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## 

## (9610)

## Outline Schemes of Work

## 

For teaching from September 2016 onwards

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**Introduction**

This Scheme of work has been prepared by teachers for teachers. We hope you will find it a useful starting point for producing your own schemes.

The Scheme of Work is designed to be a flexible medium term plan for the teaching of content and development of the skills that will be assessed. It covers the needs of the specification for the International AS units of Biology 9610.The teaching of investigative and practical skills is embedded within the specification. We are producing a Practical Handbook that provides further guidance on this. There are also opportunities in this scheme of work, such as the inclusion of rich questions.

We have provided links to some resources. These are illustrative and in no way an exhaustive list. We would encourage teachers to make use of any existing resources, as well as resources provided by Oxford International AQA Examinations and new textbooks written to support the specification. Please note there maybe access restrictions to certain websites from certain countries.

Prior knowledge noted below comprises knowledge from the current AQA double science (ie Core and Additional Science) International GCSE specifications. Students who studied the separate Science International GCSE courses will have this knowledge but may also have been introduced to other topics which are relevant to the International A-level content. Topics only found in separate sciences International GCSE courses are not included in the prior knowledge section.

We know that teaching times vary from school to school. In this scheme of work we have made the assumption that it will be taught over about 30 weeks with 4½ to 5 hours of contact time per week. Teachers will need to fine tune the timings to suite their own students and the time available. It could also be taught by one teacher or by more than teacher with topics being taught concurrently.

The **assessment opportunities** column details AQA past paper questions that have been mapped to this new Oxford International AQA qualification and are available through the international Exampro from early 2016. Of course there are also Sample Assessment Materials for download at oxfordaqaexams.org.uk/9610

## **3.1 Unit 1: The diversity of living organisms**

**Unit description**

The variety of life is extensive and is reflected in the similarities and differences in its biochemical basis and cellular organisation. Factors such as size and metabolic rate affect the requirements of organisms and this gives rise to adaptations such as specialised gas-exchange surfaces.

Classification is based on the concept of a species and is a way of organising the variety of life based on relationships between organisms. Although a species may be defined in terms of similarity, there is frequently considerable intraspecific variation and this is influenced by both genes and the environment. Variation both within and between species contributes to the biodiversity of communities and ecosystems.

**3.1.1 Biological molecules**

#### 3.1.1.1 Monomers and polymers

Prior knowledge:

- Many small molecules (monomers) join together to form very large molecules (polymers).

- Representing the formation of a polymer from a given monomer.

-Protein molecules are made up of long chains of amino acids;

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Monomers are the smaller units which may be joined together to form polymers.  Condensation is the joining together of molecules with a chemical bond and the elimination of a molecule of water.  Hydrolysis is the breaking of the chemical bond between two molecules in a reaction involving a water molecule. | 0.2 weeks | • explain what a monomer and polymer are.  • identify some biological polymers, and the monomer from which they are made.  • explain the concept of condensation and hydrolysis reactions in forming/breaking down polymers. | **Learning activities:**  - Baseline assessment of knowledge.  - Present pictures of biological molecules and ask for identification of monomer repeating units.  - Introduce biological polymers and their monomers, including hydrolysis and condensation.  - Word equations to summarise.  **Skills developed by learning activities:**  AO1 – Knowledge and understanding of scientific principles and concepts. |  | **Rich questions:**  - During which process/group of processes are polymers hydrolysed in the body into monomers?  - What catalyses hydrolysis in the body? |

#### 3.1.1.2 Carbohydrates

Prior knowledge:

– Starch can be broken down into sugars.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The monomers from which larger carbohydrates are made are monosaccharides. Common monosaccharides are glucose and fructose.  Glucose exists as two isomers, α-glucose and β-glucose, for which the structural formulae should be known. | 0.2 weeks | • identify common monosaccharides.  • represent the structure of α-glucose and β–glucose diagrammatically  • explain why α-glucose and β–glucose are isomers.  • describe the monosaccharides from which lactose, maltose and sucrose are made.  • explain what is meant by a glycosidic bond and how they form through condensation. | **Learning activities:**  - Introduce monosaccharides, with examples.  - Molymod modelling from structural formulas.  - Molymods: Challenge students to produce structural isomers of glucose.  - Introduce α-glucose and  β–glucose and how they are formed.  - Link models of monosaccharides to model condensation.  - Introduce disaccharides.  **Skills developed by learning activities:**  AO1 – Knowledge and understanding of scientific principles and concepts. | **Past exam paper materials:**  BIOL1 Jan13 - Q3a  BYA1 Jun08 - Q1a-b | **Rich questions:**  - If a glucose and a fructose (both with the formula C6H12O6) joined together in a condensation reaction, what would be the disaccharide which formed and what would its molecular formula be?  - Provide the structures of two monosaccharides and ask students to draw the structure of the disaccharide which would result from condensation. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Many monosaccharides may join by condensation to form a polysaccharide.  Starches are composed of amylose and amylopectin and formed by condensation of  α –glucose.  Cellulose is formed by condensation of  β –glucose.  The relationship of the structure of starch and cellulose to their functions in the cells of plants.  Apply knowledge to demonstrate how condensation and hydrolysis occur in unfamiliar carbohydrates. | 0.4 weeks | • describe how polymerisation of  α-glucose can form starch.  • explain why glycosidic bonds between  α –glucose form starch and how this relates to its function and properties.  • explain why glycosidic bonds between β –glucose form cellulose and how this relates to its function and properties.  • when provided with relevant molecular structures or formulae, demonstrate how unfamiliar carbohydrates might be joined by condensation or broken down by hydrolysis. | **Learning activities:**  - Introduce polysaccharides and expand on the earlier concept of condensation.  - Provide stimulus material for students to research either starch or cellulose (structure and properties) and produce a presentation.  - Get students to present their findings to the other group, who can “question the experts”.  - Feedback, AfL and consolidatory teaching if required.  - Introduce hydrolysis, with examples. Get students to draw hydrolysis for the known polysaccharides and disaccharides covered previously.  - Provide unfamiliar carbohydrates and get students to demonstration how condensation/hydrolysis might occur.  - Past exam questions.  **Skills developed by learning activities:**  AO1 – Knowledge and understanding of scientific principles and concepts.  AO2 – Application of knowledge and understanding of scientific principles and concepts to both familiar and novel contexts. | **Past exam paper material:**  BIOL2 Jan13 - Q1;  BIOL2 Jun12 - Q3;  BIOL2 Jan11- Q1b – 1c;  BIOL2 Jun10 - Q1;  BYB1 Jan 05 - Q2 | **Rich question:**  Why does the structure of starch and cellulose mean that starch is a good molecule for storage whilst cellulose is a good structural molecule in cell walls? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Biochemical tests using Benedict’s reagent for reducing and non-reducing sugars and iodine/potassium iodide solution for starch. | 0.2 – 0.4 weeks | • describe the tests for starch, a reducing and non-reducing sugar in detail.  • explain what is meant by qualitative and quantitative testing. | **Learning activities:**  **-** Introduce biochemical test procedures and the concept of reducing and non-reducing sugars.  - Hazcard risk assessment.  - Provide 3 unknown samples for students to test and identify e.g. soluble starch, glucose, sucrose.  - Exam question.  **Skills developed by learning activities:**  AO1 – Knowledge and understanding of scientific principles and concepts.  AO4 – The ability to describe the tests for reducing and non-reducing sugars, and for starch. | **Past exam paper materials:**  BIOL1 Jun11 -Q1a and 1b  BYB1 Jan 07 -Q1  BYA1 Jan 04 - Q1  **Exampro –** BYB1 Jan 04 Q4 | [**http://www.mrothery.co.uk/module1/Mod%201%20techniques.htm**](http://www.mrothery.co.uk/module1/Mod%201%20techniques.htm) |
| Extension |  |  | - Practical: Produce dilution series and produce a calibration curve from known concentrations to work out unknown concentration. This could be done via colorimetry, mass of precipitate or colour matching. | BIO3T ISA 2014 |  |

#### 3.1.1.3 Lipids

Prior knowledge:

– Oils do not dissolve in water but can form emulsions with water if an emulsifier is present.

- Saturated and unsaturated molecules and the representation of a double bond as =.

- Vegetable oils are unsaturated as they contain a double bond. These may be hardened by hydrogenation to add to the double bond.

– Lipids (fats and oils) consist of/are broken down into fatty acids and glycerol.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The emulsion test for lipids. | 0.2 weeks | • describe the stages of the emulsion test.  • interpret the results of the emulsion test. | **Learning activities:**  - Introduce what a lipid is and the emulsion test for lipids.  - Practical: Use of the emulsion test to test samples for the presence of lipids.  **Skills developed by learning activities:**  AO1 – Knowledge and understanding of scientific principles and concepts.  AO4 – The ability to describe the emulsion test. | **Past exam paper material:**  BIOL1 Jan12 – Q1a. | [**http://brilliantbiologystudent.weebly.com/ethanol-emulsion-test-for-lipids.html**](http://brilliantbiologystudent.weebly.com/ethanol-emulsion-test-for-lipids.html)  [**http://igbiologyy.blogspot.co.uk/2012/12/32-emulsion-ethanol-test-for-fats.html**](http://igbiologyy.blogspot.co.uk/2012/12/32-emulsion-ethanol-test-for-fats.html)  **Rich questions:**  - Describe how you would conduct an emulsion test for lipids.  - Is the emulsion test quantitative or qualitative? Explain your answer. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| A fatty acid may be represented by the chemical formula RCOOH. The R-group may be either saturated or unsaturated.  Triglycerides are formed by the condensation of one glycerol molecule and three fatty acid molecules. Ester bonds are formed as a result.  In phospholipids, one of the fatty acids is substituted by a phosphate-containing group. | 0.4  weeks | • describe the structure of triglycerides.  • explain how triglycerides form.  • recognise, from diagrams, saturated and unsaturated fatty acids.  • describe the structure of phospholipids.  • explain the properties and functions of triglycerides and phospholipids in relation to their structure.  • contrast the different properties and functions of saturated and unsaturated triglycerides and phospholipids. | **Learning activities:**  - Teacher explanation of two lipid groups.  - Teacher explanation of triglyceride structure and saturation/ unsaturation of fatty acid R groups.  **-** Highlighting exercise, highlighting the differences between triglycerides and phospholipids.  - Teacher explanation of phospholipids and the concepts of hydrophilic and hydrophobic head/tail.  - Card sort – Sort different diagrams/formulae of triglycerides and phospholipids into two categories.  - Past exam questions.  **Skills developed by learning activities:**  AO1 – Knowledge and understanding of scientific principles and concepts. | **Past exam paper material:** BIOL1 Jan11 – Q4.  BIOL1 Jan12 – Q1b.  **Exampro –** BYB1 June 04 Q2 | **Rich questions:**  Are triglycerides (and phospholipids) polymers? Explain your answer.  Why is the degree of saturation of the fatty acid chains important?  Where might the hydrophobic nature of lipids be useful within a cell and why? |

#### 3.1.1.4 Proteins

Prior knowledge:

– Protein molecules are made of chains of amino acids, which fold to produce a specific shape.

– The roles of proteins in the body include: enzymes; structural components of tissue, e.g. muscle; antibodies; hormones.

– Chromatography can be used to separate mixtures and identify molecules within a mixture (in the context of food colourings).

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The monomers from which proteins are made are amino acids (for which a general structure should be known).  There are twenty amino acids that are common in all organisms and they differ only in their R-groups amino acids.  The biuret test for proteins. | 0.2 weeks | • describe the general structure of an amino acid.  • describe the Biuret test and how it can be interpreted.  • explain the variety of functions that proteins have and why they are so important to the body. | **Learning activities:**  - Teacher explanation of the Biuret test.  - Students do Biuret test to test labelled samples (can be mock samples) of things within the body, e.g. amylase, bile. Arrive at a list of roles played by proteins.  - Provide diagrams of 20 amino acids and ask students to generate “Golden Rules” about structure.  - Past exam question.  **Skills developed by learning activities:**  AO1 – Knowledge and understanding of scientific principles and concepts.  AO4 – The ability to describe the biuret test. | **Past exam paper material:**  BIOL1 Jan10 – Q1b-Q1c.  Exampro -  BYA1 June 04 Q1 | **Rich questions:**  - Describe the biuret test.  - A student took a sample of 100% pure starch and added the enzyme amylase to it. After 1 hour, they tested the solution using the Benedict’s, Iodine, Emulsion and Biuret tests. Which tests would be positive and why? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Amino acids may join by condensation to form a peptide bond. Dipeptides are formed by the condensation of two amino acids.  Polypeptides are formed by the condensation of many amino acids.  The role of hydrogen bonds, ionic bonds and disulfide bridges in the structure of proteins.  The relationship between primary, secondary, tertiary and quaternary structure, and protein function. | 0.4  weeks | • explain how dipeptides and polypeptides form.  • explain the hierarchical organisation of protein structure.  • describe the types of bond involved in protein structure and the relative properties of each.  • relate the structure of proteins to properties of proteins (this is required for proteins named throughout the specification). | **Learning activities:**  **Some of the following**  - Use molymods to make glycine molecules, and then join them together to model condensation.  - Teacher explanation of properties of globular and fibrous proteins, and of primary, secondary, tertiary and quaternary structure (using videos and animations).  - Modelling of protein structure using Tangle toys. Ask students to apply knowledge of protein structure to the model and present to class.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 and AO2 –** Demonstration and application of knowledge of scientific idea.  - Extended exam/essay answers. | **Past exam paper material:**  HBIO1 Jan09 -Q3a-b;  HBIO1 Jun14 – Q1; | [**http://www.bcconline.com/biol10rs/Pearson-Animations/protein\_structure.swf**](http://www.bcconline.com/biol10rs/Pearson-Animations/protein_structure.swf)  [**http://www.rasmol.org/**](http://www.rasmol.org/software/RasMol_2.7.4.2_Manual.html)  [**http://www.amazon.com/dp/B006GCUXDA?psc=1**](http://www.amazon.com/dp/B006GCUXDA?psc=1)  **Rich question:**  Show some bonds between functional groups covered so far and ask students to identify them as ester, peptide or glycosidic.  - Provide the structures of two amino acids and ask students to draw the structure of the dipeptide which would result from condensation. |
| Extension |  |  | - Student research into proteins, e.g. haemoglobin, collagen, relating structure to function. RASMOL could be used to research structure and apply knowledge. |  |  |

### 3.1.2 Cells and cell structure

#### 3.1.2.1 The structure of eukaryotic cells

Prior knowledge:

– Animal cells have a nucleus, cytoplasm, ribosomes, mitochondria and cell membrane. In addition to these, plants also have chloroplasts, a cell wall and a permanent vacuole.

- Yeast cells have a nucleus, cytoplasm and cell membrane surrounded by a cell wall.

– Cells may be specialised to a particular function.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Microscopes are important tools in the study of cells. The principles and limitations of optical microscopes, transmission electron microscopes and scanning electron microscopes.  The difference between magnification and resolution. | 0.4 weeks | • describe how a light microscope and an electron microscope work.  • explain the concepts of magnification and resolution and how they differ.  • compare and contrast light and electron microscopes.  • perform calculations to work out magnification or the actual size of cells (when provided with appropriate information).  • convert units (as appropriate). | **Learning activities:**  -Teacher explanation of difference between resolution and magnification. This could be illustrated by showing pictures magnified by the same amount but taken with a 2 mega pixel vs a 10 mega pixel camera.  - Introduce light and electron microscopy.  - Students circulate around research stations containing videos, comprehensions, internet sites, teacher explanation etc. to investigate light and electron microscopes.  - Accept feedback, assess understanding and then tackle areas of weakness through teacher explanation.  - Students could write an essay comparing and contrasting light and electron microscopes or do past exam questions.  - Teacher explanation of how to use and manipulate the magnification formula, including conversion of units if required.  - Students could be provided with microscopy pictures with a scale printed on it, and use it to calculate magnification.  - Past exam questions.  **Skills developed by learning activities:**  Extended exam answers.  **Mathematical requirement 1 and 12 -** Understand and convert numbers from standard to ordinary form and calculation of magnification.  **AO1 –** Development of knowledge and understanding of microscopy techniques. | **Past exam paper material:** BIOL1 Jun12 –Q1; BIOL 1 Jan09 - Q7b;  BIOL 1 Jan11 Q1c;  BIOL 2 Jan12 – Q1;  HBIO1 – Jun09 Q1 | [**http://bigpictureeducation.com/video-electron-microscopy**](http://bigpictureeducation.com/video-electron-microscopy)  [**http://bigpictureeducation.com/video-light-microscopy**](http://bigpictureeducation.com/video-light-microscopy)  **http://learn.genetics.utah.edu/content/cells/scale/**  [**http://www.biologymad.com/**](http://www.biologymad.com/)  **Rich question:**  Light microscopes were invented hundreds of years ago, whilst electron microscopes were invented in the 1930’s. Suggest why some parts of the cell until the 1940’s and 1950’s, whilst others like mitochondria were discovered much earlier. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The principles of cell fractionation and ultracentrifugation in the separation of cell components. | 0.2 weeks | • describe the processes of cell fractionation and ultracentrifugation.  • explain why the separation of cell components is important in studying cells and their components.  • explain the use of low temperatures and buffers during cell fractionation.  • explain the principles of separation by ultracentrifugation. | **Learning activities:**  - Think, Pair, Share: What are the limitations of using only microscopy to investigate structures within cells? What are the difficulties that need to be overcome in investigating the function cell components and organelles?  - A simple demonstration can be carried out by centrifuging ‘bitty’ orange juice to produce a pellet and supernatant.  - Teacher explanation of cell fractionation and ultracentrifugation in obtaining fractions for investigation. Use animations and videos to support explanation.  - Provide students with information on organelles encountered at GCSE and ask them to suggest what order they would sediment at.  - Past exam questions.  **Skills developed by learning activities:**  **AO4 –** Development of knowledge and understanding of cell fractionation procedures and the reasoning behind stages.  **AO2 -** Apply knowledge of organelles and their size to interpret results of what organelles would be in the pellet and supernatant after centrifugation at particular speeds. | **Past exam paper material:**  BIOL1 Jun09 – Q1;  BIOL1 Jun10 – Q3;  BIOL1 Jan13 – Q2.  Exampro - BYB1 Jun 06 Q1c  BYB1 Jun 05 Q3 | [**http://www.sumanasinc.com/webcontent/animations/content/cellfractionation.html**](http://www.sumanasinc.com/webcontent/animations/content/cellfractionation.html)  [**http://www.accessexcellence.org/RC/VL/GG/cellBreak1.php**](http://www.accessexcellence.org/RC/VL/GG/cellBreak1.php)  [**http://homepages.gac.edu/~cellab/chpts/chpt8/ex8-1.html**](http://homepages.gac.edu/~cellab/chpts/chpt8/ex8-1.html)  **Rich question:**  - Put the cell organelles in order of sedimentation as the speed of the centrifuge is increased.  - Why are fractionated cells kept in a solution that is ice cold, buffered and isotonic? |
| Extension |  |  | - The extraction of chloroplasts from spinach leaves could be undertaken if the centre has the appropriate equipment and time. |  |  |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The appearance, ultrastructure and function of the structures within eukaryotic cells (listed in the specification). | 0.6  weeks | • explain what is meant by a eukaryotic cell and the defining characteristics of a eukaryotic cell.  • explain the roles of different components and organelles within eukaryotic cells.  • interpret pictures, diagrams and electron micrographs to identify specific cell organelles.  • perform calculations to work out the actual size of organelles (when provided with appropriate information). | **Learning activities:**  - Student exploration of parts of the cell using animations/virtual cell tour.  - Teacher explanation of eukaryotic cells.  - Students circulate round information posters containing information about the components and organelles within eukaryotic cells. Link to an activity/question sheet.  - Collate findings.  - Teacher explanation of areas of weakness or misconception (using videos, diagrams and animations).  - Get students to develop analogies of the cell and its organelles, e.g. analogy to a country.  - Set students the task of arranging organelles in order, with dimensions being given in different units. Ask them to represent the final, converted dimensions in standard form.  - In groups, provide optical microscope photos and electron micrographs of organelles. Ask students to identify the organelle and work out the magnification.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 1 and 12 -** Understand and convert numbers from standard to ordinary form and calculation of magnification.  **AO1 –** Development of knowledge of cell structure.  **AO2 –** Application of knowledge to micrographs. | **Past exam paper material:**  BIOL 1 Jan 2013 – Q2.  Exampro – BYB1 June 06 Q1a | [**http://cell-cell-cell.com/resources/activities/**](http://cell-cell-cell.com/resources/activities/)  [**http://learn.genetics.utah.edu/content/cells/insideacell/**](http://learn.genetics.utah.edu/content/cells/insideacell/)  [**http://vcell.ndsu.nodak.edu/animations/flythrough/movie-flash.htm**](http://vcell.ndsu.nodak.edu/animations/flythrough/movie-flash.htm)  [**http://bigpictureeducation.com/cell**](http://bigpictureeducation.com/cell)  **http://www.cellsalive.com/cells/cell\_model.htm**  **Rich question:**  Evaluate the statement “Mitochondria produce energy during respiration”. |
| Extension |  |  | - Students could use an optical microscope to identify stained starch grains in plant cells and measure them.  - Students could also produce models of cell components. |  |  |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| In complex multicellular organisms eukaryotic cells have specific functions. Cells are organised into tissues, tissues into organs and organs into systems. | 0.4 weeks | • identify examples of specialised eukaryotic cells.  • explain common adaptations that cells have to particular functions.  • apply knowledge of eukaryotic cells  features in suggesting the role of cells based on their adaptations.  • explain the hierarchical organisation in multicellular organisms, in terms of tissues, organs and organ systems. | **Learning activities:**  - Ask students to link knowledge from GCSE/last lesson to explain adaptations.  - Jigsaw task: Students work in teams of 6, with each investigating one specialised cell from information or the internet. They then feedback to each other.  - Students come up with “Golden Rules” for looking at common adaptations and the role they play within the cell e.g. large surface area for exchange.  - Provide diagrams of unknown cells and ask them to suggest adaptations and potential roles.  - Teacher explanation of the hierarchical organisation exhibited in complex multicellular organisms.  **-** Tissues could be observed using pre-prepared microscope slides showing tissues of eukaryotic cells, e.g. vascular tissue in plants. Alternatively a chicken leg dissection could be undertaken to examine the different tissues which students can find.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of cell differentiation.  **AO2 –** Application of knowledge to explain cellular adaptations. | **Past exam paper material:**  BIOL1 Jan12 – Q3;  BIOL 2 Jun11 – Q1;  BIOL 2 Jan10 – Q1. | [**http://bigpictureeducation.com/annotated-cells-images**](http://bigpictureeducation.com/annotated-cells-images)  [**http://www.cellsalive.com/gallery.htm**](http://www.cellsalive.com/gallery.htm)  [**http://www.biologymad.com/**](http://www.biologymad.com/)  **Rich question:**  Provide students with new cells that they have not encountered, e.g. B lymphocytes, and ask them to identify their adaptations and suggest a role, e.g. large numbers of mitochondria and rough E.R. indicative of large amounts of protein synthesis to produce antibodies. |

