Qualification Accredited

Oxford Cambridge and RSA

AS and A LEVEL

Delivery Guide

BIOLOGY A

H020/H420
For first teaching in 2015

Biological Molecules 2.1.2

Version 2

Introduction

AS and A LEVEL
BIOLOGY A

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resources.feedback@ocr.org.uk

Would you prefer a Word version?

Did you know that you can save this pdf as a Word file using Acrobat Professional?

Simply click on **File** > **Export to** and select **Microsoft Word**

(If you have opened this PDF in your browser you will need to save it first. Simply right click anywhere on the page and select ***Save as . . .*** to save the PDF. Then open the PDF in Acrobat Professional.)

If you do not have access to Acrobat Professional there are a number of **free** applications available that will also convert PDF to Word (search for *pdf to word* converter).

We value your feedback

We'd like to know your view on the resources we produce. By clicking on the icon above you will help us to ensure that our resources work for you.

2.1.2 Biological molecules

		Where appropriate, this section should include diagrams to represent molecular structure and bonding.
(a)	how hydrogen bonding occurs between water molecules, and relate this, and other properties of water, to the roles of water for living organisms	A range of roles that relate to the properties of water, including solvent, transport medium, coolant and as a habitat **AND** roles illustrated using examples of prokaryotes and eukaryotes. HSW2, HSW8
(b)	the concept of monomers and polymers and the importance of condensation and hydrolysis reactions in a range of biological molecules	
(c)	the chemical elements that make up biological molecules	To include: C, H and O for carbohydrates C, H and O for lipids C, H, O, N and S for proteins C, H, O, N and P for nucleic acids.
(d)	the ring structure and properties of glucose as an example of a hexose monosaccharide and the structure of ribose as an example of a pentose monosaccharide	To include the structural difference between an α- and a β-glucose molecule AND The difference between a hexose and a pentose monosaccharide.
(e)	the synthesis and breakdown of a disaccharide and polysaccharide by the formation and breakage of glycosidic bonds	To include the disaccharides sucrose, lactose and maltose
(f)	the structure of starch (amylose and amylopectin), glycogen and cellulose molecules	HSW8
(g)	how the structures and properties of glucose, starch, glycogen and cellulose molecules relate to their functions in living organisms	HSW2, HSW8
(h)	the structure of a triglyceride and a phospholipid as examples of macromolecules	To include an outline of saturated and unsaturated fatty acids.
(i)	the synthesis and breakdown of triglycerides by the formation (esterification) and breakage of ester bonds between fatty acids and glycerol	
(j)	how the properties of triglyceride, phospholipid and cholesterol molecules relate to their functions in living organisms	To include hydrophobic and hydrophilic regions and energy content **AND** illustrated using examples of prokaryotes and eukaryotes. HSW2, HSW8
(k)	the general structure of an amino acid	
(l)	the synthesis and breakdown of dipeptides and polypeptides, by the formation and breakage of peptide bonds	
(m)	the levels of protein structure	To include primary, secondary, tertiary and quaternary structure **AND** hydrogen bonding, hydrophobic and hydrophilic interactions, disulfide bonds and ionic bonds. HSW8

(n)	the structure and function of globular proteins including a conjugated protein	To include haemoglobin as an example of a conjugated protein (globular protein with a prosthetic group), a named enzyme and insulin. An opportunity to use computer modelling to investigate the levels of protein structure within the molecule. **PAG10**
(o)	the properties and functions of fibrous proteins	To include collagen, keratin and elastin (no details of structure are required).
(p)	the key inorganic ions that are involved in biological processes	To include the correct chemical symbols for the following cations and anions: cations: calcium ions (Ca^{2+}), sodium ions (Na^{+}), potassium ions (K^{+}), hydrogen ions (H^{+}), ammonium ions (NH_4^{+}) anions: nitrate (NO_3^{-}), hydrogencarbonate (HCO_3^{-}), chloride (Cl^{-}), phosphate (PO_4^{3-}), hydroxide, (OH^{-}).
(q)	how to carry out and interpret the results of the following chemical tests: • biuret test for proteins • Benedict's test for reducing and non- reducing sugars • reagent test strips for reducing sugars • iodine test for starch • emulsion test for lipids	**PAG9** HSW3, HSW4, HSW5
(r)	quantitative methods to determine the concentration of a chemical substance in a solution	To include colorimetry and the use of biosensors (an outline only of the mechanism is required). **PAG5** HSW3, HSW4, HSW5
(s)	**(i)** the principles and uses of paper and thin layer chromatography to separate biological molecules / compounds	To include calculation of retention (*Rf*) values.
	(ii) practical investigations to analyse biological solutions using paper or thin layer chromatography.	For example the separation of proteins, carbohydrates, vitamins or nucleic acids. *M0.1, M0.2, M1.1, M1.3, M2.2, M2.3, M2.4* **PAG6** HSW2, HSW3, HSW4

