# Scheme of work

## Combined Science: Trilogy - Foundation

## Biology – Cell biology

This resource provides guidance for teaching the Cell biology topic from our new GCSE in Combined Science; Trilogy (Biology) 8464. It has been updated from the draft version to reflect the changes made in the accredited specification.

A new Required practical activity on microscopy has been added in section 4.1.1.2. In addition some minor changes have been made to the specification in sections 4.1.1.2. Animal and plant cells, 4.1.1.4 Cell differentiation, 4.1.2.3 Stem cells and 4.1.3.2 Osmosis. These alterations have not required changes to the scheme of work.

The scheme of work is designed to be a flexible medium term plan for teaching content and development of the skills that will be assessed.

It is provided in Word format to help you create your own teaching plan – you can edit and customise it according to your needs. This scheme of work is not exhaustive; it only suggests activities and resources you could find useful in your teaching.

### 4.1 Cell biology

### 4.1.1 Cell structure

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop scientific communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment**  **Opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.1.1.1 | Eukaryotes and prokaryotes | Plant and animal cells (eukaryotic cells) have a cell membrane, cytoplasm and genetic material enclosed in a nucleus. | 1 | Discuss the composition of the objects and how they are made of even smaller structures called cells.  Draw and label a generalised animal cell and describe the functions of the various parts.  Pupils can illustrate their drawings of cells with a scale bar (multiplying the object’s size by 10 or 20x).  State that an average animal cell is around 10 – 100 µm. Discuss what micrometres are in relation to cm.  State that structures inside the cell are measured in nanometres, which are one billionth of a metre. | Pupils observe different things under a microscope, include:   * hair * feather * sand * thread * wool * paper * textiles * insects (or parts of).   Measure the sizes of the larger objects using a mm ruler or callipers if available.  [Microscope Imaging Station](http://www.exploratorium.edu/imaging-station/gallery.php?Section=Introduction)  Demonstrate an understanding of the scale and size of cells and be able to make order of magnitude calculations.  [Genetic Science Learning Center | Cell Size and Scale](http://learn.genetics.utah.edu/content/cells/scale/)  [Scale of the small | Scale of earth, sun, galaxy and universe | Khan Academy](https://www.khanacademy.org/science/cosmology-and-astronomy/universe-scale-topic/scale-earth-galaxy-tutorial/v/scale-of-the-small) | [Exampro user guide PowerPoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX) |
| 4.1.1.1 | Eukaryotes and prokaryotes | Bacterial cells (prokaryotic cells) are much smaller in comparison. They have cytoplasm and a cell membrane surrounded by a cell wall.  The genetic material is not enclosed in a nucleus. It is a single DNA loop and there may be one or more small rings of DNA called plasmids. Students should be able to explain how the main sub-cellular structures, including the nucleus, cell membranes, mitochondria, chloroplasts in plant cells and plasmids in bacterial cells are related to their functions. | 1 | Determine that bacteria are everywhere and are around 0.2 micrometres so completely invisible even under a microscope, unless they are growing in colonies.  Draw and label the structure of a bacterial cell and relate the sub-structures to their function.  Determine that some bacteria cause disease, but many are useful and most are harmless. | Examine the shapes of different bacterial cells photographed under electron microscopes (available online). |  |
| 4.1.1.2 | Animal cells | Most animal cells have the following parts:   * a nucleus, which controls the activities of the cell * cytoplasm, in which most of the chemical reactions take place * a cell membrane, which controls the passage of substances into and out of the cell * mitochondria, which is where aerobic respiration takes place * ribosomes, which are where protein synthesis occurs. | 1 | Draw and label an animal cell including the cell organelles.  State the function of ribosomes and mitochondria in relation to the survival of the whole animal.  Determine that cell structures in different animals are alike and perform similar functions. | Examine cheek cells under the light microscope. Stain with methylene blue for a clear image.  Pupils can consolidate this and the following lesson to make a 3D model of either an animal or plant cell, using various materials and sweets. |  |