#### 3.1.2.2 The structure of prokaryotic cells

Prior knowledge:

– A bacterial cell consists of cytoplasm and a membrane surrounded by a cell wall; the genes are not in a distinct nucleus.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The structure of prokaryotic cells, including the differences between prokaryotic and eukaryotic cells and the additional features of the cell which may be present. | 0.2 weeks | • describe the structural differences between prokaryotic and eukaryotic cells.  • explain the purpose of plasmids, capsules and flagella.  • compare and contrast eukaryotic and prokaryotic cells. | **Learning activities:**  - Teacher introduction to prokaryotic cells and explanation about the differences in size and structure for eukaryotic and prokaryotic cells (using videos and animations).  - Students could convert information about the size of prokaryotic cells and organelles into standard form or different units.  - Students work in groups to produce a guide to the prokaryotic cells, and how they differ from eukaryotic ones.  - Identification of cell components on light and electron micrographs.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 1 -** Understand and convert numbers from standard to ordinary form and calculation of magnification.  **AO1 –** Development of knowledge of prokaryotes.  **AO2 –** Application of knowledge to micrographs. | **Past exam paper material:** BIOL1 Jan09 -Q7a;  BIOL1 Jan11 -Q1;  HBIO1 Jan09 -Q2;  HBIO1 Jun12 -Q1;  Exampro – BYB1 Jun06 Q1b;  BYB7 Jun05 Q2 | [**http://www.cellsalive.com/cells/bactcell.htm**](http://www.cellsalive.com/cells/bactcell.htm)  **Rich question:**  - Compare and contrast prokaryotic and eukaryotic cells. |

### 3.1.3 Biochemical reactions in cells are controlled by enzymes

#### 3.1.3.1 Enzymes and enzyme action

Prior knowledge:

- Temperature is a measure of the average kinetic energy that particles within a system are moving/vibrating with.

– The shape of an enzyme is vital to its function in speeding up chemical reactions. Enzymes are affected by temperature and pH.

– The use of enzymes in the body during digestion, protein synthesis and respiration.

– The use of enzymes industrially and within the home, including the advantages and disadvantages of using enzymes.

– Evaluation of the use of catalysts in industrial processes.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Enzymes are proteins and their properties depend on the tertiary structure of their active sites. They combine with a complementary substrate to form an enzyme-substrate complex.  An enzyme lowers the activation energy of the reaction that it catalyses.  Models of enzyme action have changed over time. This is illustrated by the lock and key and induced fit models of action. | 0.2 weeks | • interpret energy level diagrams and identify the activation energy.  • explain the induced fit model of enzyme action.  • evaluate the strengths of the induced fit model against the lock and key theory.  • apply knowledge of tertiary structure to explain enzyme specificity and the formation of enzyme-substrate complexes. | **Learning activities:**  - Practical demonstration of how long it takes to decompose hydrogen peroxide using manganese IV oxide in one tube, liver or potato in another and no catalyst in a third.  - Teacher explanation of activation energy, and lock and key and induced fit models, using animations or videos.  - Past exam questions.  **Skills developed by learning activities:**  **AO3-** Interpret graphs of energy changes during reactions, to identify activation energy.  **AO1 and AO2 –** Demonstration and application of knowledge of scientific ideas to explain enzyme catalysis.  **AO3 –** Interpret scientific information and ideas to evaluate the strength of enzyme catalysis models. | **Past exam paper material:** BIOL1 Jun09 – Q3a and 3b;  BIOL1 Jan11 – Q2b;  BIOL1 Jun10 – Q5;  HBIO1 Jan09 -Q4a;  HBIO1 June13 - Q1; | **Rich question:**  What aspects of enzyme catalysis cannot be explained using lock and key?  Why is induced fit a more refined model of enzyme catalysis than lock and key?  Students could also extend their learning by researching why the specificity of enzymes in catalysing reactions makes them useful in industrial processes and biosensors. |
| Extension |  |  | - Student modelling of each model using plasticine.  - Student evaluation of which model is stronger and why. |  |  |

#### 3.1.3.2 The properties of enzymes

Prior knowledge:

– The kinetic theory of states of matter.

– Temperature is a measure of the average kinetic energy that particles within a system are moving/vibrating with.

– The shape of an enzyme is vital to its function in speeding up chemical reactions. Enzymes are affected by temperature and pH.

– The calculation of rate and the factors which affect the rate of chemical reactions.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Enzymes are catalysts that are specific.  The rate of reaction of an enzyme is related to number of collisions that take place between an enzyme and its substrate. This explains the effect of substrate concentration, enzyme concentration and temperature on the rate of an enzyme-controlled reaction.  The rate of reaction is also related to the ability of the active site to bind with complementary substrate molecules. This explains the effect of temperature, pH and competitive/non competitive inhibitors on the rate of an enzyme-controlled reaction.  (N.B. One of the experiments listed should be conducted as a full investigation for required practical 1). | 1 week | • explain how temperature, pH, substrate concentration, enzyme concentration, and the presence of inhibitors affect enzyme catalysis.  • describe and explain trends within graphs, relating this back to the tertiary structure of active sites and the effect of these variables.  • calculate rate of reaction from graphs and raw data, and explain the advantage of using initial rate.  • interpret graphs of enzyme catalysed reactions and apply knowledge to explain them. | **Learning activities:**  - Conduct group investigations relating to each variable (leave one to be conducted as full investigation in next section).  - Get students to calculate rate and produce graphs for each practical.  - Teacher explanation of trends within graphs for each factor.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 2,5,11,14, 16,18 -** Calculate means from repeated experiments. Construct appropriate tables and line graphs from data. Calculate rate from values on a graph, and/or using the slop of a tangent to a curve. Use appropriate units for rate.  **AO1 –** Develop knowledge and understanding of factors which influence the rate of enzyme catalysed reactions.  **AO2/AO4 -** Apply knowledge to practical contexts. | **Past exam paper material:**  BIOL1 Jan12 - Q7a-7c,  BIOL 1 Jan11 - Q2b,  BIOL1 Jun11 Q3,  BIOL1 Jan10 - Q3;  BIO3X 2011 EMPA;  HBIO1 Jun14 -Q3; | [**http://www.nuffieldfoundation.org/practical-biology/investigating-enzyme-controlled-reaction-catalase-and-hydrogen-peroxide-concentrat**](http://www.nuffieldfoundation.org/practical-biology/investigating-enzyme-controlled-reaction-catalase-and-hydrogen-peroxide-concentrat)  [**http://www.nuffieldfoundation.org/practical-biology/investigating-effect-ph-amylase-activity**](http://www.nuffieldfoundation.org/practical-biology/investigating-effect-ph-amylase-activity)  [**http://www.nuffieldfoundation.org/practical-biology/investigating-effect-concentration-activity-trypsin**](http://www.nuffieldfoundation.org/practical-biology/investigating-effect-concentration-activity-trypsin)  [**http://www.saps.org.uk/attachments/article/95/SAPS%20-%20Inhibitors%20on%20enzyme%20beta-galactosidase%20-%20Scottish%20Highers.pdf**](http://www.saps.org.uk/attachments/article/95/SAPS%20-%20Inhibitors%20on%20enzyme%20beta-galactosidase%20-%20Scottish%20Highers.pdf) |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **Required practical 1 - Investigation into the effect of temperature, pH or substrate concentration on the rate of an enzyme-controlled reaction.**  Design a valid experiment, using the work of others as a starting point, to investigate and solve a problem in a scientific context.  Identify variables including those that must be controlled.  Calculate initial rate.  Plot and interpret graphs.  Evaluate findings to draw meaningful conclusions. | 1 week | • explain the features of good experimental design.  - process data to calculate rates.  - represent raw and processed data clearly using tables and graphs.  - apply knowledge to draw and explain conclusions.  - evaluate the quality of results and reliability of conclusions. | **Learning activities:**  Students design an experiment to investigate the effect of a named variable on the rate of an enzyme-controlled reaction. This should include:  - risk assessment  - carrying out (subject to teacher approval)  - processing and presentation of data  - evaluation and explanation findings.  **Skills developed by learning activities:**  **Mathematical requirement 2,5,11,14,16,18 -** Use and convert units for concentration. Calculate means from repeated experiments. Construct appropriate tables and line graphs from data.  Calculate rate from values on a graph, and/or using the slop of a tangent to a curve.  **AO2/AO3** – Application of knowledge to explain trends in the data.  **AO4 –** Evaluate, select and refine scientific procedures. | Students could undertake investigations/questions from the following Biology and Human Biology ISAs:  **BIO3T P10**  **BIO3T P11**  **BIO3T P13**  **BIO3T Q12**  **HBI3T P11**  **HBI3T Q09** | [**http://www.nuffieldfoundation.org/practical-biology/investigating-enzyme-controlled-reaction-catalase-and-hydrogen-peroxide-concentrat**](http://www.nuffieldfoundation.org/practical-biology/investigating-enzyme-controlled-reaction-catalase-and-hydrogen-peroxide-concentrat)  [**http://www.nuffieldfoundation.org/practical-biology/investigating-effect-ph-amylase-activity**](http://www.nuffieldfoundation.org/practical-biology/investigating-effect-ph-amylase-activity)  [**http://www.nuffieldfoundation.org/practical-biology/investigating-effect-concentration-activity-trypsin**](http://www.nuffieldfoundation.org/practical-biology/investigating-effect-concentration-activity-trypsin)  [**http://www.nuffieldfoundation.org/practical-biology/quantitative-food-test-protein-content-powdered-milk**](http://www.nuffieldfoundation.org/practical-biology/quantitative-food-test-protein-content-powdered-milk)  **Rich question:**  Evaluate the statements:  “temperature denatures enzymes”;“acidic and alkaline pH’s denature enzymes”. |

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### 3.1.4 Transport into and out of cells

#### 3.1.4.1 Plasma membranes

Prior knowledge:

– Dissolved substances can move into and out of cells by diffusion. The greater the difference in concentration, the greater the rate of diffusion.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The arrangement of phospholipids, proteins and carbohydrates in the fluid-mosaic model of membrane structure.  Cholesterol may also be present and restricts the movement of other molecules making up the membrane.  The role of microvilli in increasing the surface area of cell-surface membranes. | 0.4 weeks | • describe the arrangement of proteins, glycoproteins, glycolipids, phospholipids and cholesterol in the fluid mosaic model of membranes.  • explain the roles/importance of the constituent parts of the membrane.  • relate the structure of the membrane to its role around/inside cells. | **Learning activities:**  **-** Questioning to recap the structure and properties of phospholipids (from section 3.1.1.3).  - Brainstorm the roles played by the plasma membrane, e.g. partially permeable, cell signalling etc.  - Teacher led explanation of the role of the plasma membrane, including cholesterol and the role of extrinsic and intrinsic proteins. A 3D model or animation can be used here.  - Reinforce concept by modelling the fluid and 3-D nature of membranes by half filling a tray with water, adding in marshmallows (representing phosphate heads of phospholipids) and coloured polystyrene chunks (representing the other components, e.g. proteins and glycoproteins, which float).  - Past exam questions.  **Skills developed by learning activities:**  **AO2/AO3 -** Apply knowledge about the role of cholesterol to practical data about membrane fluidity.  **AO1/AO2** – Application of knowledge and understanding from Section 3.1.1.3 to understand the structure and function of plasma membranes. | **Past exam paper material:**  Exampro –  BYB1 Jun06 Q2  BYB1 Jan06 Q7a  BYB1 Jan05 Q4a-b  BYB1 Jun04 Q3a  BYB9 Jan04 Q2a;  HBIO1 Jun10 Q4a;  HBIO1 Jan12 Q1; | [**http://glencoe.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::550::400::/sites/dl/free/0078802849/383931/Plasma\_Membrane\_The\_Fluid\_Mosaic\_Model.swf::The%20Fluid%20Mosaic%20Model**](http://glencoe.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::550::400::/sites/dl/free/0078802849/383931/Plasma_Membrane_The_Fluid_Mosaic_Model.swf::The%20Fluid%20Mosaic%20Model)  [**http://teach.genetics.utah.edu/content/begin/cells/print/BuildAMembrane.pdf**](http://teach.genetics.utah.edu/content/begin/cells/print/BuildAMembrane.pdf)  **Rich questions:**  - Describe the structure of the cell membrane.  - Explain how the structure of the membrane relates to its role as being partially permeable. |
| Extension |  |  | Students could further develop their skills in experimental design, carrying out, analysis and evaluation by conducting investigations into the effect of temperature or alcohol concentration on the permeability of cell membranes. |  | [**http://www.nuffieldfoundation.org/practical-biology/investigating-effect-temperature-plant-cell-membranes**](http://www.nuffieldfoundation.org/practical-biology/investigating-effect-temperature-plant-cell-membranes) |

#### 3.1.4.2 Diffusion

Prior knowledge:

– Dissolved substances can move into and out of cells by diffusion. The greater the difference in concentration, the greater the rate of diffusion.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Diffusion as the passive movement of substances down a concentration gradient.  Diffusion across plasma membranes may be limited by the nature of the phospholipid bilayer.  Surface area, difference in concentration and the thickness of the exchange surface affect the rate of diffusion. | 0.2  weeks | • define what is meant by diffusion.  • describe Fick’s law. | **Learning activities:**  - Assess prior learning and understanding of diffusion. Ask pupils to think-pair-share examples of diffusion in biological organisms that they have encountered in their earlier studies.  **-** Students observe diffusion using agar cubes containing phenolphthalein. Place in dilute sodium hydroxide solution for 5-10 minutes and cut the cubes open to show where NaOH has diffused to. This could be conducted with different concentrations to allow investigation of concentration gradients, or with cubes of different surface area and volume.  - Teacher explanation of Fick’s law and the factors which affect the rate of diffusion.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of diffusion.  **AO2/AO3 -** Apply knowledge of diffusion to explain trends in data obtained from the NaOH investigation.  **Mathematical requirement 19 –** Calculate the volumes of cuboidal prisms. | Exampro –  BYA1 Jun04 Q6a-ci | [**http://www.nuffieldfoundation.org/practical-biology/effect-size-uptake-diffusion**](http://www.nuffieldfoundation.org/practical-biology/effect-size-uptake-diffusion) |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Facilitated diffusion involves the use of proteins. These may act as carriers or provide channels. | 0.2  weeks | • define what is meant by facilitated diffusion.  • explain the process of facilitated diffusion.  • identify which substances rely on facilitated diffusion and why they cannot enter/leave cells by simple diffusion.  • interpret data to identify when a substance is moving by facilitated diffusion or diffusion. | **Learning activities:**  -Teacher explanation of why water soluble molecules cannot pass across the bilayer by simple diffusion. Introduce facilitated diffusion and the role of channel and carrier proteins. Use animations and video clips to support.  - Discuss some data showing data on facilitated diffusion and ask students to explain trends. Model an answer,  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of facilitated diffusion.  **AO2/AO3 -** Apply knowledge of facilitated diffusion to explain trends in experimentally derived data on the movement of molecules and ions. | Exampro –  BYA1 Jan05 Q5  BYA1 Jun04 Q6cii | [**http://highered.mheducation.com/sites/9834092339/student\_view0/chapter5/how\_facilitated\_diffusion\_works.html**](http://highered.mheducation.com/sites/9834092339/student_view0/chapter5/how_facilitated_diffusion_works.html)  **Rich question:**  Show students a list of substances and ask them to categorise them as those which can diffuse by simple diffusion and those that cannot. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Osmosis is a special case of diffusion in which water moves from a solution of higher water potential to one of lower water potential through a partially permeable membrane. | 0.4 weeks | • define osmosis in terms of water potential.  • explain the movement of water due to osmosis in or out of cells in relation to water potential.  • explain the effect of osmosis on plant and animal cells. | **Learning activities:**  - Visking tubing demo – Visking tubing with straw filled with concentrated sucrose/salt solution and placed into distilled water. Note the solution level in the straw at the start and the end of the demonstration. Get students to explain using prior knowledge.  **-** Teacher explanation of osmosis and water potential to arrive at an A-level definition.  - Jigsaw learning: Working in teams of three, one student goes to each information station to discover about the effect of placing plant and animal cells in hypotonic, isotonic and hypertonic solutions.  - Students feedback to one another.  - Teacher assessment and explanation to address areas of weakness.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge of osmosis and water potential.  **AO2** – Application of knowledge and understanding of osmosis to explain observations/concepts such as plasmolysis, haemolysis and turgor. | **Past exam paper material:**  HBIO1 Jan10 - Q9;  HBIO1 Jan12 - Q5  Exampro | [**http://www.nuffieldfoundation.org/practical-biology/observing-osmosis-plasmolysis-and-turgor-plant-cells**](http://www.nuffieldfoundation.org/practical-biology/observing-osmosis-plasmolysis-and-turgor-plant-cells)  [**http://highered.mheducation.com/sites/0072495855/student\_view0/chapter2/animation\_\_how\_osmosis\_works.html**](http://highered.mheducation.com/sites/0072495855/student_view0/chapter2/animation__how_osmosis_works.html)  **Rich question:**  Present diagrammatic representation of cells with numerical water potentials, and ask students to represent the net movement of water with arrows between cells. |
| Extension |  |  | Microscopy to observe and draw plasmolysis and turgor in onion cells. Red onion or rhubarb petiole give clear results. Ask students to explain using GCSE knowledge. |  |  |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **Required practical 2 -**Investigation of the effect of solute concentration on the uptake or loss of water from plant tissue. | 0.6-0.8 weeks | • apply your knowledge to explain how the water potential of a plant tissue can be experimentally determined.  • represent raw and processed data clearly using tables and graphs.  • process data to calculate percentage gain/loss.  • apply your knowledge to explain trends in graphs in relation to osmosis, water potential and mass change.  - evaluate the quality of results and reliability of conclusions. | **Learning activities:**  Students conduct an experiment to identify the water potential of plant tissue. This could include:  - research into methods  - carrying out  - processing and presentation of data  - evaluation and explanation findings  - A past ISA paper (relevant to practical).  **Skills developed by learning activities:**  **Mathematical requirement 3,5,14,16,17–**  Calculate % change in mass and the means from repeated results. Construct tables and graphs, and determine the water potential of plant tissues using the intercept of a graph of water potential of solution against gain/loss of mass.  **AO2** – Application of knowledge to explain trends and to understand serial dilutions.  **AO3 –** Analyse and evaluate data to draw conclusions.  **AO4 –** Selection, describe and evaluate scientific procedures. | Students could undertake the investigations/  questions from the following ISAs:  BIO3T P14.  BIO3T Q09  HBI3T P10  HBI3T P12  HBI3X 2014  **Past exam paper material:**  BIOL1 Jan09 - Q3;  BIOL1 Jan11 - Q5;  BIOL1 Jan10 - Q5. | [**http://www.nuffieldfoundation.org/practical-biology/investigating-effect-concentration-blackcurrant-squash-osmosis-chipped-potatoes**](http://www.nuffieldfoundation.org/practical-biology/investigating-effect-concentration-blackcurrant-squash-osmosis-chipped-potatoes) |