Students have the opportunity to undertake a variety of practical activities to support the learning of topics within 2.1.2 Biological Molecules. These could include modelling, qualitative tests, quantitative tests and chromatography.

The first few activities listed here support the practical Learning Outcomes 2.1.2(q) – (s) and can be linked back to earlier Learning Outcomes in 2.1.2.

Many websites cover the biological molecules in this section. For example, a summary of the biological molecules covered can be found here:

http://alevelnotes.com/Biological-Molecules/49#/?id=49

Activity 1
Building biological molecules with jelly mods activity

Carbohydrates 2.1.2(d) and (e).

OCR 'Jelly Mods' biological molecules activity allows students to build biological molecules of varying complexity and explore the concepts of structure and bonding.

There is also a starter or plenary 'bingo' activity that consolidates key terms and some questions and answers.

https://www.ocr.org.uk/qualifications/as-and-a-level/biology-a-h020-h420-from-2015/planning-and-teaching/#a-level-teaching-activities-biological-molecules

Activity 2
Biuret test using different approaches

Biuret test for proteins 2.1.2(q) and (r).

This straightforward test can be modified by giving students different beans/pulses. These can be tested for protein, either qualitatively or quantitatively, to find who has the most protein in their bean. This works well and could relate to **PAG5**, **9** and/or **12**. It could also cover mathematical skills such as *M3.2* and *M3.3*.

Alternatively, the biuret test could be used in a crime scene context where 'blood' samples have been 'found'. Paint, diluted ketchup or blood could be used. This could also be linked with 3.1.2(i) the role of haemoglobin.

The general method can be found at;

http://brilliantbiologystudent.weebly.com/biuret-test-for-protein.html

Activity 3
Benedict's test in a medical context

Testing for sugars 2.1.2(q) and (r).

This works well in a medical context. Students take roles of the patient or medic, although both do the analysis! Students are given samples of 'urine' that could potentially show whether they are diabetic or not. The medic then analyses the sample, with the patient's help. This can be qualitative or quantitative using a standard curve and extended by weighing the mass of precipitate for each solution. This can be linked with 5.1.4(e) diabetes and insulin secretion. The standard curve can either be provided or constructed by each student/pair. This is also a simple way of using glucose test strips, as students role playing the patient could complain about the lack of accuracy with the strips and demand further analysis!

This could relate to **PAG5** for serial dilutions to construct the standard curve and **PAG9** qualitative testing.

It could also cover mathematical skills such as *M3.2* and *M3.3*.

The general method can be found at;

http://brilliantbiologystudent.weebly.com/benedicts-test-for-reducing-sugars.html

Also, this article looks at colours of precipitates for standard solutions and colours with urine samples;

http://jcp.bmj.com/content/25/10/892.full.pdf

Activity 4
Synoptic approach to using the iodine test

This links well with 2.1.5(d) and (e) diffusion and osmosis. This resource describes a visual way of demonstrating diffusion through a semi-permeable membrane. It can be used as a model for the human gut or for investigating the effect of amylase on starch by adjusting the experiment. Iodine and Benedict's reagent tests are used to test for the presence of starch and reducing sugars.

https://www.stem.org.uk/resources/elibrary/resource/34378/visking-tubing

Activity 5
Separating and identifying amino acids using paper chromatography

Learner Resource 1

Chromatography 2.1.2(s) (**PAG6**).

This activity also allows for consideration of risk assessment and safe practice (1.2.1(b) A Level only) and for Rf values to be calculated, providing an opportunity for mathematical skills coverage (eg *M0.3*). See Learner Resource 1.

Students can produce individual chromatograms if sufficient materials are available as more than one chromatogram can be placed in the solvent tanks.