| 4.1.1.2 | Plant cells | In addition to the parts found in animal cells, plant cells often have:   * chloroplasts, which absorb light to make food by photosynthesis * a permanent vacuole filled with cell sap.   Plant and algal cells also have a cell wall made of cellulose, which strengthens the cell. | 1 | Draw and label a plant cell including the cell organelles.  State the function of chloroplasts, ribosomes and mitochondria in relation to the survival of the whole plant.  Discuss what part of the plant cell gives us fibre in our diet and what function it plays in plants. | Examine onion skin cells under the light microscope. Stain with iodine for a clear image.  Pupils can consolidate this and the previous lesson to make a 3D model of either an animal or plant cell, using various materials and sweets. |  |
| 4.1.1.3 | Cell specialisation | Students should be able to, when provided with appropriate information, explain how the structure of different types of cells relate to their function in a tissue, an organ or organ system, or the whole organism.  Cells may be specialised to carry out a particular function:   * sperm cells, nerve cells and muscle cells in animals * root hair cells, xylem and phloem cells in plants. | 1 | Draw and label the structure and function of different specialised cells.  Describe how the number of mitochondria might be different in different cells, depending on their function. | Examine slides of different specialised cells under the microscope. If slides are not available, there are many images online, eg:  [Cell images](http://a.files.bbci.co.uk/bam/live/content/z4wkq6f/large)  [Microscope cells](http://www.fife-education.org.uk/scienceweb/Resources/Biology/Hot_Potatoes_Files/S1/Microscopes_Cells/graphics/my%20paintings/specialised2a1.jpg)  Examine a germinating broad bean to identify the root hair cells. |  |
| 4.1.1.4 | Cell differentiation | As an organism develops, cells differentiate to form different types of cells. Most types of animal cell differentiate at an early stage whereas many types of plant cells retain the ability to differentiate throughout life. In mature animals, cell division is mainly restricted to repair and replacement. As a cell differentiates it acquires different sub-cellular structures to enable it to carry out a certain function. It has become a specialised cell. | 1 | Pupils can write job descriptions for different cells and interview non-specialised cells for the role.  Determine that plant cells can change their job, but animal cells must remain doing the same job. | Examine stages of development for embryos and plant seeds.  [TutorVista – Factors Affecting Germination of Seeds](http://www.tutorvista.com/biology/factors-affecting-germination-of-seeds)    [BBC Bitesize – Stem cells and meristems](http://www.bbc.co.uk/education/guides/z9t4jxs/revision) |  |
| 4.1.1.5 | Microscopy  **Required practical**: **Microscopy**  Use a light microscope to observe, draw and label a selection of plant and animal cells. A magnification scale must be included.  AT skills covered by this practical activity: biology AT 1 and 7. | An electron microscope has much higher magnification and resolving power than a light microscope. This means that it can be used to study cells in much finer detail. This has enabled biologists to see and understand many more sub-cellular structures.  Limited to the differences in magnification and resolution. | 1 | View projected images of various different cells:  [The Cell: An Image Library](http://www.cellimagelibrary.org/)  Ask pupils how big they are on the screen. Determine that cells are magnified so we can see them and that a scale is used.  Show various images with scale bars:  [Red blood cells](http://www.exploratorium.edu/imaging-station/gallery.php?Asset=Human%20red%20blood%20cells&Group=&Category=Blood%20Cells&Section=Introduction)  [Columnar epithelial cells](http://www.freethought-forum.com/images/anatomy6/s_columnar_epithelium.jpg)  [Plant cell](http://www.exploratorium.edu/imaging-station/gallery.php?Asset=%3Ci%3EElodea%3C/i%3E%20leaf%20cells&Category=Plants&Group=&Section=Introduction)  [Nematode](http://www.exploratorium.edu/imaging-station/gallery.php?Asset=%3CI%3EC.%20elegans%3C/I%3E&Group=&Category=%3Ci%3EC.%20elegans%3C/i%3E&Section=Introduction)  Carry out calculations involving magnification, real size and image size using the formula:  Describe how electron microscopy has increased understanding of subcellular structures. | Pupils can draw scale diagrams of simple shapes onto squared paper and label them with scale bars:  [Scale Drawing grid](http://www.k6-geometric-shapes.com/image-files/scale.jpg)  [Scale Drawing image](http://static.prometheanplanet.com/images/resources/resource-thumbnails/thumb-nalg1-04-02-0003-diagram-thumb-lg-png.png) | Pupils exchange scale diagrams and determine the size of the original object using the scale. |