#### 3.1.4.3 Active Transport

Prior knowledge: Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| ATP may be synthesised from ADP and phosphate and provides the immediate source of energy for biological processes.  The role of carrier proteins and ATP in the transport of substances against a concentration gradient. | 0.4 weeks | • explain what ATP is and its significance.  • define what is meant by active transport.  • explain the process of active transport.  • compare and contrast active transport and facilitated diffusion.  • interpret data to identify when a substance is being actively transported. | **Learning activities:**  -Teacher explanation of ATP and its significance. Link this to active transport, using animations and video clips to support.  - Discuss some data showing data on active transport and ask students to explain trends. Model an answer.  - Provide data showing a range of different transport processes and ask pupils to identify the transport process from the data to summarise the processes covered in this section of the specification.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of active transport.  **AO3 -** Interpret data about active transport from a variety of tables and graphs.  **AO2 -** Apply knowledge of active transport to explain trends in experimentally derived data on the movement of molecules and ions. | **Past exam paper material:**  BIOL1 Jun13 - Q5,  BIOL1 Jun12 - Q4,  BIOL1 Jun11 - Q5;  BIOL1 Jan13 - Q9a;  BIOL1 Jun10 - Q7a;  HBIO1 Jun10 -Q4b  Exampro -  BYB1 Jan06 Q7b | [**http://www.nuffieldfoundation.org/practical-biology/tracking-active-uptake-minerals-plant-roots**](http://www.nuffieldfoundation.org/practical-biology/tracking-active-uptake-minerals-plant-roots)  [**http://highered.mheducation.com/sites/9834092339/student\_view0/chapter5/primary\_active\_transport.html**](http://highered.mheducation.com/sites/9834092339/student_view0/chapter5/primary_active_transport.html)  **Rich questions:**  Why do poisons which inhibit respiration, result in active transport stopping?  Suggest why overwatering of plants can kill the plant. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Relate the structure and properties of exchange surfaces to their function. | 0.2 weeks | • explain the adaptations of exchange surfaces, and the cells which make them up, to maximising the rate of transport across their exchange surfaces. | **Learning activities:**  - Questioning to assess understanding of diffusion, facilitated diffusion and active transport.  - Provide groups with diagrams/pictures of exchange surfaces and/or their cells around the room and a short synopsis of the context in terms of what is being exchanged e.g. fish gills, villi, epithelial cells of the ileum. Ask pupils to suggest how their structure and properties allow them to fulfil this function.  - Ask class to generate “Golden rules” to look for, e.g. cells involved in active transport have large numbers of mitochondria as these produce the ATP needed to transport against a concentration gradient.  - Past exam questions.  **Skills developed by learning activities:**   * Extended exam answers. | **Past exam paper material:**  BIOL1 Jun11 Q8b  Exampro | **Rich questions:**  - What does Fick’s law state?  - What common adaptations do exchange surfaces/cells of exchange surfaces have? |
| Extension |  |  | Microscopy of cells that have adaptations for exchange. Ask pupils to identify and explain these adaptations.  - Teacher led explanation based on feedback. |  |  |

### 3.1.5 Gas exchange and the transport of oxygen in living organisms.

#### 3.1.5.1 Surface area to volume relationship

Prior knowledge:

**Nothing explicit in Core/Additional GCSE specifications.**

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The relationship between the size of an organism and its surface area to volume ratio.  Differences in body shape and the development of systems in larger organisms as adaptations that facilitate exchange as the relationship between surface area.  In large organisms the efficient supply of materials, such as oxygen, is achieved by mass transport and volume changes. | 0.2  weeks | • explain how the size of an organism affects its surface area to volume ratio, and why this is important.  • apply your knowledge of surface area to volume ratio, to explain adaptations to body shape or the development of exchange systems.  • calculate surface area to volume ratios when supplied with cell/organism dimensions. | **Learning activities:**  - Get students to make multilink block cubes, increasing in size, and investigate the effect on SA:vol ratio.  - Get students to calculate the surface area and volume of the cubes, and work out the ratios. Ask them to draw conclusions linking SA:vol ratio to diffusion.  - Question about the consequences to larger organisms.  - Teacher led explanation as to how this has necessitated the development of exchange surfaces and mass transport systems, or a change to body shape for larger organisms.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 3 -** Calculate the surface area to volume ratios of different shaped object/cells/organisms when supplied with their dimensions.  **AO1 –** Development of knowledge of why larger organisms have specialised surfaces and mass transport systems, or particular body shapes. | **Past exam paper material:**  BIOL2 Jun12 Q1a;  HBIO2 Jun13 – Q1;  HBIO2 Jun09 – Q5;  BIO3X 2013 EMPA. |  |
| Extension |  |  | - Model 1cm3 ‘animals’ in plasticine in various shapes, e.g. sphere, cube, cylinder. Calculate SA:vol ratio. Squash into a different shape, eg flatten, and re-calculate.  - Students use multilink blocks to produce shapes with larger SA;vol ratios to model the changes to body shape. |  |  |

#### 3.1.5.2 Gas exchange systems

Prior knowledge:

- Exercise increases the rate and depth of breathing.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Adaptations of gas exchange systems, as shown by gas exchange across the body surface of a single celled organism and in the tracheal system of an insect.  Structural and functional compromises between gas exchange and the limitation of water loss shown by terrestrial insects. | 0.4 weeks | • explain the adaptations that single celled organisms have to efficient gas exchange.  • describe the structure of insect tracheal systems.  • explain how the tracheal system is adapted to ensuring efficient gas exchange.  • explain how tracheal systems balance the needs for gas exchange whilst minimising water loss. | **Learning activities:**  - Question students about the necessity for gases to be exchanged, and how a single celled organism might be adapted to doing this. Extend by asking why larger organisms would need further specialised surfaces and systems for doing this.  - Observe breathing movements of a stick insect held in a boiling tube.  - Centres could conduct a dissection of a locust ventilatory system or observe locust mounts under a microscope (this is not a requirement of the specification).  - Teacher led explanation about the gas exchange systems in insects and how they are adapted. Link to the compromise which is reached between sufficient gas exchange and limiting water loss.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge of the adaptations shown by single celled organisms and by insect tracheal systems, and how gas exchange in insects has to be balanced against water loss. | **Past exam paper material:**  BIOL2 Jun13 - Q8b-8g**;**  BIOL2 Jun09 - Q8a;  BIOL2 Jan12 - Q9b-9f;  BIOL2 Jan10 - Q8. | [**http://www.nuffieldfoundation.org/practical-biology/dissection-ventilation-system-locust**](http://www.nuffieldfoundation.org/practical-biology/dissection-ventilation-system-locust)  **Rich questions:**  - Explain the adaptations present in insect tracheal systems. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Adaptations of gas exchange systems as shown by gas exchange by leaves of dicotyledonous plants.  Structural and functional compromises between gas exchange and the limitation of water loss shown by xerophytic plants. | 0.4 weeks | • describe the internal structure of a leaf.  • explain how the structure is adapted to allow efficient gas exchange, and why this is necessary.  • explain what a xerophytic plant is.  • explain the adaptations that xerophytic plants have and how these balance the needs for gas exchange whilst minimising water loss. | **Learning activities:**  - Microscopy of vertical sections through dicotyledonous plant leaf.  - Microscopy of nail varnish painted on underside of the leaf to see stomata.  - Teacher explanation of how the structure of a leaf is adapted for gas exchange. Link this to photosynthesis.  - Highlighting exercise on xerophytic plants, in which students highlight any adaptations they have to water conservation.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge of leaf structure, and the adaptations present in xerophytes.  **AO2 –** Application of earlier learning on features which increase the rate of exchange, to explain features to reduce water loss in xerophytic plants. | **Past exam paper material:**  BIOL2 Jun12 Q1b.  BIOL2 Jan10 Q5  Exampro –  BYB3 Jun06 Q1  BYB3 Jan06 Q2 | [**http://www.saps.org.uk/secondary/teaching-resources/799-video-clip-leaf-structure**](http://www.saps.org.uk/secondary/teaching-resources/799-video-clip-leaf-structure)  **Rich questions:**  - Explain the ways in which the structure of a leaf is adapted to gas exchange.  - Explain the adaptations present in xerophytic plants in reducing water loss. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The gross structure of the human gas exchange system, limited to the alveoli, bronchioles, bronchi, trachea and lungs.  The mechanism of breathing to include the role of the diaphragm and the intercostal muscles in bringing about pressure and volume changes in the thoracic cavity. | 0.4 weeks | • explain the purpose of ventilation in terms of maximising gas exchange.  • explain inspiration and expiration in terms of the movements of the ribs and diaphragm and the pressure changes which these cause in the thoracic cavity.  • interpret and explain data relating to breathing, e.g. spirometer traces. | **Learning activities:**  **-** Assess prior learning/understanding.  - Dissection of lungs with emphasis on identification of key parts.  - Teacher explanation of key aspects of lungs, e.g. C-shaped rings of cartilage.  **-** Use balloon lungs in a jar, or get students to construct a lung model, to show breathing is due to changes in pressure due to changes in thoracic volume.  - Teacher explanation of the process of inspiration and expiration and the mechanism by which it occurs.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge of mechanism of breathing and associated measurements.  **AO3/AO2 -** Interpret graphs showing spirometer traces. | **Past exam paper material:**  BIOL1 Jan13 - Q1;  BIOL1 Jan12 - Q2;  BIOL1 Jun10 -Q2.  BIOL4 Jun12 - Q6.  BIOL 4 Jan11 - Q6a and 6b. | [**http://www.nuffieldfoundation.org/practical-biology/modelling-human-ventilation-system**](http://www.nuffieldfoundation.org/practical-biology/modelling-human-ventilation-system)  [**http://www.nuffieldfoundation.org/practical-biology/dissecting-lungs**](http://www.nuffieldfoundation.org/practical-biology/dissecting-lungs)  **Rich questions:**  Compare and contrast the human gas exchange system with that of an insect or a fish.  Why do the trachea and bronchi have C-shaped rings of cartilage, but the bronchioles do not? |
| Extension |  |  | - Students conduct a practical to measure volumes of air being breathed in e.g. spirometers **or** respirometers with manometer tube and scale and 3 way tap. |  | [**http://www.nuffieldfoundation.org/practical-biology/measuring-rate-metabolism**](http://www.nuffieldfoundation.org/practical-biology/measuring-rate-metabolism)  [**http://www.nuffieldfoundation.org/practical-biology/using-spirometer-investigate-human-lung-function**](http://www.nuffieldfoundation.org/practical-biology/using-spirometer-investigate-human-lung-function) |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The essential features of the alveolar epithelium and capillaries as a gas exchange surface. | 0.2 weeks | • explain the process of gas exchange, related to blood circulation and ventilation.  • describe the features of the squamous epithelium which makes up the gas exchange surface.  • describe the features of the capillaries which lie adjacent to the alveoli, and how they allow gas exchange.  • explain how the squamous epithelium is adapted to maximising gas exchange (related to Fick’s law).  • use the principles involved in the exchange of gases to identify and explain the adaptations of unfamiliar examples of gas exchange surfaces. | **Learning activities:**  **-** Teacher led explanation of the process of gas exchange linked to ventilation and circulation.  - Relate the maintenance of a diffusion gradient to circulation and ventilation.  - Provide unfamiliar examples of gas exchange surfaces e.g. fish gills, and ask students to identify the adaptations e.g. large surface area of gill lamellae.  - Exam questions.    **Skills developed by learning activities:**  **AO1 –** Development of knowledge of mechanism of gas exchange across the alveolar epithelium and capillaries.  - Extended exam answers | **Past exam paper material:**  BIOL 1 Jun13 - Q3;  BIOL1 Jun12 - Q3;  BIOL 1 Jun09 - Q6;  BIOL 1 Jun10 - Q7b;  BIOL 1 Jan10 - Q2. | [**http://highered.mheducation.com/sites/0072495855/student\_view0/chapter25/animation\_\_gas\_exchange\_during\_respiration.html**](http://highered.mheducation.com/sites/0072495855/student_view0/chapter25/animation__gas_exchange_during_respiration.html)  **Rich questions:**  - Explain the adaptations present alveoli to maximising gas exchange. |
| Extension |  |  | - Microscopy of squamous epithelial cells to look for further adaptations related to Fick’s law.  - Collate feedback and emphasise key points about the features of the alveolar epithelium. |  |  |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Lung diseases relating to the effects of lung disease on gas exchange and ventilation. | 0.2 weeks | • interpret information relating to the effects of lung disease on gas exchange and ventilation.  • suggest explanations as to the causes and symptoms of some common lung diseases. | **Learning activities:**  - In advance of the lesson, ask students to conduct some independent research into some common lung diseases, e.g. asthma, emphysema, fibrosis.  - Get students to share findings, e.g. through group talk or a class presentation.  - Use a past exam question to model the process of interpreting lung disease data.  - Teacher explanation of how to critically analyse and evaluate data showing correlations.  - Past exam questions  **Skills developed by learning activities:**  **AO3** – Analyse and interpret scientific information and evidence to assess the effects of the disease on gas exchange and ventilation. | **Past exam paper material:**  BIOL1 Jun11 - Q4;  BIOL1 Jan09 - Q4;  BIOL1 Jan11 - Q7b; | **Rich questions:**  - What are the causes and symptoms of each lung disease?  - What effect does the disease have on ventilation and/or gas exchange? |

#### 3.1.5.3 Haemoglobin and the transport of oxygen

Prior knowledge:

- Exercise increases the heart rate.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The general pattern of blood circulation in a mammal involving arteries, capillaries and veins (limited to the coronary arteries and vessels entering and leaving the heart and liver). | 0.2 weeks | • explain what is meant by a double circulatory system.  • describe the structure of the circulatory system, with particular reference to the blood vessels supplying the heart muscle and entering/leaving the heart and liver.  • link the structure of the circulatory system to its role in exchanging and transporting materials. | **Learning activities:**  **-** Teacher explanation of why mass transport systems are needed in large organisms.  - Teacher explanation of the double circulatory system, using animations and videos.  - Students complete labelled diagram of organs and blood vessels, based on their learning.  - Exam questions from Exampro.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding or circulation and the key blood vessels entering and leaving the liver and heart and supplying the cardiac muscle. | **Past exam paper material:**  BIOL2 Jun09 -Q1a - 1b | [**http://www.kscience.co.uk/animations/blood\_system.swf**](http://www.kscience.co.uk/animations/blood_system.swf)  **Rich questions:**  - Why do humans need a double circulatory system?  - Describe the journey of a red blood cell around one circuit of the body, naming the main blood vessels and the chambers of the heart. |
| Extension |  |  | - Student modelling of the double circulatory system – mark out the classroom to have a double circulation with the heart in the centre and desks for other organs. Students have to pick up oxygen, carbon dioxide, glucose and urea cards at key points and drop them at the correct points where they leave the blood. |  |  |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The haemoglobins are a group of chemically similar molecules found in many different organisms. They have a similar chemical structure consisting of a number of polypeptide globin chains each of which is associated with an iron-containing haem group.  The role of haemoglobin and red blood cells in the transport of oxygen in relation to the oxygen-haemoglobin dissociation curve.  The effect of carbon dioxide on the transport of oxygen by haemoglobin. | 0.4 weeks | • relate knowledge of protein structure to the structure of haemoglobin.  • explain what is meant by the term “partial pressure”.  • explain how the binding of one oxygen molecule changes the shape of haemoglobin, and how this affects the binding of further oxygen molecules.  • relate knowledge to explain the shape of an oxygen dissociation curve.  • explain the effect of carbon dioxide concentration on oxygen dissociation.  • relate this knowledge to explain oxygen loading and unloading in different tissues. | **Learning activities:**  - Use RasMol/information sheets to investigate the structure of haemoglobin. Ask students to relate this back to protein structure from 3.1.1.4.  - Teacher introduction to the dual role of haemoglobin in red blood cells of loading in the lungs and unloading in the respiring tissues (using animations).  - Teacher explanation of the oxygen dissociation curve, the concept of partial pressure and the Bohr effect (using animations).  - Get students to generate “Golden Rules” about what a shift to the left or right on the oxygen dissociation curve means.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge on oxygen loading, transport and unloading.  **AO2 –** Application of knowledge to explain the Bohr effect on an oxygen dissociation curve.  **AO3 -** Interpret data from graphs showing oxygen dissociation curves. | **Past exam paper material:**  BIOL2 Jun13 - Q6;  BIOL2 Jan12 - Q9a;  BIOL2 Jun10 - Q7a;  BIOL2 Jun10 - Q9 (except 9c). | [**http://www.rasmol.org/**](http://www.rasmol.org/software/RasMol_2.7.4.2_Manual.html)    [**http://www.johnwiley.net.au/highered/interactions/media/Respiration/content/Respiration/resp3a/screen0.swf**](http://www.johnwiley.net.au/highered/interactions/media/Respiration/content/Respiration/resp3a/screen0.swf)  **Rich questions:**  - Why does haemoglobin have a quaternary structure?  - What effect does the first oxygen binding have on the structure of haemoglobin?  - What are haemoglobin’s two seemingly conflicting roles (in the lungs and respiring tissues)?  - How are both roles achieved? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Many animals are adapted to their environments by possessing different types of haemoglobin with different oxygen-transporting properties. | 0.4 weeks | • describe and explain differences between the dissociation curves of different species.  • relate the oxygen transporting properties of different types of haemoglobin to the environment and way of life of the organism concerned. | **Learning activities:**  - Questioning used to recap and assess understanding of the Bohr effect and oxygen dissociation.  - Think – Pair – Share – Show dissociation curves comparing human and bird haemoglobin and ask students to suggest why birds have a curve to the right.  - Provide environmental information on other organisms, e.g. lugworms and ask students to suggest what challenges they face and what their oxygen dissociation curve would be like in comparison to Human haemoglobin. They can present with explanation.  - Accept feedback and use as a prompt for discussion.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge on oxygen loading, transport and unloading.  **AO3/AO2 -** Interpret data showing oxygen dissociation curves and apply knowledge of oxygen dissociation and adaptations of organisms to suggest explanations. | **Past exam paper material:**  BIOL2 Jan11 - Q2;  BIOL2 Jun09 - 8b-c;  BIOL2 Jun11 - Q6a;  BIOL2 Jun10 - Q7b;  BIOL2 Jan10 - Q4. | **Rich questions:**  Provide examples of organisms and the conditions in which they live e.g. birds. Then show oxygen dissociation curves and ask students to relate this to the environmental conditions. |

### 3.1.6 Living organisms vary

Prior knowledge:

- Variation between organisms can be caused by the genes they inherit, the conditions in which they develop, or both.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Intraspecific variation is variation between members of a species.  Interspecific variation is variation between species.  **Required practical 3:**  Use of chromato-graphy to investigate the pigments present in leaves. | 0.4 weeks | • explain what is meant by intraspecific and interspecific variation.  • analyse and interpret data referring to intraspecific and interspecific variation.  • explain how to extract photosynthetic pigments from leaves and separate them using chromatography.  • calculate Rf values from experimentally derived results. | **Learning activities:**  - Question students about what they understand by the term “variation”.  - Introduce the concept of intraspecific and interspecific variation, drawing analogies to the use of the prefix intra and inter in other contexts, e.g. intranet and internet.  - Think – Pair – Share discussion using rich question.  - Students investigate differences in photosynthetic pigments present between different plant species.  - Students calculate Rf values.  - Comparison of Rf values to published data to identify pigments.  - Discussion and conclusions about the differences found in plant leaves of different species and from different environments.  - Provide students with data to interpret showing the variation in a characteristic within a species/between species. Ask pupils to analyse it and interpret it.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge about interspecific and intraspecific variation.  **AO3/AO2 -** Interpret data about inter/intraspecific variation. | **Past exam paper material:**  Exampro  BIO6T P12 ISA. | [**http://www.saps.org.uk/secondary/teaching-resources/181-student-sheet-10-thin-layer-chromatography-for-photosynthetic-pigments**](http://www.saps.org.uk/secondary/teaching-resources/181-student-sheet-10-thin-layer-chromatography-for-photosynthetic-pigments)  **Rich question:**  Would interspecific variation show greater diversity or less diversity than intraspecific variation? Explain your answer.  - What is chromatography used for?  - What is meant by Rf values? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Similarities and differences between individuals within a species may be the result of genetic factors, differences in environmental factors or a combination of both.  The concept of normal distribution about a mean. Understanding of mean and standard deviation as measures of variation within a sample. | 0.4 weeks | • explain what causes variation between individuals of the same species.  • explain what is meant by the terms “continuous” and “discontinuous” variation.  • explain what is meant by a normal distribution, and the mathematical properties it possesses.  • explain what a mean and standard deviation are, how they are calculated and what they show as measures of variation within a population. | **Learning activities:**  - Teacher introduction as to the causes of variation.  - Introduce graphs showing discontinuous and continuous patterns of variation and explain the causes behind them.  - Card sort – Provide cards containing features which vary between individuals, e.g. intelligence, blood group, ability to play the trumpet etc. Sort features into three categories: genetic only; environmental only and combination of the two.  - Students could measure variation within the group for characteristics showing discontinuous variation and continuous variation and plot results using spreadsheets.  - Teacher led discussion of trends in data and the types/causes of variation.  - Explain the concept of a normal distribution and introduce the concepts of a mean and standard deviation. Show how each is calculated.  - Provide a practice example for students to work the calculations through/get students to do the calculations on the data taken in their study.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 4, 5, 9, 16 –** Calculation of standard deviation and mean. Understanding of the terms median and mode. Interpretation of graphs.  **AO1 –** Development of knowledge about interspecific and intraspecific variation.  **AO3/AO2 -** Interpret data about inter/intraspecific variation. | **Past exam paper material:**  BIOL2 Jan13 - Q4;  BIOL2 Jun15 - Q2a  HBIO4 Jan13 - Q3.  HBIO4 Jun11- Q4 and Q10e | [**http://learn.genetics.utah.edu/content/variation/sources/**](http://learn.genetics.utah.edu/content/variation/sources/)  **Rich questions:**  - Is a mean useful information when measuring variation?  Explain your answer.  - Provide data showing two identical means for a feature in two different populations, e.g. leaf length. Ask students whether you would expect the leaves to be the same.  -Explain why it is useful to calculate standard deviation alongside a mean.  -Evaluate the statement “The standard deviation is the same as the range”.  - What causes discontinuous and continuous variation?  - Explain why siblings are so varied, even though they have the same parents. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| In investigations of intraspecific variation, the need for random sampling and the importance of chance in contributing to the difference between samples.  The importance of appropriate sample size in ensuring that data are representative. | Up to 1  week | • explain how random samples can be obtained.  • represent raw and processed data clearly using tables and graphs.  • interpret data in terms of means and the overlap of standard deviation bars.  • apply knowledge of to draw and explain conclusions.  • evaluate the quality of results and reliability of conclusions. | **Learning activities:**  - Introduce students to the concepts of probability and chance. Explain that trends or differences between sets of data may not have a biological cause. (You may wish to briefly introduce null hypotheses and stats tests at this point).  - Introduce the concept of sampling at random to eliminate bias, and need to take sufficient samples.  - Students conduct a quantitative investigation into variation, e.g. the effect of light intensity on leaf size. This could include:  - research into methods.  - designing a practical.  - carrying out (subject to teacher approval).  - processing and presentation of data.  - evaluation and explanation findings.  - 2011 ISA Paper BIO3T Q.  **Skills developed by learning activities:**  **Mathematical requirement 4, 5, 6, 7, 9, 14 –** Correct use of the terms chance and probability. Understand the need for random sampling and appropriate sample sizes to ensure that the data is representative. Calculation of standard deviation and mean. Construct and interpret tables.  **AO4 -** Understand how to use sampling techniques.  **AO3** – Analyse, interpret and evaluate scientific information and evidence to make judgements and reach conclusions. | **BIO3T ISA Q11**  **Past exam paper material:**  BIOL2 Jan13 - Q4,  BIOL2 Jan12 - Q7.  BIOL4 Jun10 - Q7a. | [**http://www.nuffieldfoundation.org/practical-biology/recording-variation-ivy-leaves**](http://www.nuffieldfoundation.org/practical-biology/recording-variation-ivy-leaves)  [**www.aqa.org.uk**](http://www.aqa.org.uk)  **Rich questions:**  Describe how we could obtain random samples.  Explain why we need to ensure that samples are random. |

### 3.1.7 DNA, genes and chromosomes.

#### 3.1.7.1 The structure of nucleic acids.

Prior knowledge:

– DNA holds the genetic information for our features and characteristics.

– Chromosomes are made of DNA which has a double helix structure.

– DNA is contained within the nucleus of cells.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| DNA is a polymer of nucleotides. Each nucleotide is formed from a pentose, a phosphate group and a nitrogen-containing organic base.  DNA nucleotides consist of deoxyribose, a phosphate group and one of the bases adenine, cytosine, guanine or thymine.  A molecule of DNA is a double helix with two polynucleotide chains held together by hydrogen bonds formed between complementary base pairs. | 0.4 weeks | • explain the significance of DNA to organisms.  • explain the structure of DNA, and identify structural components from diagrams.  • apply knowledge of complementary base pairing rules to work out the frequency of certain bases, when provided with information about the frequency the other bases.  • explain why many scientists initially doubted that DNA was the genetic code. | **Learning activities:**  - Show data from Chargaff’s experiments. Students generate “Golden rules” and questions it raises.  - Teacher explanation of nucleotide structure and how this assembles to a double helix structure (using animations, videos and diagrams).  - Questioning about how structure relates to function, and ask students to suggest why many scientists did not believe DNA to be the genetic code.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Knowledge and understanding of scientific ideas.  **AO2/AO3 –** Analysing data on base frequency, and applying knowledge of base pairing, to work out frequency of other bases. | **Past exam paper material:**  BIOL2 Jun12 -Q5a,  BIOL2 Jun09 -Q2;  HBIO2 – Jun13 - Q4a | [**http://www.yourgenome.org/teachers/zoom.shtml**](http://www.yourgenome.org/teachers/zoom.shtml)  [**http://cell-cell-cell.com/wp-content/uploads/CCC\_Activity\_ModellingTheHelix\_v01.doc**](http://cell-cell-cell.com/wp-content/uploads/CCC_Activity_ModellingTheHelix_v01.doc)  [**http://genetics.thetech.org/online-exhibits/zooming-dna**](http://genetics.thetech.org/online-exhibits/zooming-dna) |
| Extension |  |  | - Modelling DNA structure using molymod DNA kit, jelly babies or paper model. |  | [**http://www.yourgenome.org/teachers/yummy.shtml**](http://www.yourgenome.org/teachers/yummy.shtml)  [**http://www.yourgenome.org/teachers/origami.shtml**](http://www.yourgenome.org/teachers/origami.shtml) |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| RNA is a polymer of nucleotides. Each nucleotide is formed from a pentose, a phosphate group and a nitrogen-containing organic base.  RNA nucleotides consist of ribose, a phosphate group and one of the bases adenine, cytosine, guanine or uracil.  Ribonucleic acid is important in all living cells, as it transfers genetic information from DNA to ribosomes.  A molecule of RNA is a relatively short polynucleotide chain. The structure of mRNA and tRNA. | 0.2 weeks | • explain the roles of mRNA and tRNA.  • explain the general structure of RNA, and identify structural components of an RNA nucleotide from diagrams.  • compare and contrast the similarities and differences between DNA and RNA.    • compare and contrast the similarities and differences between mRNA and tRNA. | **Learning activities:**  - Teacher explanation of types of RNA and their roles, with focus on messenger and transfer RNA.  - Comprehension on RNA structure. Students highlight differences to DNA.  - Teacher explanation of single stranded RNA structure related to function.  - Provide DNA sequence (sense strand) and ask students to produce the complementary mRNA sequence.  - Show structures of mRNA and tRNA and ask students to compare and contrast.  - Get students to generate a summary table comparing and contrasting the similarities and differences between DNA, mRNA and tRNA.  - Past exam questions  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding about RNA.  **AO2 –** Interpreting DNA sequence and applying knowledge to work out complementary mRNA code. | **Past exam paper material:**  HBIO2 Jan12 - Q1;  Exampro  BYA3 Jan03 Q1a  BYB2 Jun09 Q3a - 3c;  BYB2 Jun05 Q3; | **Rich questions**:  Why can we not work out the frequency of bases in RNA when provided with data about the frequency of some of the other bases?  How does the short, single stranded structure of RNA suit its role?  What similarities do mRNA and tRNA have?  What differences do mRNA and tRNA have? |

#### 3.1.7.2 DNA, genes and chromosomes

Prior knowledge:

– Chromosomes are made of DNA which has a double helix structure.

– A gene is a small section of DNA with the code for a particular combination of amino acids which make a specific protein.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| In the nucleus of a eukaryotic cell, DNA is in the form of linear molecules which are associated with proteins. Some of these proteins are the histones that package and order DNA to form a chromosome.  The DNA found in mitochondria and chloroplasts and in prokaryotic cells is shorter in length, circular and is not associated with proteins.  Most genes occupy fixed loci on particular DNA molecules. A gene is a section of DNA that codes for polypeptides that determine the nature and development of an organism.  In eukaryotes, much of the nuclear DNA does not code for polypeptides. There are non-coding multiple repeats of base sequences between genes. Even within a gene, only some sequences, called exons, code for amino acid sequences. Within the gene, these exons are separated by non-coding sequences called introns.  The concept of the genome. | 0.4 weeks | • explain what is meant by the terms genome, chromosome and gene.  • compare and contrast DNA in eukaryotes with that of prokaryotes, mitochondria and chloroplasts.  • explain what a gene could code for.  • explain why much of eukaryotic DNA can be considered as non-coding.  • explain what is meant by an intron and an exon. | **Learning activities:**  - Questioning about the meaning of key terms like gene, chromosome and allele based on prior learning.  - Practical: Extracting DNA from a source material such as peas or kiwi fruit (as a stimulus to DNA and chromosomes).  - Use animation to show scale of chromosomes in eukaryotic cells, and how chromosomes are made of DNA and histones. Introduce the concept of a gene and the genome.  - Teacher explanation about the difference between the arrangement of DNA in prokaryotic cells and eukaryotic cells. Explain that eukaryotic DNA contains non-coding regions between and within genes.  - Students generate a summary table comparing and contrasting prokaryotic and eukaryotic DNA.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of the arrangement of DNA in eukaryotes and prokaryotes, and of coding and non-coding sections. | **Past exam paper material:**  HBIO4 Jan12 -Q2c;  HBIO2 Jun14 -Q2 a and c;  HBIO2 Jan13 - Q2;  HBIO2 Jan13 - Q7;  HBIO2 Jun12 - Q4a-b;  HBIO4 Jan10 - Q8a; | [**http://www.nuffieldfoundation.org/practical-biology/extracting-dna-living-things**](http://www.nuffieldfoundation.org/practical-biology/extracting-dna-living-things)  [**http://www.yourgenome.org/teachers/zoom.shtml**](http://www.yourgenome.org/teachers/zoom.shtml)  [**http://learn.genetics.utah.edu/content/chromosomes/**](http://learn.genetics.utah.edu/content/chromosomes/)  **Rich questions:**  - A textbook stated that “The bacterial chromosome is found in the cytoplasm of the cell”. Evaluate this statement.  - What is the difference between a gene and a chromosome?  - What are introns and exons?  - Does the genome vary between different types of cell? Explain your answer. |
| Extension |  |  | - Ask students to compare the structure of prokaryotic cells with mitochondria and chloroplasts, identify similarities and suggest a theory. This may lead on to a discussion about the theory of endosymbiosis. |  |  |

#### 3.1.7.3 DNA replication

Prior knowledge:

– When a cell divides by mitosis or meiosis, copies of the genetic information are made.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The semi-conservative replication of DNA, in terms of:   * the unwinding of the double helix. * breakage of hydrogen bonds between complementary base pairs. * the role of DNA helicase. * attraction of new nucleotides to exposed bases. * complementary base pairing. * the role of DNA polymerase in joining DNA nucleotides. | 0.2  weeks | • describe the process of DNA replication.  • explain the significance of DNA replication. | **Learning activities:**  - DARTS task – Students convert comprehension on DNA replication into a diagrammatic representation and then present to group.  - Evaluation of presentations.  - Teacher explanation, focussed on remaining weaknesses, using videos and animations.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of DNA replication.  - Extended exam answers. | **Past exam paper material:**  BIOL2 Jan13 - Q8a**;**  BIOL2 Jun13 -4a-4b;  HBIO2 Jun14 -Q5;  HBIO2 Jun13 - Q3 (except b);  HBIO2 Jun10 – Q1; | **Rich questions:**  **-** Describe the process of semi-conservative DNA replication, including the role of key enzymes. |
| Extension |  |  | - Teacher explanation of Meselson-Stahl experiment.  - Application of knowledge to predict band patterns for subsequent generations. | HBIO2 Jan10 -Q4; | [**http://www.sumanasinc.com/webcontent/animations/content/meselson.html**](http://www.sumanasinc.com/webcontent/animations/content/meselson.html) |

### 3.1.8 Protein synthesis

#### 3.1.8.1 The genetic code

Prior knowledge:

– A gene is a small section of DNA with the code for a particular combination of amino acids which make a specific protein.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The genetic code as base triplets that code for specific amino acids.  The genetic code is universal, non-overlapping and degenerate. | 0.2 weeks | • explain how the DNA base sequence is able to code for the primary structure of a polypeptide.  • explain the terms degenerate, universal and non-overlapping. | **Learning activities:**  - Remind students that there are 20 amino acids and only 4 bases. Ask how many bases would have to code for an amino acid to give sufficient combinations.  - Teacher explanation of the triplet code and the fact that there is degeneracy (as well as the fact it is universal and non-overlapping).  - Ask the rich question how many bases code for a polypeptide of 24 amino acids.  - Explain why the answer might in fact be more than 72 as there are introns in the gene. Introduce the idea of introns and also non-coding regions between genes.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical Requirement 3 -** Students could calculate the fraction/ratio/percentage of human DNA which does code for polypeptides, when supplied with data about the number of coding bases and the total number of bases.  **AO1 –** Development of knowledge and understanding of the triplet code. | **Past exam paper material:**  BIOL2 Jun12 -Q5b,  BIOL2 Jun11- Q3a,  BIOL2 Jan10 - Q3;  HBIO2 Jun10 - Q4; | [**http://www.yourgenome.org/teachers/dnaprotein.shtml**](http://www.yourgenome.org/teachers/dnaprotein.shtml)  **Rich questions:**  What is meant by the terms:   * degenerate? * non-overlapping? * universal?   A polypeptide is made of 24 amino acids. What is the minimum number of bases that the gene coding for it must have had?  Why might it be more than this in reality? |

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#### 3.1.8.2 Polypeptide synthesis.

Prior knowledge:

– Protein synthesis occurs in the ribosomes.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | | | **Assessment opportunities** | | **Resources** |
| Transcription as the production of mRNA from DNA. The role of RNA polymerase in joining RNA nucleotides.  - In prokaryotes, transcription results directly in the production of mRNA from DNA.  - In eukaryotes, transcription results in the production of pre-mRNA. Pre-mRNA is then spliced to form mRNA. | 0.4 weeks | • interpret data from experimental work investigating the role of nucleic acids.  • explain the process of transcription in prokaryotes.  • explain the process of transcription and splicing in eukaryotes, linking this to knowledge of introns.  • explain the structure of mRNA and how it is related to its function. | **Learning activities:**  **-** Questioning to recap knowledge about the role of DNA and RNA from section 3.1.7.1.  - Provide students with data from experimental work investigating the role of nucleic acids, e.g. the Hershey-Chase experiment, and ask them to interpret this.  - Introduce concept of genome and proteome.  - Teacher explanation of the process of transcription, and how the structure of mRNA relates to its function of transferring the code to the ribosomes. Use animation to support this.  - Mini-whiteboards. Provide a DNA code, identify the sense strand, and ask students to transcribe it (assuming there are no introns).  - Past exam questions.  **Skills developed by learning activities:**  **AO2/AO4-** Apply knowledge of transcription and nucleic acids to explain experimental data from investigations into the role of nucleic acids.  **AO1 –** Development of knowledge around transcription, and the structure and role of mRNA. | | | **Past exam paper material:**  BIOL5 Jun10 - Q2,  BIOL5 Jun11- Q1a-b | | [**http://www.yourgenome.org/teachers/dnaprotein.shtml**](http://www.yourgenome.org/teachers/dnaprotein.shtml)  **Rich questions:**  What are the advantages of mRNA being used to carry the genetic code to the ribosomes, rather than DNA?  Explain how mRNA is adapted to its function.  What is the difference between mRNA and pre-mRNA in eukaryotes?  Provide students with a DNA sense strand code and ask them to transcribe it into pre-mRNA/mRNA. |
| **Learning objective** | **Time taken** | **Learning Outcome** | | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | | **Resources** | |
| Translation is the production of polypeptides, from the sequence of codons on mRNA. The roles of ribosomes, tRNA and ATP. | 0.4 weeks | • explain the process of translation.  • explain the specific roles of ribosomes, ATP and tRNA in translation.  • explain how the structure of tRNA is related to its function.  • relate the base sequence of nucleic acids to the amino acid sequence of polypeptides, when provided with suitable data about the genetic code. | | **Learning activities:**  **-** Questioning to recap knowledge about transcription, the role of ribosomes from section 3.2.1 and ATP from section 3.1.6.  - Teacher explanation of the process of translation, and how the structure of tRNA relates to its function in delivering the specific amino acid to the amino-acyl site. Use animation to support this.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge around translation, and the structure and role of tRNA.  **AO2 –** Application of knowledge to translate a mRNA sequence into a sequence of amino acids. | **Past exam paper material:**  BIOL5 Jun12- Q1 (except Q1cii and 1d);  HBIO4 Jun11- Q1;  HBIO2 Jun12- Q6b;  HBIO2 Jan10 - Q2; | | [**http://www.yourgenome.org/teachers/dnaprotein.shtml**](http://www.yourgenome.org/teachers/dnaprotein.shtml)  **Rich questions:**  Evaluate the statement “DNA is a triplet code which instructs the ribosomes how to make amino acids”.  Explain how the structure of tRNA is adapted to its function.  Provide students with a mRNA code and ask them to translate it into an amino acid sequence (when provided with appropriate information). | |
| Extension |  |  | | - Students could be given velcro strips and could velcro mRNA nucleotide letters to produce a sequence which their partner has to interpret and translate into an amino acid sequence. This can be done with amino acid cards, which they join using treasury tags.  - Students could produce a video podcast summarising the whole process of protein synthesis (using plasticine models as an aid). |  | |  | |

#### 3.1.8.3 Protein folding

Prior knowledge:

– The shape of a protein is vital to its function.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Protein folding as the process by which a polypeptide folds into its characteristic three-dimensional structure.  Protein folding is determined by the amino acid sequence of the polypeptide.    Specialised proteins called chaperones assist in the folding of other proteins. | 0.2 weeks | • explain the relationship between the tertiary structure of a protein, the primary structure of a protein and the nucleic acid sequence of a gene.  • explain the role of chaperone proteins. | **Learning activities:**  - Question students about the hierarchical organisation of proteins covered in section 3.1.1.4, with particular emphasis on the bonds involved in tertiary structure.  - Set students the overarching question “How is DNA able to code for your features?”. Through discussion arrive at the idea that proteins play a key part in determining our features and the DNA sequence determines the order of amino acids in a polypeptide. This in turn determines the folding.  - Teacher led explanation of the process of polypeptide folding and the role of chaperone proteins. Use the animation to support this (although not all of it is required).  - Students could produce an overview of polypeptide synthesis, transcription to polypeptide folding, in a style of their choice, e.g. flow diagram, annotated comic strip format, essay etc.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge around protein folding and the role of chaperone proteins. |  | [**http://www.sumanasinc.com/webcontent/animations/content/lifecycleprotein.html**](http://www.sumanasinc.com/webcontent/animations/content/lifecycleprotein.html)  **Rich questions:**  - If chaperone proteins were not present during polypeptide synthesis, what might happen? What would the consequence of this be?  - What role does ATP play in the folding process? |

### 3.1.9 Genetic diversity may arise by meiosis

#### 3.1.9.1 Meiosis

Prior knowledge:

- Cells in reproductive organs divide to form gametes by a process called meiosis.