1. Draw pencil line 2 cm from the bottom of the chromatography paper strip.
2. Using capillary tubing add samples of known amino acids and an unknown sample mixture along the pencil line. Label in pencil.
3. Hang in chromatography tank (already containing suitable solvent eg butan-1-ol / ethanoic acid /water in ratio 60 : 15 : 25 at 1cm depth). Ensure that the bottom of the paper strip is in the solvent but the pencil line of samples remains out of the solvent.
4. Place a lid on the tank and leave for about 1 hour. The chromatograms must be checked regularly to ensure that the solvent does not run off the top of the paper strips.
5. Wearing gloves remove the chromatograms and mark in pencil a line where the solvent has reached.
6. Allow to dry in a fume cupboard and then spray with ninhydrin (follow CLEAPSS® guidelines).
7. Calculate Rf values and identify amino acids in unknown sample.

For more information on chromatography check out:
http://chromatographyscience.blogspot.co.uk/p/introduction-to-chromatography.html

Approaches to teaching the content

Biological Molecules is the chemical part of module 2 and can cause a dichotomy of understanding, with students who like chemistry finding the context and concepts easy and students who are not chemically inclined, struggling from the start. Modelling and role-play scenarios are interesting and can make these topics more accessible to all students in the class.

Common misconceptions or difficulties students may have

Many students learn the properties of water (2.1.2a) in a rote manner without understanding the power of the hydrogen bond. The 'Bonding boppers' activity works well for all levels of understanding and provides laughs throughout the activity. It serves to link all the aspects of the roles of water and is highly adaptable for both teachers and students to think of additions to enhance their understanding of water's properties and thus its roles in nature. This activity can be linked with 2.1.2(j) and membranes in 2.1.5.

However, for 2.1.2(j) lipids and hydrophobicity, students often confuse polar to polar interactions with the idea of ionic bonding and thus mistake the polar nature of the lipid/water interaction with the attractive forces of ions. A quick and fun starter for this learning outcome is outlined in the 'I'm forever blowing bubbles' activity and can be revisited for 2.1.5.

Polymerisation underpins this topic and a quick way of illustrating this is outlined in the 'Let's group together' activity. This helps with understanding the origin of the terms condensation and hydro-lysis, which is often vague and meaningless to students.

Conceptual links to other areas of the specification – useful ways to approach this topic to set students up for topics later in the course

As many of the learning outcomes are abstract for students it is good to try to link with social and industrial examples to aid in the descriptions and teaching. The 'It's fondant time!' activity shows how the confectionary industry can be used to teach 2.1.2(e) along with molecular model kits or video clips. It can be linked with 2.1.4 Enzymes and 6.2.1(i) where lactose intolerance and lactose free milk could also be used to illustrate this learning outcome.

A generalised technique to cover the folding aspects of biomolecules (2.1.2 f, h, I, m and n) involves coloured wire with and without modelling clay balls. This gives students a feel for the different folding structures and bonds being formed and can be extended to illustrate how the structures inform their functions (2.1.2g, j, n and o). The 'Folds and functions' activity highlights this approach for the levels of protein structure (2.1.2m and n).

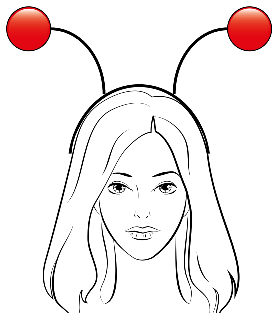
There are various video clips available to illustrate this content, for example, a detailed video for proteins can be found below. This video has good 3D rotational images (link to **PAG10**) and links well with 4.1.1(h) antibodies and 5.1.4(d) insulin.

http://www.youtube.com/watch?v=qBRFIMcxZNM

Learner Activity 1
Bonding boppers

Understanding water 2.1.2(a).

Students wear bobble head-bands similar to those shown below (these can be bought online if necessary). The boppers are the hydrogens and the student's head is the oxygen. This actually allows for a good indication of the bond angles in water, which students familiar with chemistry, will appreciate. It also encourages more accurate drawing of the structure of the water molecule.



To illustrate the hydrogen bond (after emphasizing the covalent bonds are represented by the springs) the students can bend their heads and move towards fellow students with a bobble pointing towards the other student's head.

To illustrate the role of water as a solvent/transport medium, one student (without a head-band) has a circle on their head (or can hold a circle) to represent a polar molecule/ion, labelled if desired. The 'water molecules' can then move to the molecule/ion and surround it. This can also be used to show water's lipophobic nature and would link with 2.1.5 biological membranes.

A balloon could be used to represent a pond skater (especially a long balloon) and students could try to balance the balloon on their heads (individually) and then come together and balance it collectively to illustrate surface tension.

