	The molecular structure and functions of haemoglobin and collagen are thoroughly covered in *Biology*, Jones, Fosbery, Taylor and Gregory. If you wanted to take this work further, the use of paper chromatography to analyse the amino acids in albumen is described in *Practical Advanced Biology*, King et al, and in *Comprehensive Practical Biology*, Siddiqui. *Advanced Biology principles and applications. Study Guide* Clegg and Mackean also describes a method for analysing amino acids using chromatography *Biofactsheet 80: Structure and biological functions of proteins.*

	and the role of bonding in determining shape and stability. – individual students or pairs to make an A4 poster showing the role of one kind of bonding in one level of protein structure, so that the whole group covers all types of bonding and all levels of structure			

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
B(a)	carry out the biuret test for proteins **Learning activities** – Use the biuret test on a solution of egg white, skimmed milk, chicken or tofu and water	Students are likely to have come across this test already, from earlier work. They need this learning reinforced, and they need any confusions corrected.	http://www.mrothery.co.uk/bio_web_prac/practicals/2Food%20Tests.doc has clear protocols including this one.	*Advanced Biology principles and applications. Study Guide* Clegg and Mackean has a flow chart to show how the different tests, such as the biuret test, can be used to identify unknown substances or substances in a mixture. *Practical Advanced Biology*, King and Reiss, and *Comprehensive Practical Biology* Siddiqui and *Biology*, Jones, Fosbery, Taylor and Gregory include suitable protocols for this test.