- When a cell divides during meiosis, copies of the genetic information are made and then the cell divides twice to form four gametes, each with a single set of chromosomes.

- When gametes join at fertilisation, a single body cell with new pairs of chromosomes is formed.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Meiosis results in daughter cells that are genetically different from each other.  The process of meiosis involves two nuclear divisions and forms four haploid daughter cells.  Independent segregation and crossing over result in genetically different daughter cells.  Random fertilisation of haploid gametes further increases genetic variation within a species. | 0.4 weeks | • explain how meiosis results in variation.  • describe and explain chromosomal behaviour in appropriate drawings or photographs of meiosis.  • complete diagrams showing the chromosome content of cells after the first and second meiotic division, when given the chromosome content of the parent cell.  • explain how random fertilisation of haploid gametes further increases genetic variation within a species. | **Learning activities:**  - Introduce the convention of 2n and n. Students then calculate the number of possible chromosome combinations (without crossing over).  - Think, Pair, Share – There is more variation possible than our calculated number – where does the extra genetic diversity come from?  - Teacher explanation of the process of meiosis, supported by animations and videos.  - Students interpret information about meiosis from diagrams/photos, explaining the behaviour of chromosomes.  - Past exam questions.    **Skills developed by learning activities:**  **AO1 –** Development of knowledge of meiosis.  **AO2 –** Application of knowledge to describe/explain diagrams or photos. | **Past exam paper material:**  BIOL2 Jun13 - Q1;  BIOL2 Jun10 - Q5;  BIOL2 Jan11 - Q4;  HBIO2 Jan13 - Q5;  HBIO2 Jun09 - Q4a-b; | [**http://www.nuffieldfoundation.org/practical-biology/preparing-anther-squash**](http://www.nuffieldfoundation.org/practical-biology/preparing-anther-squash)  [**http://highered.mheducation.com/sites/0072495855/student\_view0/chapter3/animation\_\_how\_meiosis\_works.html**](http://highered.mheducation.com/sites/0072495855/student_view0/chapter3/animation__how_meiosis_works.html)  [**http://highered.mheducation.com/sites/0072495855/student\_view0/chapter2/animation\_\_comparison\_of\_meiosis\_and\_mitosis\_\_quiz\_1\_.html**](http://highered.mheducation.com/sites/0072495855/student_view0/chapter2/animation__comparison_of_meiosis_and_mitosis__quiz_1_.html)  [**http://www.sumanasinc.com/webcontent/animations/content/meiosis.html**](http://www.sumanasinc.com/webcontent/animations/content/meiosis.html)  **Rich question:**  Evaluate the statement “One of the ways that meiosis results in genetic diversity is through random fertilisation”. |
| Extension |  |  | - Practical to produce slides/use prepared slides to observe/draw cells in the stages of meiosis. |  |  |

### 3.1.10 Species and taxonomy

#### 3.1.10.1 The concept of a species

Prior knowledge:

- The concept of what a species is.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Species as the basic unit of biological classification.  A species may defined as the largest group of organisms capable of interbreeding and producing fertile offspring. | 0.2 weeks | • explain what a species is.  • explain the difficulties in defining the term species.  • critically examine the definition of a species when provided with data relating to specific examples. | **Learning activities:**  - Provide students with photos of organisms (some similar and some very different). Ask them how many species there are in the photos. Include some examples to throw them like several different breeds of dog.  - Provide the answer and ask students to consider why you have classed some as the same species and some as different species.  - Teacher explanation defining what a species is.  - Think – Pair – Share – Suggest what problems this definition of a species presents?  - Provide data relating to specific examples of similar organisms being different species, e.g. chromosome numbers, differences in courtship behaviours etc. and ask them to interpret the data.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of what a species is.  **AO2/AO3 –** Application of knowledge to interpret information and data relating to examples of whether the individuals are the same species. | **Past exam paper material:**  HBIO2 Jun13 - Q8a-b;  HBIO2 Jan12 - Q10biii;  HBIO2 Jan10 - Q1a;  BIOL2 Jan12 -Q3c;  BIOL2 Jun12 -Q6bii;  HBIO5 Jun12 -Q8bii | **Rich questions:**  - Define what a species is.  - Why are different types of dogs all members of the same species?  - What is the difficulty in applying this definition to species such as a bacterial species?  - What is the difficulty in applying this definition to fossil discoveries made which show close resemblance? |

**3.1.10.2 Biological classification**

Prior knowledge:

- Studying the similarities and differences between organisms allows us to classify organisms and understand evolutionary/ecological relationships.

- The concept of what a species is, and how fossil evidence shows how species have changed over time.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Biological classification attempts to arrange species in groups that reflect their relationships and may reflect their evolutionary origins. It uses a hierarchy in which smaller groups are placed with larger groups. Each group is called a taxon.  One taxonomic hierarchy comprises the taxa: domain, kingdom, phylum, class, order, family, genus and species.  Each species is universally identified by a binomial consisting of the name of its genus and species. | 0.4 weeks | • explain the hierarchical taxonomic ranks used in the classification of species.  • interpret phylogenetic trees.  • apply knowledge to identify different taxonomic ranks from information provided.  • appreciate the difficulties in constructing valid phylogenetic classifications. | **Learning activities:**  - Provide students with some pictures e.g., CD covers and ask them to group them into groups, becoming ever smaller until they reach CD level. Each group is likely to classify in a different way, underlining the difficulty of constructing a valid phylogenetic classification. This could also be done using a selection of nails, screws, paperclips, hair pins, drawing pins etc.  - Introduce hierarchical system used for classification of organisms. Relate to their CD classification.  - Students develop mnemonics to remember hierarchical taxonomic ranks.  - Provide pictures of organisms and ask them to repeat classification exercise.  - Discuss difficulties in constructing phylogenetic classifications based on external features e.g. fish and dolphins are very different, why anatomical and physiological features are better to use, and why modern day classification is still being refined.  - Exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of classification.  **AO2 –** Application of knowledge to the context of particular species, based on binomial name, to identify genus and species. | **Past exam paper material:**  BIOL 2 June 2009 – Q6a-6c; BIOL 2 Jan 2012 – Q3  BIOL 2 Jan 2010 – Q2;  HBIO2 – Jan 2013 Q6a-b;  HBIO2 – June 2012 Q6a;  Exampro  BYA4 June 05 - Q5; | **Rich questions:**  Provide information about the classification of different organisms and ask students to fill in the gaps e.g. determining the genus from the binomial name. |
| Extension |  |  | - Students could research and investigate comparative anatomy and embryology. |  |  |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Advances in immunology and genome sequencing help to clarify evolutionary relationships between organisms. | 0.2 weeks | - explain how genetic sequencing and immunology can help us to update our understanding of evolutionary relationships.  - interpret results from genetic and immunological analysis to clarify taxonomic relationships between organisms.  • explain how gene technology has changed the way in which relationships between organisms are worked out. | **Learning activities:**  - Show students a phylogenetic tree and ask them questions requiring them to interpret relationships and discuss common ancestors.  - Explain how changes in evolutionary features must have been mirrored by changes in proteins and therefore in DNA.  - Explain how DNA sequencing and immunological analysis can be used to determine how closely related organisms are. Link to the idea that this is refining our idea on classification and leading to reclassification of some species.  - Provide data from these experiments and ask students to interpret them.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of how the results genomic sequencing and immunological techniques can be used to refine our understanding of evolutionary relationships.  **AO2/AO3 –** Application of knowledge to interpret data and draw conclusions on evolutionary relationships. | **Past exam paper material:**  BIOL 2 Jan 2012 – Q6;  BIOL 2 June 2011 – Q7  HBIO2 – Jan 2013 Q6c;  HBIO2 June 2010 – Q7b;  **Exampro** | [**http://www.saps.org.uk/secondary/teaching-resources/815-classification-techniques-and-useful-plants**](http://www.saps.org.uk/secondary/teaching-resources/815-classification-techniques-and-useful-plants)  **Rich questions:**  - Explain why determining the similarity of DNA sequences for common genes is a valid way of determining evolutionary relationships.  - Explain why immunological comparisons are a valid way of determining evolutionary relationships.  - Explain why these techniques allow us to classify more accurately than comparing anatomical features. |

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### 3.1.11 Biodiversity within a community

#### 3.1.11.1 Genetic diversity

Prior knowledge:

- Studying the similarities and differences between organisms allows us to classify organisms and understand evolutionary/ecological relationships.

- Variation between organisms can be caused by the genes they inherit, the conditions in which they develop, or both.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Genetic diversity within, or between species, can be made by comparing the base sequences of DNA or mRNA, the frequency of specific base sequences or alleles in populations, or the amino acid sequences of encoded proteins. | 0.6 weeks | • explain how DNA hybridisation, DNA sequencing and biochemical analysis can be used to suggest relationships between different organisms within/between species.  • interpret data relating to  DNA hybridisation, DNA sequencing or biochemical analysis.  • interpret data relating to similarities and differences in base sequences or in amino acid sequences to suggest relationships between different organisms. | **Learning activities:**  - Teacher explanation about the methods for assessing genetic diversity and how this can be applied to allow revision of the classification system and how some organisms relate to each other.  - Work through some data analysis exercises together to assess genetic diversity and the relationships between organisms.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 14 -** Interpret tabular data relating to amino acid sequences or DNA hybridisation of different organisms, and draw conclusions about the evolutionary relationships between the organisms.  **AO1 –** Development of knowledge and understanding of how genetic diversity can be measured.  **AO2/AO3 –** Application of knowledge to interpret data and draw conclusions on evolutionary relationships. | **Past exam paper material:** BIOL2 Jan13 -Q3;  BIOL2 Jun12 -Q6 (except 6c);  BIOL2 Jan11 – Q3**;**  BIOL2 Jun13 – Q1;  BIOL2 Jun09 – Q8d;  BIOL2 Jan12 – Q6;  BIOL2 Jun11 – Q7;  BIOL2 June10 – Q6;  BIOL2 Jan10 – Q10f. | [**http://www.hhmi.org/biointeractive/creating-phylogenetic-trees-dna-sequences**](http://www.hhmi.org/biointeractive/creating-phylogenetic-trees-dna-sequences) |

#### 3.1.11.2 Species diversity

Prior knowledge:

Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Species richness is a measure of the number of different species in a community.  Biodiversity can also be measured by calculating an index. An index of diversity describes the relationship between the number of different species in a community and the number of individuals in each species.  Calculation of the index of diversity (d) | 0.2 weeks | • explain what is meant by the terms biodiversity, species richness and index of diversity.  • recall the formula for the index of diversity and use it to calculate values from given data.  • interpret information and draw conclusions from the index of diversity for different habitats. | **Learning activities:**  **-** Teacher led explanation of the concepts of biodiversity, species richness and the index of diversity.  - Worked examples of how to calculate the index of diversity.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 11 –** Translate information between numerical and algebraic forms. Solve algebraic equations.  **AO1 –** Development of knowledge and understanding of biodiversity.  **AO2 –** Application of knowledge to the context of question to correctly calculate the index of diversity. | **Past exam paper material:** BIOL2 Jan13 – Q7;  BIOL 2 Jun11 – Q8;  BIOL2 Jan10 – Q7;  BYA4 – Jan04 Q7;  BYB6 – Jun06 Q3;  BYB6 – Jun04 Q7 | **Rich questions:**  - Define what we mean by the terms: biodiversity; species richness; and index of diversity.  - Why is the index of diversity a more useful measure than counting the number of species in an area? |

## **3.2 Unit 2: Biological systems and disease**

**Unit description**

The digestive system, is an example of a system in which an organism exchanges substances with its environment. Mass transport systems ensure efficient movement from exchange surfaces in large organisms. In a mammal, mass transport is by way of the blood system; in a flowering plant, by the xylem and phloem. The systems described in this unit, as well as others in the body, may be affected by disease. Some of these diseases, such as cholera, HIV/AIDs may be caused by microorganisms. Other non-communicable diseases such as those affecting the heart and circulatory system and cancers also have a significant impact on human health. Knowledge of biology allows us not only to explain symptoms but also to interpret data relating to risk factors. The blood has a number of defensive functions which together with the use of drugs helps to limit the spread and effects of disease.

### 3.2.1 The causes of disease: pathogens, lifestyle and genes

#### 3.2.1.1 Pathogens

Prior knowledge:

- Microorganisms that cause infectious disease are called pathogens.

**-** Bacteria and viruses may reproduce rapidly inside the body and may produce poisons (toxins) that make us feel ill. Viruses damage the cells in which they reproduce.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Pathogens include bacteria and viruses.  Disease can result from pathogenic microorganism’s penetrating any of an organisms interfaces with the environment. In a mammal these include the digestive, reproductive and gas-exchange systems.  Pathogens cause disease by damaging the cells of the host and by producing toxins. | 0.2 weeks | • explain the terms pathogen, transmission, infection and disease.  • explain how infection can occur and the sites it can occur at.  • explain the mechanisms by which pathogens cause disease. | **Learning activities:**  - Get students to produce a spider diagram showing the different causes of disease, e.g. pathogens, genetic.  - Assess prior learning and understanding about pathogens.  - As a stimulus, provide students with a series of disease cards and ask them to sort them into categories of their choosing (some might go for transmission method, others might choose type of micro-organism).  - Provide a comprehension exercise on how pathogens infect, attach, colonise and cause disease. Pupils can work in pairs and collect questions from the front to answer using the comprehension as part of a question race.  - Assess learning/understanding and reinforce any areas of misunderstanding through teacher explanation.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of pathogens and the mechanisms of infection and pathogenicity. | **Past exam paper material:**  BIOL1 – Jan13 Q8;  Exampro:  BYB7 Jun06 Q7 (except b). | **Rich questions:**  What is the difference between infection and disease? |
| Extension |  |  | The transmission of pathogens between hosts can be modelled by giving each student a test tube with 2cm3 of liquid in it. Most students have water as the liquid, but 2 tubes have NaOH. Students circulate and mix liquids with 3 others in the class. Those “infected” individuals can be tested at the end using phenolphthalein indicator.  Students could also research topical pathogens that are currently in the news and the diseases they cause. |  |  |

#### 3.2.1.2 Lifestyle, coronary heart disease and cancer

Covered as part of section 3.2.7.2 and 3.2.11

### 3.2.2 Digestion and absorption

#### 3.2.2.1 The human digestive system.

Prior knowledge:

- The hierarchical organisation of cells into tissues, organs and organ systems, exemplified by the stomach and the digestive system.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The gross structure of the human digestive system limited to oesophagus, stomach, duodenum, ileum, colon and rectum.  The glands associated with the system, limited to salivary glands and pancreas.  Digestion is the process in which large molecules are hydrolysed by enzymes to produce smaller molecules. The products of digestion can be absorbed and assimilated. Undigested food is egested as faeces. | 0.4- weeks | • explain the purpose of digestion.  • describe the gross structure of a mammalian digestive system and identify the organs and associated glands within it.  • explain the general roles of the organs and associated glands within the digestive system. | **Learning activities:**  - Assess prior learning and understanding about the digestive system in terms of structure and function.  - Teacher led explanation about the necessity to digest food and the distinction between mechanical and chemical digestion (linked back to hydrolysis).  - A simple overview of digestion could be modelled using a pair of tights with the bottom cut off. Into the top, add a moist food substance, and use hands to model peristalsis and mechanical digestion. The exit of liquid through the wall of the tights can model absorption, whilst the food coming from the bottom of the tights models egestion.  - Model gut activity (e.g. using starch and amylase, or triglycerides, bile and lipase). Ask them to relate this to digestion.  - Provide instructions for dissection of a rat, which students can follow. Ask students to identify each organ once dissected.  - Teacher explanation of the function of each part of the digestive system.  - Provide a blank diagram of the digestive system for students to label, with explanations of function.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of the purpose of digestion and how the digestive system fulfils this function with specialised organs. |  | [**http://www.nuffieldfoundation.org/practical-biology/evaluating-visking-tubing-model-gut**](http://www.nuffieldfoundation.org/practical-biology/evaluating-visking-tubing-model-gut)  **Rich questions:**  What is the purpose of digestion?  Why do vitamins and minerals not require digestion? |

#### 3.2.2.2 Digestion

Prior knowledge:

- The role of amylase, protease and lipase enzymes in the digestion of large, insoluble food molecules, and their sites of production.

- The role of bile in emulsifying fats and neutralising acid from the stomach, and the site of its production/storage.

- Diffusion is the movement of molecules from a region of high to low concentration.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| In the human digestive system, digestion of:  • carbohydrates by amylases and membrane-bound disaccharidases  • lipids by lipase  • proteins by endopeptidases, exopeptidases and membrane-bound dipeptidases. | 0.4 weeks | • describe the intermediate and final breakdown products of the digestion of carbohydrates, proteins and lipids.  • explain the role of different enzymes in the digestive process, and relate the specificity of enzymes back to protein structure. | **Learning activities:**  - Recap questioning students about the purpose of digestion and where key events happen in the digestive system.  - Jigsaw task: In groups of three, each person goes to a different information station (text, videos etc.), to learn about the digestion of starch, protein **or** lipids. They then feedback to other group members to gain a complete picture of other two.  - Assess learning using mini-whiteboards.  - Teacher led explanation to consolidate any areas of continued difficulty.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of digestion. | **Past exam paper material:**  BIOL1 Jun09 - Q7;  BIOL1 Jan09 - Q2;  BIOL1 Jan13 - Q3;  BIOL1 Jun12 - Q6;  Exampro  HBI3X 2011 EMPA;  HBI3X 2012 EMPA. | [**http://bigpictureeducation.com/anatomy-digestive-system-images**](http://bigpictureeducation.com/anatomy-digestive-system-images) |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The role of bile salts. | 0.2 weeks  (allow longer if also doing 2010 ISA paper) | • describe the intermediate and final breakdown products of the digestion of carbohydrates, proteins and lipids.  • explain the role of different enzymes in the digestive process, and relate the specificity of enzymes back to protein structure.  • explain the role of bile. | **Learning activities:**  - Students could undertake an investigation into the role of bile and its effect on the rate of triglyceride digestion. Ask students to suggest an explanation for results.  - Teacher explanation of the role of bile.  - Students modify conclusions if needed.  - Past exam questions.  - Students could write an extended writing piece around the title “The digestive journey of a chicken sandwich” to check the full understanding of the digestive process.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of the role of bile salts.  **AO2/AO3** – Application of knowledge to explain exam questions/data showing the reduction in pH when lipase and bile are added to milk.  **AO3** – Analyse, interpret and evaluate scientific information and evidence to make judgements and reach conclusions.  - Extended exam answers. | **Past exam paper material:**  Exampro  BIO3T 2010 ISA P | [**https://shsbiology.pbworks.com/f/Breaking+Down+Fat+Digestion+CH+29+Lab.pdf**](https://shsbiology.pbworks.com/f/Breaking+Down+Fat+Digestion+CH+29+Lab.pdf)  [**http://www.nuffieldfoundation.org/practical-biology/investigating-effect-temperature-activity-lipase**](http://www.nuffieldfoundation.org/practical-biology/investigating-effect-temperature-activity-lipase)  [**www.aqa.org.uk**](http://www.aqa.org.uk)  **Rich question:**  Explain the journey of a chicken sandwich through the digestive system. |