For the low density as a solid, students could get into groups of four and see if they can form a tetrahedral structure. To avoid becoming too chemical, students could just space themselves out more but lower their heads to illustrate that ice has more space between molecules, thus is less dense. It is best to start with them close to each other with heads touching to show surface tension, then show them that it is hard to move apart for high boiling point and then they can move apart when temperatures drop for the lower density and ice formation.

Learner Activity 2
Monomers and polymers activity

Monomers and polymers 2.1.2(b).

Students can model condensation and hydrolysis reactions by holding a ball (or balloon) in their right hand and then link hands (or arms) but only when they have thrown the ball away. This models the loss of water when forming polymers. The 'water molecules' can then be collected up and used to show why the process is called condensation. For hydrolysis, the ball is thrown (gently, balloons may be more appropriate here) at the linked hands/arms and they break when the right hand has caught the ball.

https://www.youtube.com/watch?v=ZMTeqZLXBSo - although note in this video the condensation reaction is called dehydration.

Learner Activity 3
Breakdown of a disaccharide

Breakdown of a disaccharide 2.1.2(e).

Hand out mints or chocolates that have a soft, fondant centre and ask the students how they think the centre is formed. Then use this to explain that invertase is added to the centre and over a few days it breaks down the disaccharide sucrose (sometimes referred to as saccharose in the confectionary industry) to glucose and fructose. The University of Sheffield has a section on this as part of their Edible Experiments project. This links with 2.1.4 Enzymes.

https://www.youtube.com/watch?v=f_vRDobetnQ and the demo sheet at https://www.sheffield.ac.uk/polopoly_fs/1.660655!/file/InvestigatingInvertase_EE.pdf

Learner Activity 4
Construct a protein

Protein structure 2.1.2(m).

Students are given a good length of coloured wire. Each student will be given a card (example shown below) and they construct the protein sub-unit detailed on the card. The cards are not necessarily accurate but serve to enhance the understanding of the student. Modelling clay can be given for any conjugated metal ion. In the example below, make sure there are at least four students with haemoglobin and, when completed, the students can move around the room and look for their fellow sub-units to complete the quaternary structure.

Discussions can then be extended to look at the function of these proteins and encompass 2.1.2(n) and (o). This cements the structure/function relationship of the proteins for the students. Further development could involve some students helping others with the folding and then taking the students around to find their fellow 'sub-unit' and thus they are acting as chaperones. This is not required as a learning outcome but is an excellent way of developing and expanding their knowledge without imposing confusion.

Haemoglobin

60% alpha helix
40% beta sheet
Globular protein
4 subunits
conjugated with iron

An alternative approach to represent the levels of protein structure would be to glue a series of pieces of coloured paper together to show primary, secondary and tertiary structure with white strips to represent the hydrogen bonds.

Thinking contextually

Activities

This topic needs to be as kinesthetic and visual as possible otherwise the ideas and concepts can be too abstract for a firm understanding.

Modelling with a molecular model kit or wire and modelling clay is a clear and easy (and cheap) way of illustrating many of the learning outcomes in 2.1.2 (2.1.2b, f, h, i, l and m).

Practical work can be linked with many of the learning outcomes as well as fulfilling 2.1.2(q)-(s). For example, learning outcome 2.1.2(e) can be linked with the Benedict's test as outlined in the 'Trust the doctor' activity (above). This allows for many mathematical skills to be covered, could support PAG coverage, and provides a social context that many students will be familiar with or will aspire to.

Role-play is a fun and effective tool for visualizing bond formation on a general level. The 'Bonding boppers' and 'Let's group together' activities (above) provide some examples of how this can work for 2.1.2(a), (b) and (j), and could link in with 2.1.5 Biological Membranes.

Computer modelling and video clips are powerful tools for illustrating the 3D nature of the biomolecules and should be used where possible. They are good starters when model building has been employed. Manipulating structures using programs such as RasMol supports learning and could be used towards **PAG10**.

Formulae can be combined with function and fun, aas outlined in the 'Ionic bingo' activity (below) and allows for good differentiation of students.

Activities

Learner Activity 1
Sticky structures

Skeletal formula 2.1.2(d) and (k).

Constant drawing of skeletal formula should be avoided as it can disengage the student, however, learning outcomes (d) and (k) need to be covered in this level of detail. Stickers could be used to break up the structures and students could be asked to add the stickers in the correct order.