#### 3.2.2.3 Absorption

Prior knowledge: Nothing relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The histological structure of the ileum in relation to its absorptive function. | 0.2 weeks | • explain the adaptations of the ileum wall to exchange.  • explain the adaptations of ileum epithelial cells to exchange. | **Learning activities:**  - Questioning to recap the adaptations that exchange surfaces have (from section 3.1.4.2). Link to absorption.  - Show video or pictures showing the internal structure of the ileum. Ask students what they observe as adaptations to exchange.  - Model the effect that villi can have on surface area by getting students to cut out 10cm x 10cm squares of corrugated card. Having worked out the surface area, they can peel off the top and bottom layers, and then stretch out the corrugated layer before measuring and calculating the increased surface area (due to folding).  - Show a diagram of a cross section through and villus, and a diagram of an epithelial cell. Teacher explanation of the adaptations of both the villus and an epithelial cell.  - Past exam questions.  **Skills developed by learning activities:**  - Extended exam answers.  **AO1 –** Development of knowledge and understanding of the processes involved in absorption.  **AO2 –** Application of earlier learning from section 3.1.4.2 | **Past exam paper material:**  BIOL 1 June11 – Q8b;  Exampro | **Rich questions:**  Coeliac disease is a disease in which the immune system damages the microvilli of epithelial cells. Explain why coeliac disease reduces absorption of soluble food molecules. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The roles of diffusion, active transport and co-transport involving sodium ions in the absorption of monosaccharides and amino acids.  The role of micelles in the absorption of lipids and their transport as chylomicrons | 0.2 weeks | • define what is meant by co-transport.  - explain the mechanisms of absorption of amino acids and glucose by diffusion, co-transport and active transport.  - explain the role of micelles in the absorption of lipids. | **Learning activities:**  - Ask students to label a small intestine epithelial cell for adaptations.  - DARTS tasks. Students use a comprehension about how glucose, amino acids and lipids are absorbed and recreate this in diagrammatic form.  - Presentation of diagrams to the group and peer evaluation.  - Teacher explanation to address remaining weaknesses using videos and animations.  - Past exam questions.  **Skills developed by learning activities:**  - Extended exam answers.  **AO1 –** Development of knowledge and understanding of absorption.  **AO2 –** Application of earlier learning from section 3.2.3. **AO3 –** Evaluation of scientific information in other people’s presentations. | **Past exam paper material:**  BIOL1 Jun09 – Q7b;  BIOL1 Jan10 – Q4.  Exampro  Questions from Section B of the 2014 BIO3T Q14 ISA. | **Rich questions:**  - Explain the mechanisms by which each of the products of digestion is absorbed.  - Describe the process of co-transport in detail.  - How does co-transport differ from direct active transport? |

### 3.2.3 Cholera

#### 3.2.3.1 Cholera and its symptoms

Prior knowledge: Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Cholera bacteria secrete toxins which increase the secretion of chloride ions into the lumen of the intestine.  This affects the water potential gradient across the intestinal epithelium and results in severe diarrhoea. | 0.2 weeks | • explain how cholera is spread and the symptoms it causes.  • explain the mechanism by which cholera leads to severe diarrhoea and dehydration. | **Learning activities:**  - Ask students to research cholera and its symptoms in advance of the lesson. Get students to feedback their findings.  - Teacher explanation of the mechanism by which cholera toxin causes severe diarrhoea resulting in dehydration.  - Exam questions  **Skills developed by learning activities:**  - Extended exam answers.  **AO1 –** Development of knowledge and understanding of cholera.  **AO2 –** Application of earlier learning from section 3.1.3.2 about water potential. | **Past exam paper material:**  BIOL1 Jan13 – Q4a  Exampro  BYB7 Jan04 Q6. | **Rich questions:**  Explain why cholera results in the severe dehydration of other tissues and not just the ileum epithelial tissue. |

#### 3.2.3.2 Oral rehydration

Prior knowledge: Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The use of oral rehydration solutions (ORS) in the treatment of cholera and other diarrhoeal diseases. | 0.2 weeks | • describe the contents of oral rehydration solution.  • explain how oral rehydration solution causes the absorption of water and salts.  • discuss the applications and implications of science in developing improved oral rehydration solutions.  • discuss the ethical implications of trialling improved oral rehydration solutions on humans. | **Learning activities:**  - Think – Pair – Share - Ask students how we could rehydrate people with cholera. Provide cognitive conflict as to why drinking water would be insufficient, if this is suggested.  - Provide students with a highlighting exercise detailing how ORS works and the role that each ingredient plays. Ask students to highlight the role(s) of each ingredient.  - Question students as to why ORS so important and effective.  - Teacher led explanation of how ORS has developed and been improved, and some of the issues that early ORS therapies resulted in, e.g. high blood pressure).  - Data analysis task using Section B of BIO3T 2009 ISA Q  - Exam questions.  **Skills developed by learning activities:**  - Extended exam answers.  **Mathematical requirement 14 –** Interpret data in tables, charts etc. during ISA questions.  **AO1 –** Development of knowledge and understanding of ORS.  **AO2 –** Application of earlier learning from section 3.1.3.2 about water potential.  **AO3 –** Evaluate scientific information in the data analysis task. | **Past exam paper material:**  BIOL1 Jun10 - Q1;  BIOL1 Jan09 - Q6a-b;  BIOL1 Jan13 – Q4ba  Questions from Section B of the 2009 BIO3T Q09 ISA. | **Rich questions:**  Why must ORS be made in boiled water? |

### 3.2.4 HIV as an example of a human disease caused by a virus.

#### 3.2.4.1 The structure of HIV

Prior knowledge: Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The structure of a human immunodeficiency virus to include:  • genetic material in the form of RNA;  • a protein capsid enclosing the genetic material and the enzymes reverse transcriptase, integrase and protease;  • an envelope originating from the host cell plasma membrane and containing glycoproteins. | 0.2 weeks | • describe the structure of HIV virus particles.  • explain the roles of the enzymes reverse transcriptase, integrase and protease.  • relate the structure of a HIV virus to its replication within cells. | **Learning activities:**  - Provide students with a labelled/annotated diagram of a HIV virus, covered at the side of the room. Working in small groups, students go up one at a time and have a minute to memorise some of the diagram, before returning to their group and recreating it from memory. Each person visits once.  - Teacher explanation of HIV virus structure.  - Get students to relate the cell components found in prokaryotic and eukaryotic cells that viruses do not have, to the roles that viruses would be unable to do. Relate this to a brief description of virus life cycles.  - Students could convert information about the size of viruses, e.g. from nm to µm. Ask them to work out how many viruses could fit in the same length as one bacterial cell.  **Skills developed by learning activities:**  **Mathematical requirement 1,2 -** Convert between units, e.g. µm and nm. Understand standard form when applied to the size of viruses.  **AO1 –** Development of knowledge of HIV virus structure. | **Past exam paper material:**  HBIO1 Jun14 - Q6a;  HBIO1 Jun09 - Q8a;  HBIO1 Jun14 - Q6;  Exampro  BYA3 Jun06 – Q3c | **http://www.yourgenome.org/facts/what-is-hiv**  **Rich question:**  - Why are viruses described as particles rather than cells?  - Why do scientists disagree about whether viruses should be classified as living? |

#### 3.2.4.2 The replication cycle of HIV

Prior knowledge:

Viruses damage the cells in which they reproduce.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| HIV binds to receptors on CD4 helper T-cells. These are cells that initiate the body's response to infections.  The contents of the HIV capsid including the RNA and the viral enzymes are released into the host cell.  The viral RNA genome is transcribed into double-strand DNA, which is then integrated into a host cell chromosome.  The viral DNA may be transcribed producing new viral RNA and proteins. These are packaged and released from the cell as new virus particles, completing the replication cycle. | 0.2 – 0.4 weeks | • explain why viruses are not classified as being living organisms.  • describe the sequence of events by which viruses replicate.  • use their knowledge of the structure and replication cycle of HIV to explain the effects of drugs used in treatment of HIV/AIDS when provided with appropriate information. | **Learning activities:**  **-** Questioning about HIV structure.  - Activity circus around the room containing information which students can access based on learning style, e.g.  • video station  • comprehension/Textbook  • internet sites  - Activity/quiz relating to their findings.  **-** Reinforce with teacher led explanation of the lifecycle of HIV. Link to the work done in 3.1.7 on nucleic acids.  - Students produce an overview of one cycle in the HIV replication cycle in a style of their choice, e.g. in an annotated comic strip format, essay etc.  **Skills developed by learning activities:**  **AO1** – Knowledge and understanding ofHIV replication cycle. | **Past exam paper material:**  BIOL1 Jan13 – Q8a;  HBIO1 Jun09 -Q8;  HBIO1 Jun10 -Q2;  HBIO1 Jun09 - Q8b-c  Marking of student’s overview. | [**http://www.wellcome.ac.uk/Education-resources/Education-and-learning/Resources/Animation/WTDV026676.htm**](http://www.wellcome.ac.uk/Education-resources/Education-and-learning/Resources/Animation/WTDV026676.htm)  [**http://highered.mheducation.com/sites/0072495855/student\_view0/chapter24/animation\_\_hiv\_replication.html**](http://highered.mheducation.com/sites/0072495855/student_view0/chapter24/animation__hiv_replication.html)  **Rich question:**  - Why do AIDS sufferers generally die from common infections? |
| Extension |  |  | To extend their learning, students could be provided with information about the recent discovery that HIV is becoming less virulent. |  | **https://www.newscientist.com/article/dn26643-hiv-evolves-into-less-deadly-form/** |

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### 3.2.5 The defensive functions of mammalian blood

#### 3.2.5.1 The principles of immunology

Prior knowledge:

– White blood cells help to defend against pathogens by: ingesting pathogens; producing antibodies; and producing antitoxins.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| A cell has specific molecules on its surface that identify it. These molecules include proteins and enable the immune system to identify pathogens and toxins, cells from other organisms of the same species and abnormal body cells.  Definition of antigen. | 0.2 weeks | • explain what is meant by an antigen, and the types of molecules which can act as antigens.  • explain why antigen recognition is important for the immune system.  • identify cells which the immune system would launch an immune response against. | **Learning activities:**  **-** Assess prior learning and understanding.  - Define an antigen and explain which molecules can constitute antigens. Explain importance of antigens in identification by the immune system.  - Discuss with students that abnormal cells of the body can produce antigens which would initiate an immune response, e.g. cancer cells.  - Past exam question.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of antigens and their importance. | **Past exam paper material:**  Exampro  BYA3 Jun06 Q1a | **Rich questions:**  - Define what an antigen is.  - Why do cells have antigens? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The effect of antigen variability on disease and its prevention. | 0.2 weeks | • explain why some diseases can be caught more than once.  • explain how mutations can cause antigen variability, and how this can cause new strains of pathogen.  • explain the consequences of antigen variability on the incidence of disease and the development of therapies against that disease. | **Learning activities:**  - Teacher led introduction to antigenic variability through mutation of the genetic code.  - Students examine information about past epidemics/pandemics, e.g. influenza outbreaks over the last century and why periodically some are so serious.  - Students could research the modern focus on disease prevention using internet materials and why recent outbreaks, e.g. avian and swine flu, have attracted such media focus.  - Teacher summary could bring together their findings and discuss the consequences of antigen variability of disease preventing and treatments.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of antigen variability and its consequences.  **AO2 –** Application of knowledge of antigen variability to the context of recent outbreaks of influenza (and other diseases). | **Past exam paper material:**  Exampro – BYB7 Jun04 Q6  HBIO1 Jun12 Q2 | [**http://www.newscientist.com/topic/bird-flu**](http://www.newscientist.com/topic/bird-flu)  [**http://bigpictureeducation.com/epidemics**](http://bigpictureeducation.com/epidemics)  [**http://bigpictureeducation.com/influenza-special-issue**](http://bigpictureeducation.com/influenza-special-issue)  **Rich questions:**  - Suggest why we can suffer from some diseases multiple times, but we get others only once and are then immune.  - Why is it so difficult to develop a vaccine against the common cold or HIV?  - Why have many animal flu viruses, e.g. bird flu, made the news so often in recent years? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| T cells are involved in cell-mediated immunity whereas B cells are primarily responsible for humoral immunity. Humoral immunity involves the production and release of antibodies.  Phagocytosis of pathogens and subsequent digestion by lysozymes. | 0.2 weeks | • explain what is meant by the specific and non-specific immune response.  • describe the process of phagocytosis, in detail.  • explain the role of lysozymes in the destruction of pathogens.  • explain the purpose of antigen presentation following destruction.  • describe the types of lymphocyte, and their involvement in the different types of specific response. | **Learning activities:**  **-** Teacher introduction to the concept of non-specific and specific immune responses, and phagocytosis.  - Explore phagocytosis in greater detail using the videos, with teacher explanation.  - Past exam questions.    **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of phagocytosis.   * Extended exam answers. | **Past exam paper material:**  BIOL1 Jun11 -Q8a;  BIOL1 Jun12 Q5a and 5b; BIOL1 Jan09 -Q5a. | [**http://www.dnatube.com/video/116/Neutrophil-attacts-on-bacteria**](http://www.dnatube.com/video/116/Neutrophil-attacts-on-bacteria)  [**http://highered.mheducation.com/sites/0072495855/student\_view0/chapter2/animation\_\_phagocytosis.html**](http://highered.mheducation.com/sites/0072495855/student_view0/chapter2/animation__phagocytosis.html)  [**http://highered.mheducation.com/sites/0072495855/student\_view0/chapter24/animation\_\_the\_immune\_response.html**](http://highered.mheducation.com/sites/0072495855/student_view0/chapter24/animation__the_immune_response.html)  **Rich questions:**  - Describe the process of phagocytosis from start to finish.  - Evaluate the statement “Phagocytes eat the pathogen”. |
| Extension |  |  | - Students could produce a narrated video of the process using Flip cameras (or equivalent) and plasticine.  - Peer assess quality of explanations. |  |  |

#### 3.2.5.2 The response of B cells to a foreign antigen

Prior knowledge:

– White blood cells help to defend against pathogens by: ingesting pathogens; producing antibodies; and producing antitoxins.

– The immune system of the body produces specific antibodies to kill a particular pathogen. This leads to immunity from that pathogen.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The definition of an antibody and its structure.  The formation of an antigen-antibody complex leading to the destruction of the antigen, limited to agglutination and phagocytosis of bacterial cells. | 0.2 weeks | • relating previous knowledge of protein structure, describe the structure of antibodies.  • explain the specificity of an antibody to a particular antigen.  • explain how antibodies lead to the destruction of pathogens. | **Learning activities:**  **-** Questioning about protein structure and the roles of proteins.  - Teacher definition of an antibody.  - Highlighting exercise about how antibodies bind to and lead to the destruction of pathogens that have complementary antigens (specification only requires agglutination and destruction by phagocytosis). Students can also generate their own questions that they would like answered.  - Show students antibody structure and explain variable and constant regions, and how the antigen binding site means specificity for one antigen.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of the antibody structure and how antibodies lead to the destruction of pathogens. | **Past exam paper material:**  BIOL1 Jan12 - Q6.  HBIO1 Jun12 -Q4a | **Rich questions:**  - Define what an antibody is.  - Explain the importance of the variable region of antibodies.  - Explain the structure of antibodies in terms of the hierarchy of protein structure. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| B cells are primarily responsible for humoral immunity. Humoral immunity involves the production and release of antibodies.  The roles of plasma cells and of memory cells in producing  primary and secondary immune responses. | 0.2 weeks | • explain the purpose of antigen presentation by phagocytes and B cells.  • explain the humoral (antibody-mediated) immune response.  • explain the roles of plasma cells in producing a primary response and memory cells in producing a secondary response. | **Learning activities:**  - Teacher explanation of the humoral immune response in detail (linked to antigen presentation and the roles of B-lymphocytes and of TH -cells). Use videos and animations to support.  - Card sort – Put the stages in the correct order.  - Provide data on the antibody concentrations in the blood after a primary and secondary response. Ask students to explain and ask for improvements to statements such as “the body knows how to fight it off in the secondary response”.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of the humoral response.  **AO2 –** Application of knowledge on the humoral response to explain data on antibody concentrations during the primary and secondary immune responses. | **Past exam paper material:**  HBIO1 Jun12 -Q4b;  HBIO1 Jan13 - Q6 | [**http://highered.mheducation.com/sites/0072507470/student\_view0/chapter22/animation\_\_the\_immune\_response.html**](http://highered.mheducation.com/sites/0072507470/student_view0/chapter22/animation__the_immune_response.html)  [**http://www.sbs.utexas.edu/psaxena/MicrobiologyAnimations/Animations/HumoralImmunity/micro\_humoral.swf**](http://www.sbs.utexas.edu/psaxena/MicrobiologyAnimations/Animations/HumoralImmunity/micro_humoral.swf)  **Rich questions:**  - Would the humoral response be used during a viral infection? Explain your answer.  - Why does the secondary immune response mean that pathogens are destroyed before they are able to make you ill? |

#### 3.2.5.3 Vaccination

Prior knowledge:

– People can be vaccinated by introducing small quantities of dead inactive forms of pathogen into the body stimulating white blood cells to produce antibodies and forming immunity against future infections.

- MMR is used to vaccinate against measles, mumps and rubella.

- If a large proportion of the population is immune to a pathogen, the spread of the pathogen is very much reduced.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The differences between active and passive immunity.  The roles of plasma cells and memory cells in producing the primary and secondary immune response.  The use of vaccines to provide protection for individuals and  populations against disease.    The concept of herd immunity. | 0.4 weeks | • compare and contrast active and passive immunity, and apply your knowledge to given examples.  • describe how antigens can be obtained for use within a vaccine.  • explain why vaccination is able to protect against diseases caused by particular pathogens.  • explain what is meant by herd immunity, and why it is able to protect unvaccinated individuals in a population.  • evaluate methodology, evidence and data relating to the use of vaccines. | **Learning activities:**  - Teacher introduction to active and passive immunity. Get students to categorise rich question statements.  - Teacher explanation of concept of vaccination and the types of vaccines which are used/in development.  - Explain the concept of herd immunity. Students could hold a debate about whether vaccination should be compulsory.  -Provide structured questions for students to analyse the data against.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge of vaccines.  **AO3 –** Evaluate scientific evidence. | **Past exam paper material:**  BIOL1 Jun13 – Q7;  BIOL1 Jan12 – Q8a;  BIOL1 Jan11 – Q6;  BIOL1 Jun09 – Q4;  BIOL1 Jun10 – Q4;  HBIO1 Jan09 - Q10 (except b);  HBIO1 Jun12 - Q2; | [**http://bigpictureeducation.com/herd-mentality**](http://bigpictureeducation.com/herd-mentality)  **Rich questions:**  Provide statements and ask students to identify them as relating to active immunity, passive immunity or both, e.g.  - Antibodies rapidly produced on re-infection by same pathogen.  - An antibody reacts with an antigen.  - Antibodies received in breast milk.  - Attenuated microorganisms in a vaccine. |
| Extension |  | • evaluate methodology, evidence and data relating to the use of vaccines. | - Get students to research or provide data from the MMR and autism research of Andrew Wakefield and Hideo Honda (and data on the impact on vaccination rates in the UK.)  **A04 -** Evaluate the scientific methods and experimental design of Andrew Wakefield. |  | [**http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(05)75696-8/fulltext**](http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(05)75696-8/fulltext)  [**http://www.nature.com/ni/journal/v9/n12/full/ni1208-1317.html**](http://www.nature.com/ni/journal/v9/n12/full/ni1208-1317.html)  [**http://www.newscientist.com/article/dn7076-autism-rises-despite-mmr-ban-in-japan.html#.U7kjL5hOWUk**](http://www.newscientist.com/article/dn7076-autism-rises-despite-mmr-ban-in-japan.html#.U7kjL5hOWUk) |

### 3.2.6 The circulation of blood and the structure of the mammalian heart

#### 3.2.6.1 The mammalian blood system

Prior knowledge: Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The structure of arteries, capillaries and veins in relation to their function.  The structure of capillaries and the importance in metabolic exchange.  The formation of tissue fluid and its return to the circulatory system. | 0.4–0.6 weeks | • describe the structure of arteries, veins and capillaries.  • relate the structure of arteries, veins and capillaries to their functions.  • compare and contrast the structure and function of different blood vessels.  • explain what tissue fluid is and which substances it contains.  • explain the formation of tissue fluid in terms of hydrostatic pressure.  • explain the reabsorption of some tissue fluid back into the capillaries, in terms of hydrostatic pressure and water potential.  • explain the role of the lymph system. | **Learning activities:**  - Introduce the relationships between the different types of blood vessels.  - Jigsaw task: Groups of 4. One from each group goes to an information station containing materials about the structure linked to the function of one of the blood vessels.  - Students feedback to each other and complete a summary table.  - Teacher assessment and explanation of weaker areas.  - Teacher explanation of the formation of tissue fluid and its return to the circulatory system.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge of the structure and function of different blood vessels.  **AO2 –** Application of knowledge of structure to the function of each blood vessels. | **Past exam paper material:** BIOL 2 Jan13 – Q2;  BIOL2 Jun12 – Q8b-8c;  BIOL2 Jan11 – Q8c;  BIOL2 Jun09 – Q1;  BIOL2 Jun11 – Q6b;  BIOL2 Jun10 – Q2;  BIOL2 Jan10 – Q6;  HBIO1 Jun10 - Q6;  BIOL2 Jun15 – Q1 |  |
| Extension |  |  | - Hang masses from an artery and vein and show that artery has more elasticity.  - Microscopy and drawing of prepared slide of sections through different blood vessels. |  | [**http://www.nuffieldfoundation.org/practical-biology/elastic-recoil-arteries-and-veins**](http://www.nuffieldfoundation.org/practical-biology/elastic-recoil-arteries-and-veins) |

#### 3.2.6.2 Heart structure and function

Prior knowledge:

* Heart rate increases with exercise.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The gross structure of the mammalian heart and its associated blood vessels in relation to function. | 0.2 weeks | • describe and label the structure of the heart.  • explain differences in the thickness of cardiac muscle between the atria and ventricles, and between different sides of the heart.  • explain the purpose of the atrio-ventricular and semilunar valves.  • explain the role of the coronary artery. | **Learning activities:**  - Introduce students to the external structure of the heart and discuss the key features, e.g. role of the coronary artery.  - Teacher explanation of the gross internal structure of the heart and reasons for that structure, building on prior knowledge.  - Students to perform a dissection, using instruction sheet.  - Students identify key internal structures/chambers.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge on the structure of the heart. | **Past exam paper material:**  Exampro  BYB3 Jan06 Q1a  BYA1 Jun05 Q2 | [**http://www.nuffieldfoundation.org/practical-biology/looking-heart**](http://www.nuffieldfoundation.org/practical-biology/looking-heart) |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Pressure and volume changes and associated movements of the atrio-ventricular and semi-lunar valves.  Cardiac output as the product of heart rate and stroke volume. | 0.4 weeks | • explain what is meant by cardiac output.  • explain the cardiac cycle in terms of atrial systole, ventricular systole and diastole.  • explain the opening and closing of AV and semi-lunar valves in terms of differences in pressure at different stages of the cardiac cycle.  • analyse and interpret data relating to pressure and volume changes during the cardiac cycle. | **Learning activities:**  **-** Introduce the concept of the heart beating at a certain rate, alongside how to calculate cardiac output.  - Students can calculate cardiac output from data supplied.  - Teacher explanation of the events within a heartbeat (diastole, atrial systole and ventricular systole) using animation. Emphasise the pressure and volume changes and how this causes the opening and closing of particular valves to maintain unidirectional flow.  - Show students data of the volume and pressure changes on a graph. Ask them to discuss in pairs and interpret the changes. Finally ask them to justify which valves will be opening and closing at which positions.  - Exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 11 and 12 –** Manipulate and solve the equation *CO* = *stroke volume* × *heart rate*  **AO1 –** Development of knowledge of the cardiac cycle, the pressure and volume changes within it and how this causes valves to open and close.  **AO2/AO3-**Interpret data from graphs/tables showing pressure/volume changes within the cardiac cycle, and apply knowledge to explain the data.  - Extended exam answers | **Past exam paper material:** BIOL1 Jun13 - Q8b;  BIOL1 Jan11 - Q3 (except 3c); BIOL1 Jun11 -Q6;  BIOL1 Jan12 - Q5;  HBIO1 Jun09 - Q6;  HBIO2 Jun12 - Q8; | [**http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/contraction.html**](http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/contraction.html) |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **Required practical 5 –** Investigation of the effect of a specific variable on human heart rate or pulse rate. | 0.8 weeks | • explain the features of good experimental design.  • process data to calculate rates.  • represent raw and processed data clearly using tables and graphs,  • apply knowledge of circulation to draw and explain conclusions.  • evaluate the quality of results and reliability of conclusions. | **Learning activities:**  Students should design an experiment to investigate the effect of exercise on human pulse. This should include the stages of:  - research to develop method.  - risk assessment.  - carrying out (subject to teacher approval).  - processing and presenting data.  - drawing conclusions and evaluating findings.  - past ISA paper (if appropriate)  **Skills developed by learning activities:**  **Mathematical requirement 2, 12, 13 -** Plot and interpret graphs showing the effect of a named variable on pulse rate.Process data to calculate rates.Make use of appropriate units in calculations.  **AO2** – Apply knowledge in a practical context.  **AO3/AO4** – Analyse, interpret and evaluate scientific information and evidence to make judgements and reach conclusions and design/refine practical design and procedures. | Students could undertake the HBI3T ISA P from 2009.  **Past exam paper material:**  BIOL1 Jan13 – Q7;  BIO3X 2012 EMPA | [**http://www.nuffieldfoundation.org/practical-biology/observing-effects-exercise-human-body**](http://www.nuffieldfoundation.org/practical-biology/observing-effects-exercise-human-body)  [**www.aqa.org.uk**](http://www.aqa.org.uk) |

### 3.2.7 Heart disease may be associated with specific risk factors

#### 3.2.7.1 The biological basis of heart disease

Prior knowledge:

Scientific investigations often seek to identify links between two or more variables. These links may be:

– causal, in that a change in one variable causes a change in another

– due to association, in that changes in one variable and a second variable are linked by a third variable

– due to chance occurrence.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Atheroma as the presence of lipid-containing material within the walls of the arteries.  The link between atheroma and the increased risk of aneurysm and thrombosis.  Myocardial infarction and its cause in terms of an interruption of blood flow to cardiac muscle. | 0.4 weeks | • explain what an atheroma is.  • explain the possible consequence of atheroma formation.  • explain how myocardial infarction is caused. | **Learning activities:**  - Quiz/assessment activity assessing students’ understanding of artery structure and the structure of the heart.  - Teacher explanation of atheroma as the build-up of lipid containing material/foam cells in the endothelium of the artery. Show pictures of this.  - Ask students to predict the effect of this on blood flow and on the artery. Teacher explanation of how atheroma increases the risk of aneurysm and thrombosis.  - Ask students about why the coronary artery is significant and to suggest what would happen if blood flow to the heart was reduced or interrupted. Link to CHD and myocardial infarction.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge of atheroma and coronary heart disease. | **Past exam paper material:**  BIOL1 Jan13 - Q9b;  BIOL1 Jan10 - Q7b;  HBIO1 Jan 09 - Q9a;  HBIO1 Jun09 -Q5b  Exampro:  BYA3 Jan06 Q9;  BYA3 Jun05 Q8;  BYA 3 Jun04 Q9 | **Rich questions:**  - What is an atheroma?  - How does atheroma affect the artery and blood flow?  - Explain how atheroma increases the risk of thrombosis and aneurysm.  - Explain how atheroma may lead to a myocardial infarction. |
| Extension |  |  | * Students could research some of the theories which have been proposed as to what causes the build up of lipid-containing material in the artery walls. |  |  |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Specific risk factors are associated with some diseases. | 0.2- 0.4 weeks | • explain the difference between a correlation and a causal relationship.  • explain what risk is.  • explain why incidence of disease ismeasured as % of the population or per number of people.  • analyse, interpret and evaluate data associated with specific risk factors and the incidence of disease. | **Learning activities:**  - Questioning to assess students understanding of the causes of apparent relationships.  - Provide a statement for students to evaluate e.g. “smoking will cause cancer”. Ask them to evaluate it and why this may not be accurate.  - Teacher explanation of the concept of risk and risk factors. Describe the incidence of disease being measured per number of the population/% of the population and how to calculate this.  - Provide some data showing a strong correlation between a risk factor and a disease, e.g. alcohol intake and cancer. Ask them whether this shows a causal relationship. Discuss the difference between the two and the idea that correlation does not prove causation.  - Teacher explanation of how to critically analyse and evaluate data showing correlations. Use a past exam question to model the analysis and evaluation process.  - Students work in groups, and then independently to look at and evaluate data showing risk factors and disease from past exam questions. They could also work through some ISA Section B questions relating to incidence of disease.  - Students generate Golden Rules for common things they should be questioning, e.g. another variable having an effect.  **Skills developed by learning activities:**  **Mathematical requirements 3, 6, 7, 15 -** Interpret scatter graphs showing correlations between diseases and associated risk factors.Calculate, and understand the use of, percentages or values per 100,000 when looking at data within populations. Understand the concept of probability and chance, and the need for appropriate sample sizes to ensure that data are representative.  **AO3** – Analyse, interpret and evaluate scientific information and evidence to assess the validity of conclusions and the strength of correlations. | **Past exam paper material:**  BIOL1 Jan12 - Q4;  BIOL2 Jan12 - Q10;  HBIO5 Jun13 - Q5  Past ISA Section B questions relating to disease, e.g. BIO3T P15 relating pulmonary embolism to duration of flights. | **Rich questions:**  **-** What is risk?  - Why does correlation not prove causation? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Risk factors associated with coronary heart disease (CHD): diet, blood cholesterol, cigarette smoking and high blood pressure.  Changes in lifestyle may be associated with a reduced risk of contracting these conditions. | 0.2  weeks | • explain the concept of risk and risk factors associated with coronary heart disease.  • analyse, interpret and evaluate data associated with specific risk factors and the incidence of coronary heart disease. | **Learning activities:**  - Question students to recap prior learning about risk and how to evaluate data.  - Discuss with students the risk factors associated with CHD, e.g. smoking and why knowing about risk factors is important to individuals and health organisations in reducing the likelihood of contracting the condition.  - Work through a past exam question as a class, questioning students to further model the interpretation and evaluation process.  - Exam questions on interpreting and evaluating data about CHD and risk factors.  **Skills developed by learning activities:**  **Mathematical requirements 3, 6, 7, 15 -** Interpret scatter graphs showing correlations between diseases and associated risk factors.Calculate, and understand the use of, percentages or values per 100,000 when looking at data within populations. Understand the concept of chance and the need for appropriate sample sizes to ensure that data are representative.  **AO1 –** Development of knowledge of coronary heart disease and associated risk factors.  **AO3** – Analyse, interpret and evaluate scientific information and evidence to assess the validity of conclusions and the strength of correlations. | **Past exam paper material:**  BIOL1 Jun13 - Q6;  BIOL1 Jun10 - Q6;  BIOL1 Jun12 - Q2;  BIOL1 Jun12 - Q8b,  BIOL1 Jan12- Q7;  BIOL1 Jan11 - Q4;  BIOL1 Jun09 - Q2;  BIOL1 Jan09 - Q1b;  HBIO1 Jun10 -Q10;  Exampro  BYA3 Jan04 Q7 | **Rich questions:**  **-** What are the risk factors associated with CHD?  - Explain why a strong correlation is not proof that a factor causes CHD. |

### 3.2.8 Mass transport systems in plants

#### 3.2.8.1 Xylem and the passage of water and mineral ions through a plant

Prior knowledge:

- Xylem and phloem tissue transports substances around a plant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Transpiration and the effects of light, temperature, humidity and air movement. | 0.2 weeks | • explain what is meant by transpiration.  • describe and explain the factors which affect transpiration.  • apply knowledge of transpiration to unfamiliar contexts. | **Learning activities:**  - Question students about their recall and understanding relating to leaf structure from section 3.1.5.2.  - Provide students with a string line containing 5 leaves kept in different conditions, e.g. a freshly picked leaf, one which was picked hours before, one picked hours before and placed in a low temp oven, one picked hours before and placed in front of a fan. Ask them to observe and suggest explanations for the differences.  - Provide stimulus material for students to research transpiration, e.g. textbooks, internet websites, videos. Ask students to refine their suggestions.  - Teacher led explanation and reinforcement of transpiration and the environmental factors which influence it. Link to graphs showing data about the impact of each factor.  - Past exam questions.  **Skills developed by learning activities:**  **AO1** – Development of understanding of transpiration and the environmental variables which influence the rate at which it occurs.  **AO2/AO3 - I**nterpret data from graphs relating to the rate of transpiration and apply knowledge. | **Past exam paper material:**  BIOL2 Jun11 – Q5;  BIOL2 Jan11 – Q8a  Exampro  BYB3 Jun06 Q3a;  BYB3 Jan06 Q3aii;  BYB3 Jan04 Q2a | **Rich questions:**  - What is transpiration?  - What is the advantage to the plant of having stomata which open and allow water to be lost by transpiration?  - Explain why each environmental factor causes a change in the rate of transpiration. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **Required practical 6 –** Investigation of the rate of water uptake by means of a simple potometer. | 0.6 - 0.8 weeks | • explain how to interpret results from potometer experiments.  • process data to calculate rates.  • represent raw and processed data clearly using tables and graphs.  • apply knowledge of transpiration to draw and explain conclusions.  • evaluate the quality of results and reliability of conclusions. | **Learning activities:**  Students should design an experiment to investigate the effect of a named environmental factor on rate of water uptake. This could include the stages of:  - research to develop method.  - carrying out using a potometer.  - processing and presenting data.  - drawing conclusions and evaluating findings.  **Skills developed by learning activities:**  **Mathematical requirement 2, 12, 13 -** Plot graphs and interpret data from graphs relating to water transport.Process data to calculate rates, and calculate rates from the slope of a tangent.Make use of appropriate units in calculations.  **AO2** – Apply knowledge in a practical context.  **AO4** – Understand the principles of using and reading values from a potometer.  **AO3/AO4** – Analyse, interpret and evaluate scientific information and evidence to make judgements and reach conclusions and design/refine practical design and procedures. | **Past exam paper material:**  BIOL2 Jun10 – Q4. | [**http://www.nuffieldfoundation.org/practical-biology/measuring-rate-water-uptake-plant-shoot-using-potometer**](http://www.nuffieldfoundation.org/practical-biology/measuring-rate-water-uptake-plant-shoot-using-potometer)  [**http://www.saps.org.uk/secondary/teaching-resources/115-potometer-measuring-transpiration-rates**](http://www.saps.org.uk/secondary/teaching-resources/115-potometer-measuring-transpiration-rates)  **Rich questions:**   * Why is a bubble of air introduced into the potometer? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The structure of a dicotyledonous root in relation to the pathway of water from root hairs, through the cortex and endodermis to the xylem.  Apoplastic and symplastic pathways. | 0.4 weeks | • describe the structure of a dicotyledonous route.  • explain what is meant by the apoplastic and symplastic pathways.  • explain, in detail, how water moves through a root as part of the transpiration stream (to replace the water lost by transpiration).  • explain how water is moved from the endodermis into the xylem. | **Learning activities:**  - Demonstrate the slicing of a carrot longitudinally and vertically for students. Provide slices for students observe the different layers that they can see so that they can get use to the orientation.  - Students could undertake microscopy of pre-prepared root slides to relate these to the LS and TS sections seen with the carrot.  - Show a diagram of a dicotyledonous root seen in LS. Teacher led explanation of water movement from root hair to endodermis via apoplastic and symplastic pathways. Relate view of diagram to carrot cuts.  - Teacher led explanation of the role of suberin in the Casparian strip, and the role of active transport of ions into the xylem in lowering the water potential to cause water movement into the xylem.  - Past exam questions.  **Skills developed by learning activities:**  **AO1** – Development of understanding of the apoplastic and symplastic pathway.  **AO2/AO3 –** Application of knowledge from section 3.1.4.2 about water potential and osmosis. | **Past exam paper material:**  BIO3T ISA P14 Q10-11;  Exampro  BYA6 Jan04 Q6a;  BYB3 June06 Q1a;  BYB3 Jun04 Q6a; | [**http://www.saps.org.uk/secondary/teaching-resources/1274**](http://www.saps.org.uk/secondary/teaching-resources/1274)  [**http://www.kscience.co.uk/animations/transpiration.swf**](http://www.kscience.co.uk/animations/transpiration.swf)  **Rich questions:**   * What is the difference between transpiration and the transpiration stream? |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The roles of root pressure and the cohesion-tension theory in moving water through the xylem. | 0.2 weeks | • explain how water transport in the xylem is linked to transpiration in the leaves (as part of the transpiration stream).  • explain the roles of root pressure and the cohesion-tension theory, and the relative contribution of each.  • analyse and interpret evidence from experiments related to the movement of water through the xylem. | **Learning activities:**  - Questioning on transpiration and movement of water via apoplastic and symplastic pathways in the routes.  - Show students the results of a pre-set up experiment showing the movement of dye up the stem of a flowering plant.  - Ask students to suggest how water, to replace that lost from the leaves, is moved from the roots against gravity.  - Teacher led explanation of movement of water against gravity due to root pressure and cohesion-tension theory (using animation) and the relative contribution of each.  - Provide further evidence from experiments relating to the movement of water through the xylem (this can be obtained through some of the exam questions). Get students to discuss and apply their knowledge to explain it.  - Past exam questions  **Skills developed by learning activities:**  **AO1** – Development of understanding of root pressure, cohesion-tension theory and water movement.  **AO2/AO3 –** Application of knowledge to explain scientific evidence from experiments. | **Past exam paper material:**  BIOL2 Jan13 – Q5;  BIOL2 Jun13 – Q8a;  BIOL2 Jan11 – Q8b;  BIOL2 Jan12 – Q8b,  Exampro:  BYA6 Jan04 Q9b  BYB3 Jun04 Q6;  BYB3 Jan05 Q6;  BYB3 Jun05 Q4;  BYB3 Jan06 Q4 | [**http://www.nuffieldfoundation.org/practical-biology/investigating-transport-systems-flowering-plant**](http://www.nuffieldfoundation.org/practical-biology/investigating-transport-systems-flowering-plant)  [**http://www.saps.org.uk/secondary/teaching-resources/1274**](http://www.saps.org.uk/secondary/teaching-resources/1274)  [**http://www.kscience.co.uk/animations/transpiration.swf**](http://www.kscience.co.uk/animations/transpiration.swf)  **Rich questions:**  How are big trees, like giant redwood trees, able to move water against gravity to the leaves at the top? |
| Extension |  |  | - Microscopy of xylem vessels within carnations/pre-prepared xylem/vascular bundle slides. | BIOL2 Jun10 Q4 | [**http://www.saps.org.uk/secondary/teaching-resources/770-microscopy-looking-at-xylem-and-specialised-cells**](http://www.saps.org.uk/secondary/teaching-resources/770-microscopy-looking-at-xylem-and-specialised-cells) |

#### 3.2.8.2 Phloem and the passage of organic substances through a plant.

Prior knowledge:

- Xylem and phloem tissue transports substances around a plant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The mass flow hypothesis as an explanation of the mechanism of translocation.  Investigating transport in plants using tracers and ringing experiments. | 0.2 weeks | • explain the role of the phloem in plants.  • explain what is meant by translocation.  • explain the mass flow hypothesis as a mechanism for translocation.  • interpret evidence from tracer and ringing experiments and to evaluate the evidence for and against the mass flow hypothesis. | **Learning activities:**  - Provide information about the methodology and the results from ringing and tracer experiments. Ask students to formulate a hypothesis.  - Teacher led explanation of translocation of sugars by mass flow.  - Ask them to evaluate earlier explanations and reform their explanations of the experimental results, in light of their new learning.  - Past exam questions.  **Skills developed by learning activities:**  **AO1** – Development of knowledge and understanding of translocation by mass flow.  **AO2 -** Apply knowledge of translocation to traces and ringing experiments.  **AO3/AO4 -** Interpret data from graphs relating to translocation.  **AO3 –** Evaluate scientific evidence in supporting scientific ideas. | **Past exam paper material:**  BIO2 Jun15 - Q3 | [**http://highered.mheducation.com/sites/9834092339/student\_view0/chapter38/animation\_-\_phloem\_loading.html**](http://highered.mheducation.com/sites/9834092339/student_view0/chapter38/animation_-_phloem_loading.html)  [**http://www.saps.org.uk/secondary/teaching-resources/1274**](http://www.saps.org.uk/secondary/teaching-resources/1274)  **Rich questions:**  Explain how ringing and tracer experiments prove the mass flow hypothesis through the phloem.  What causes translocation by mass flow? |