Learner Activity 2
Ionic bingo

Teacher Resource1

Key inorganic ions 2.1.2(p).

Students have functions on a bingo style board as shown in Teacher resource 1. The teacher reads out the bingo ball mineral and if the student has the right function they can cross it off. Bingo balls can be constructed with white polystyrene balls, annotated appropriately. Students shout 'house' when all functions are crossed off. For differentiation, some cards could have multiple functions for the same ion. The clues on the bingo card can be set for this level and adjusted to greater depth when later topics have been covered.

An Amino Acid Chromatogram

Following your experiment you will have a chromatogram similar to Figure 1 below. Using Figure 2 as an example, use the formula below to determine the Rf value for your experiment.

$$\textit{Rf value} = \frac{\textit{distance travelled by sample}}{\textit{distance travelled by solvent}} = \frac{x}{y}$$

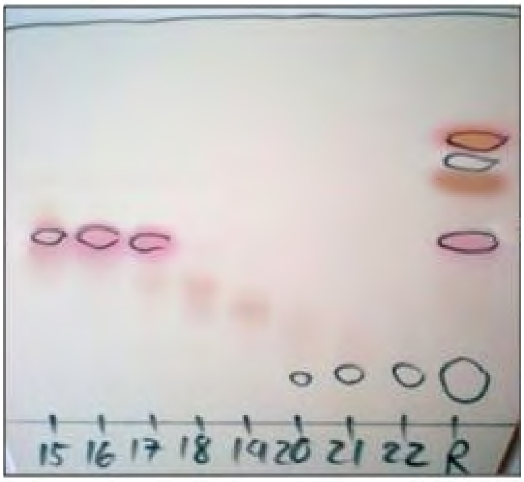


Figure 1 A chromatogram showing separated amino acids stained with nihydrin.

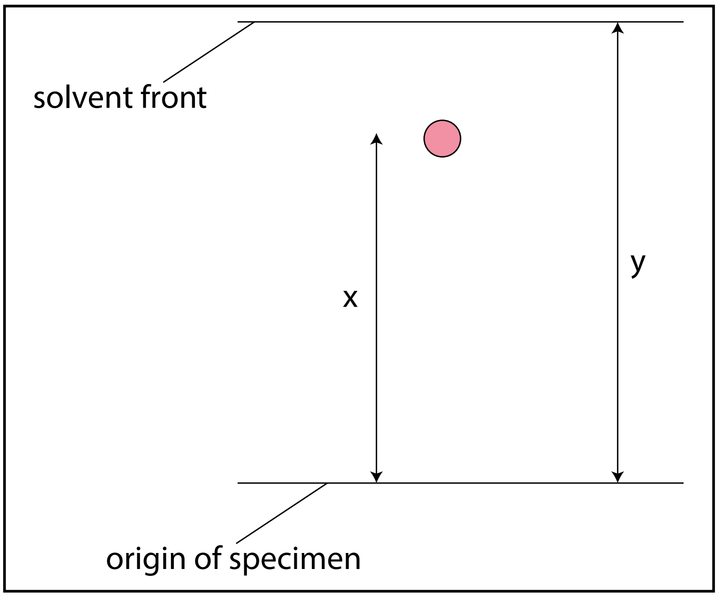


Figure 2 A diagram of a chromatogram indicating the measurement to take for the solvent front (y) and the measurement to take for distance travelled by sample (x).

Teacher Resource 1

Ionic Bingo Example

Here is an example bingo card for the 'Ionic bingo' activity.

Pumped into an axon to transmit an impulse		Formed when carbon dioxide dissolves in plasma	Needed for contraction of muscle proteins
High concentration with lower pH	Released inside cells as part of cell signalling	Needed for functioning of ATPase	Move down their electrochemical gradient in chemiosmosis
	Deamination produces these		Substrate for denitrifying bacteria

Ionic Bingo Example

Here is a blank Bingo card that can be used by teachers as a template for the 'Ionic bingo' activity, or for students to make their own.

Did you know?

OCR Resources: *the small print*

OCR acknowledges the use of the following content: N/A

Looking for a resource?

There is now a quick and easy search tool to help find **free** resources for your qualification:

www.ocr.org.uk/i-want-to/find-resources/

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our **Customer Support Centre**.

General qualifications
Telephone 01223 553998
Facsimile 01223 552627
Email general.qualifications@ocr.org.uk

www.ocr.org.uk