### 3.2.9 The role of aphids in spreading plant viruses

#### 3.2.9.1 Plant virus diseases

Prior knowledge: Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Many important plant diseases are caused by viruses. They are responsible for losses in crop production and quality of produce in all parts of the world.  Infected plants may show a range of symptoms depending on the disease. There may be yellowing of leaves, leaf distortion or abnormalities of other parts of the plant.  As plants are immobile, transmission of viruses usually involves vectors such as aphids. | 0.2 weeks | • explain the significance of plant viruses.  • explain how plant viruses are usually spread.  • explain the potential impact of plant viruses on crop production and quality.  • evaluate possible methods of controlling plant viruses and the issues associated with these. | **Learning activities:**  - Show students some pictures of plants which have been infected with viruses (e.g. Yellow vein-banding symptoms on grapevine due to *Grapevine fanleaf virus,* eggplant fruit distortion due to *Tomato bushy stunt virus*) and ask students to suggest the cause.  - Ask students to produce a spider diagram of transmission methods in animals. Now ask them which would be applicable to plants, to arrive at a discussion of the importance of insect (aphid) vectors.  - Teacher led explanation of the impact that these viruses could have on crop production and the economy, and the need to control this. Case studies could be used, e.g. the strict biosecurity and quarantine regulations in Australia and 2015’s CGMMV outbreak in Queensland.  - Students could have a debate about the use of insecticides to control aphid populations as a way of limiting viral spread. Groups could be assigned roles, e.g. farmers, environmentalists concerned about the impact on food chains, food campaigners concerned about pesticide residues in food etc. Provide stimulus material from which they can formulate arguments.  **Skills developed by learning activities:**  **AO1** – Development of understanding of plant viruses.  **AO2/AO3 –** Interpret and evaluate scientific information, and apply own knowledge, to debate issues about crop production. | **Past exam paper material:**  BIOL4 Jan13 Q7 | **Rich questions:**  - Describe some of the visible effects that viruses can have on plants.  - Why is biosecurity so important when importing food?  - Evaluate the arguments for and against the use of pesticides to control aphids. |

#### 3.2.9.2 Aphids as feeders on phloem sap

Prior knowledge: Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Aphids have sucking mouthparts called stylets. They feed by inserting the stylets into phloem vessels. Once a phloem vessel is punctured, the sap, which is under high pressure, is forced into the aphid's gut.  Some species produce winged females which migrate to start colonies on a new host plant. | 0.2 weeks | • describe the structure of aphid mouthparts.  • explain how aphids feed on the sugars in plant phloem.  • suggest some of the challenges which this method of feeding might pose.  • explain how aphids colonise new plants. | **Learning activities:**  - Show video clips of aphids feeding on a plant stem.  - Think – Pair – Share: Ask students to suggest which part of the stem they are likely to be obtaining the nutrition from (based on prior learning about xylem and phloem) and what that nutrition is likely to be.  - Back to back: Students sit in pairs with their backs to each other. Present one student with a labelled cross-sectional diagram of the aphid head puncturing a phloem vessel. This student must describe the diagram to their partner who recreates it on blank paper based only on the description.  - Teacher led explanation of the structure of the mouthparts and the process of feeding.  - DARTS task: Students could be provided with comprehension material on the aphid lifecycle, which they could transform to produce a life cycle diagram.  - Teacher led reinforcement of key messages of aphid life cycle.  **Skills developed by learning activities:**  **AO1** – Development of knowledge and understanding of aphid feeding and life cycle. |  | **https://www.youtube.com/watch?v=\_17MbT6FfDQ**  **Rich questions:**  - Suggest the advantage of some females developing wings during some parts of the lifecycle, and others being produced wingless by parthenogenesis? |
| Extension |  |  | - Ask students to discuss in groups some of the potential difficulties that this method of feeding presents (highly sugary so lowers water potential when ingested; low in essential nutrients such as amino acids). Students could research how these are overcome. |  | - Suggest what problems feeding from the contents of the phloem presents for aphids? |

### 3.2.10 Cells divide by binary fission and mitosis

#### 3.2.10.1 The cell cycle

Prior knowledge:

**-** In body cells the chromosomes are normally foundin pairs. Body cells divide by mitosis.

**-** When a body cell divides by mitosis copies of the genetic material are made then the cell divides once to form two genetically identical body cells.

- Mitosis occurs during growth or to produce replacement cells.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Eukaryotic cells that retain the ability to divide, show a cell cycle.  The period between mitotic divisions is interphase. Interphase may be divided into three phases:   * G1 phase * S phase * G2 phase   The events which occur in each phase. | 0.2 weeks | • explain what the cell cycle is and why it does not occur in some cells from multicellular organisms.  • describe the stages of the cell cycle.  • explain the events which occur during G1, S and G2 phases of interphase. | **Learning activities:**  - Provide card sort statements for students and ask them to arrange in a logical, order e.g. DNA replication, DNA polymerase made, ATP stores increase. Make it clear that these events could be repeated, so it is actually a cycle.  - Teacher explanation of the cell cycle and the events at each stage of interphase. Be clear on the difference between the cell cycle and mitosis.  - Question students to assess recall and understanding of DNA replication to make the link explicit between S-phase and the work done in section 3.1.7.3.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge and understanding of the cell cycle. | **Past exam paper material:**  BIOL2 Jan11 -Q7;  HBIO2 Jun13 - Q3b  HBIO2 Jun12 -Q2;  . | [**http://www.cellsalive.com/cell\_cycle.htm**](http://www.cellsalive.com/cell_cycle.htm)  [**http://highered.mheducation.com/sites/0072495855/student\_view0/chapter2/animation\_\_how\_the\_cell\_cycle\_works.html**](http://highered.mheducation.com/sites/0072495855/student_view0/chapter2/animation__how_the_cell_cycle_works.html)  **Rich questions:**  - Explain what happens during G1, S and G2 phases of interphase.  - Why would scientists investigating the cell cycle choose to study bone marrow cells over neurones? |

#### 3.2.10.2 Mitosis

Prior knowledge:

**-** In body cells the chromosomes are normally foundin pairs. Body cells divide by mitosis.

**-** When a body cell divides by mitosis copies of the genetic material are made then the cell divides once to form two genetically identical body cells.

- Mitosis occurs during growth or to produce replacement cells.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The part of the cell cycle during which a eukaryotic cell divides to produce two daughter cells, each with identical DNA is mitosis.  The behaviour of chromosomes during interphase, prophase, metaphase, anaphase and telophase. The role of spindle fibres attached to centromeres in the separation of chromatids. | 0.4 weeks | • recognise the stages of the cell cycle from diagrams and photographs.  • explain the appearance of cells in each stage of mitosis in terms of chromosome behaviour.  • explain the role of spindle fibres during mitosis.  • apply knowledge of the cell cycle and mitosis to explain trends in data. | **Learning activities:**  - Teacher explanation of the purpose of mitosis and the outcomes of it.  - Teacher explanation of the stages of mitosis, reinforced with videos and/or animations of the process.  - Card sort using actual pictures of cells at different stages. Ask students to put them in order, name the stage and then explain why it is that stage.  - Get students to interpret the amount of DNA in a cell and link these to different stages of the cell cycle.  - Students could calculate the number or percentage of cells in each stage of the cell cycle, based on the number of hours each stage takes and the number of cells.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematic requirement 3 -** Students could use data about the number of hours spent in each stage, to predict the ratio/% of cells in each stage of mitosis.  **AO1** – Knowledge and understanding ofstages of mitosis.  **AO2–** Interpretation of images of cells in mitosis and identification of stages.  **A03 –** Application of knowledge to explain scientific data about the amount of DNA within a cell and the length of time at each stage. | **Past exam paper material:**  BIOL2 June 12 - Q4;  BIOL2 Jan12 – Q2;  BIOL2 Jun11 – Q4;  HBIO2 Jun13 – Q5b;  HBIO2 Jun12 - Q10b;  HBIO2 Jun10 – Q2;  HBIO2 Jun09 – Q3;  Exampro BYA2 Jan 06 Q2 | [**http://bigpictureeducation.com/cell-division-images**](http://bigpictureeducation.com/cell-division-images)  [**http://www.cellsalive.com/mitosis.htm**](http://www.cellsalive.com/mitosis.htm)  **Rich question:**  - Evaluate the statement “Mitosis consists of Interphase, Prophase, Metaphase, Anaphase and Telophase”.  - Provide students with pictures of each stage of mitosis and ask them to describe what the chromosomes are doing and which stage of mitosis the cell is at. |
| Extension |  |  | - Students could produce a video podcast summarising mitosis and its role within the larger cell cycle. |  |  |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| **Required practical 4:**  **Preparation of stained squashes of root tips and examination of these with a microscope. Observation of the stages of mitosis and calculation of a mitotic index.** | 0.4  weeks | • apply knowledge of mitosis and the cell cycle, to identify cells in different stages of mitosis.  • explain what the mitotic index is and calculate the mitotic index from observed values. | **Learning activities:**  - Preparation and observation squashes of root tip cells, e.g. from allium, garlic or hyacinth.  - Observation and drawing of cells in various stages of mitosis, under a microscope.  - Calculation of the mitotic index.  - Past exam questions/Past ISA questions.  **Skills developed by learning activities:**  **Mathematic requirement 3 –** Calculation of the ratio between the number of cells undergoing mitosis and the number of cells not undergoing mitosis (mitotic index).  **AO4 –** Describe the techniques and procedures for staining chromosomes and using microscopes.  **AO2 –** Application of knowledge to use these techniques and identify stages of mitosis in tissue being observed. | **Past exam paper material:**  Exampro  BYA2 Jan 05 Q1  BYA 2 Jun 05 Q4  Students could undertake the HBI3T ISA P from 2013. | [**http://www.nuffieldfoundation.org/practical-biology/investigating-mitosis-allium-root-tip-squash**](http://www.nuffieldfoundation.org/practical-biology/investigating-mitosis-allium-root-tip-squash) |

#### 3.2.10.3 Binary fission

Prior knowledge: Nothing explicitly relevant

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Prokaryotic cells divide by binary fission. During this process:  • the circular DNA and plasmids replicate  • the cytoplasm replicates to produce two daughter cells. Each of these cells has a single copy of the circular DNA but the number of plasmids may vary. | 0.2 weeks | • explain what binary fission is and the organisms which carry out binary fission.  • describe the process of binary fission. | **Learning activities:**  - Show an agar plate with bacterial colonies. Ask students to suggest why these are visible given that bacteria are microscopic.  - Teacher led explanation of the process of binary fission in prokaryotes.  - Ask students to evaluate how it differs to the process in eukaryotic cells.  - Students could calculate the exponential growth of bacteria from one cell, each hour for eight hours, under ideal conditions.  - Exam questions from Exampro (especially relating to data).  **Skills developed by learning activities:**  **Mathematical requirement 13 (\*not required until A-level, but an opportunity to introduce it early) -** Estimate the exponential growth of bacteria after 8 hours with the assumption of binary fission occurring once every 20 minutes.  **AO1** – Knowledge and understanding ofbinary fission. |  | [**http://www.classzone.com/books/hs/ca/sc/bio\_07/animated\_biology/bio\_ch05\_0149\_ab\_fission.html**](http://www.classzone.com/books/hs/ca/sc/bio_07/animated_biology/bio_ch05_0149_ab_fission.html)  **Rich question:**  - Binary fission can happen every 20 minutes for some species, under ideal conditions. Suggest one example where this trait would be useful to humans. |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| DNA may also be passed from one species of bacterium to another during conjugation. This is horizontal gene transmission. | 0.2 weeks | • describe the process of bacterial conjugation.  • explain what is meant by horizontal and vertical gene transmission.  • explain how conjugation and horizontal gene transfer promote diversity amongst bacteria. | **Learning activities:**  - Discuss the research of Frederick Griffith on S and R strains of Streptococcus pneumonia (Griffith’s Experiment). Ask students to discuss it in groups and suggest an explanation.  - Explain that the “transforming principle” was in fact the horizontal transmission of genes by conjugation. Explain how this promotes genetic diversity amongst bacteria (in addition to mutation).  - Teacher explanation of the process of conjugation.  - Students annotate a blank diagram of the process of conjugation which can be assessed.  - Students produce a summary comparing and contrasting horizontal and vertical gene transmission.  **Skills developed by learning activities:**  **AO1** – Knowledge and understanding ofhorizontal gene transmission by conjugation.  **AO3 –** Interpretation of scientific information relating to the work of Fredrick Griffith. | **Past exam paper material:**  BIOL 2 – June 2014 Q5a. | [**http://highered.mheducation.com/sites/dl/free/0072835125/126997/animation6.html**](http://highered.mheducation.com/sites/dl/free/0072835125/126997/animation6.html)  [**http://www.quia.com/files/quia/users/hlrbiology/Animations/08\_DNA\_and\_Proteins/Griffith\_Mouse\_Experiment.swf**](http://www.quia.com/files/quia/users/hlrbiology/Animations/08_DNA_and_Proteins/Griffith_Mouse_Experiment.swf)  **Rich question:**  - Show a video of bacterial cell division by binary fission. Ask students whether this is horizontal or vertical gene transmission and why.  - Some bacteria possess genes to antibiotic resistance on plasmids. Suggest why treating relatively mild pathogens with antibiotics is something which should be discouraged. |

### 3.2.11 Mutation and cancer

#### 3.2.11.1 Gene mutations.

Prior knowledge:

**-** Mutations produce new forms of genes.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Gene mutations involve a change in the base sequence of DNA. They arise spontaneously during DNA replication.  Mutagens are physical or chemical agents that increase the frequency of mutations.  Base deletion and base substitution as examples of gene mutation.  Because of the degenerative nature of the genetic code, not all mutations result in a change in the sequence of the encoded amino acids. | 0.4 weeks | • explain what a gene mutation is and how/when they arise.  • describe what a mutagenic agent is, and identify some possible mutagenic agents.  • explain what is meant by a deletion and substitution mutation, and the potential consequences of each (linked to protein structure).  • predict the outcome of specific mutations on amino acid sequences when provided with suitable information relating to the genetic code. | **Learning activities:**  - Teacher led explanation of how gene mutations arise and mutagenic agents which can increase the risk.  - Students work through the transcription and translation activity (linked in resources). Then ask them to repeat the activity twice more but this time putting in a substitution mutation for one and a deletion mutation for another. Compare effects of the two mutations to the original amino acid sequence. Ask students to relate these effects to their knowledge on protein structure to predict the outcome.  - Teacher explanation of the effects of substitution and deletion mutations, and also the possible neutral effects of substitution due to degeneracy.  - Past exam questions.  **Skills developed by learning activities:**  **AO1 –** Development of knowledge around gene mutations and their possible consequences.  **AO2 –** Application of knowledge of mutation to a model of protein synthesis from section to suggest possible effects of gene mutation on the structure of the protein produced (using knowledge from sections 3.1.4.1 and 3.1.8). | **Past exam paper material:**  BIOL2 Jan13 - Q6a-6**;**  BIOL2 Jun13 - Q7b-7c;  BIOL2 Jan12 - Q4;  BIOL2 Jun11 - Q3b;  BIOL2 Jun10 - Q3;  BIOL5 Jun12 -Q1a-1c;  BIOL5 Jun14 -Q1c;  HBIO4 Jan13 -Q10b;  HBIO4 Jun11 -Q10c;  HBIO2 Jan12 -Q9; | [**http://cell-cell-cell.com/wp-content/uploads/CCC\_Activity\_CrackTheCodon\_v01.doc**](http://cell-cell-cell.com/wp-content/uploads/CCC_Activity_CrackTheCodon_v01.doc)  **Rich questions:**   * Evaluate this statement: “Sunbathing exposes your body to UV light which causes mutations to occur”. * Which type of gene mutation is likely to be the most damaging and why? * Because of the degenerative nature of the genetic code, not all mutations result in a change in the sequence of the encoded amino acids cell made. Why is this not correct? |

#### 3.2.11.2 Mutations and cancers.

Prior knowledge: Nothing explicitly relevant.

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| The main characteristics of benign and malignant tumours.  The rate of cell division is controlled by proto-oncogenes that stimulate cell division and by tumour suppressor genes that slow cell division.  A mutated proto-oncogene, called an oncogene, stimulates cells to divide too quickly. A mutated tumour suppressor gene is inactivated, allowing the rate of cell division to increase. | 0.6 weeks | • analyse, interpret and evaluate data associated with specific risk factors and the incidence of particular cancers.  • explain the events involved in the formation of tumours and cancers, and why this is damaging to the body.  • explain the processes within the cell cycle which are disrupted and which lead to cancer.  • relate their understanding of the cell cycle to drugs used in the treatment of cancer.  • interpret data relating to cancer treatments and their effects on the rate of cell division. | **N.B.** This topic should be approached sensitively as cancer may be a sensitive issue for some students.  **Learning activities:**  - Teacher explanation what cancer is and how tumours can form.  - Explain the main characteristics of benign and malignant tumours, and the role of tumour suppressor genes and oncogenes in cancer. The Nowgen video could support this and also use animations to help.  - Students could undertake the BRAF activity, identifying mutations in the BRAF gene and comparing against the COSMIC online database.  - Discuss cancer treatments and link to data on the reduction in cancer cells after each treatment. Link drugs back to their effects, e.g. in inhibiting spindle formation.  - Past exam questions.  **Skills developed by learning activities:**  **Mathematical requirement 16 -** Interpret graphs showing the effect of cancer treatments on the number of cancerous cells.  **AO1** – Knowledge and understanding ofcancer and its treatment.  **AO2/AO3 –** Interpretation of exam question data and application of knowledge of the impact of some treatments on mitosis and the cell cycle. | **Past exam paper material:**  BIOL1 Jan13 – Q5;  BIOL2 Jan13 – Q8b;  BIOL2 Jun13 – Q4c**;**  BIOL2 Jun13 – Q4;  BIOL2 Jan10 – Q9  HBIO4 Jun14 - Q8 (except 8b);  HBIO4 Jan13 -Q4;  HBIO4 Jan12 -Q9;  HBIO4 Jan10 -Q9d;  HBIO2 Jun14 -Q10;  HBIO2 Jan10 -Q11; | [**http://www.yourgenome.org/teachers/roguecells.shtml**](http://www.yourgenome.org/teachers/roguecells.shtml)  [**http://www.yourgenome.org/teachers/roleofcancergenes.shtml**](http://www.yourgenome.org/teachers/roleofcancergenes.shtml)  [**http://www.insidecancer.org/**](http://www.insidecancer.org/)  [**http://nowgen.org.uk/education/resource/breast-cancer-in-the-family/?tag%5B%5D=A-Level&tag%5B%5D=highlighted**](http://nowgen.org.uk/education/resource/breast-cancer-in-the-family/?tag%5B%5D=A-Level&tag%5B%5D=highlighted)  [**http://www.yourgenome.org/teachers/braf.shtml**](http://www.yourgenome.org/teachers/braf.shtml)  [**http://www.sanger.ac.uk/research/projects/cancergenome/#t\_resources**](http://www.sanger.ac.uk/research/projects/cancergenome/#t_resources) |

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| **Learning objective** | **Time taken** | **Learning Outcome** | **Learning activity with opportunity to develop skills** | **Assessment opportunities** | **Resources** |
| Specific risk factors are associated with cancer.  Changes in lifestyle may be associated with a reduced risk of contracting these conditions. | 0.4 weeks | • analyse, interpret and evaluate data associated with specific risk factors and the incidence of cancer. | **Learning activities:**  - Question students to recap prior learning about risk and how to evaluate data.  - Question students about the risk factors that they know of which are associated with cancer, e.g. exposure to UV from the sun, and why knowing about risk factors is important to individuals and health organisations in reducing the likelihood of contracting cancer.  - Work through a past exam question as a class, questioning students to further model the interpretation and evaluation process.  - Exam questions on interpreting and evaluating data about cancer and risk factors.  **Skills developed by learning activities:**  **Mathematical requirements 3, 6, 7, 15 -** Interpret scatter graphs showing correlations between diseases and associated risk factors.Calculate, and understand the use of, percentages or values per 100,000 when looking at data within populations. Understand the concept of chance and the need for appropriate sample sizes to ensure that data are representative.  **AO1 –** Development of knowledge of cancer and associated risk factors  **AO3** – Analyse, interpret and evaluate scientific information and evidence to assess the validity of conclusions and the strength of correlations. | **Past exam paper material:**  BIOL1 Jun10 -Q4;  BIOL1 Jun11 - Q2;  HBIO2 Jan 13 - Q9;  HBIO2 Jun09 - Q7;  Exampro  BYA3 Jan04 Q4 | **Rich questions:**  **-** What risk factors can lead to an elevated risk of particular cancers?  - Explain why a strong correlation is not proof that a factor causes cancer. |

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