### 4.1.2 Cell division

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop scientific communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment**  **Opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.1.2.1 | Chromosomes | The nucleus of a cell contains chromosomes made of DNA molecules. Each chromosome carries a large number of genes. In body cells the chromosomes are normally found in pairs. | 1 | Draw and label the structure of a chromosome.  State the number of chromosomes found in the nucleus of human somatic cells. | Pupils can match up the chromosomes for a human karyotype and number them to identify the correct number of pairs in a human. |  |
| 4.1.2.2 | Mitosis and the cell cycle | Cells divide in a series of stages called the cell cycle. One of these stages is mitosis where the DNA, which has already been copied, divides. During the cell cycle the genetic material is doubled and then divided into two identical cells. Before a cell can divide it needs to grow and increase the number of sub-cellular structures such as ribosomes and mitochondria. The DNA replicates to form two copies of each chromosome. One set of chromosomes is pulled to each end of the cell and the nucleus divides. Finally the cytoplasm and cell membranes divide to form two identical cells. Students should be able to recognise and describe situations in given contexts where mitosis is occurring. | 1 | State that humans start off as a single fertilised cell. Most of the cells in our bodies have identical nuclei.  State that cells divide to form identical daughter cells from the original fertilised egg.  Cell division by mitosis is important in the growth and development of multicellular organisms.  Describe the different situation where mitosis occurs in plants and animals.  Knowledge of the stages of mitosis is not required. | Put pictures showing the development stages of a human embryo in order of development.  Pupils model the stages in mitosis using plasticine to form a flow diagram. |  |
| 4.1.2.3 | Stem cells | A stem cell is an undifferentiated cell of an organism which is capable of giving rise to many more cells of the same type, and from which certain other cells can arise from differentiation.  Stem cells from human embryos and adult bone marrow can be cloned and made to differentiate into many different types of human cells.  Knowledge and understanding of stem cell techniques are not required.  Treatment with stem cells may be able to help conditions such as diabetes and paralysis.  In therapeutic cloning an embryo is produced with the same genes as the patient. Stem cells from the embryo are not rejected by the patient’s body so they may be used for medical treatment.  The use of stem cells has potential risks such as transfer of viral infection, and some people have ethical or religious objections. | 1 | Pupils can read newspaper articles about people who have had stem cell transplants:  [The Guardian – First UK patient receives stem cell treatment to cure loss of vision](http://www.theguardian.com/science/2015/sep/29/first-uk-patient-receives-stem-cell-treatment-to-cure-sight-loss)  [CTV News – Rare match: Historic sibling stem-cell transplant saves Quebec boy's life](http://www.ctvnews.ca/health/rare-match-historic-sibling-stem-cell-transplant-saves-quebec-boy-s-life-1.2574722)  [Your4State – Middletown boy gets stem cell transplant, family brings awareness for rare neurological disease](http://www.your4state.com/news/news/middletown-boy-gets-stem-cell-transplant-family-brings-awareness-for-rare-neurological-disease)  Describe a stem cell and where they can be found.  State some uses of stem cells.  Divide the class into groups of different stakeholders:   * spinal cord injury patient * stem cell researcher * religious organisation * a couple with leftover embryos from IVF.   Provide research materials for each group to come up with arguments about stem cell research from their viewpoint.  Present to class as part of a debate. | Pupils can watch excerpts of the film ‘My Sister’s Keeper’ (Scene 3, where the main character visits her lawyer to request medical emancipation: [YouTube – My Sisters Keeper What Can I Do For You](https://www.youtube.com/watch?v=n2XTSefMshU) ) |  |
| 4.1.2.3 | Stem cells in plants | Stem cells from meristems in plants can be used to produce clones of plants quickly and economically.   * Rare species can be cloned to protect from extinction. * Large numbers of identical crop plants with special features such as disease resistance. | 1 | State that cloned plants are genetically identical to their parents.  Describe reasons for cloning plants. | Pupils can prepare cauliflower florets for cloning. |  |

### 4.1.3 Transport in plants

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes**  *What most candidates should be able to do* | **Suggested timing (hours)** | **Opportunities to develop scientific communication skills** | **Opportunities to develop and apply practical and enquiry skills** | **Self/peer assessment**  **Opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.1.3.1 | Diffusion | Substances may move into and out of cells across the cell membranes via diffusion.  Diffusion is the spreading of the particles of any substance in solution, or particles of a gas, resulting in a net movement from an area of higher concentration to an area of lower concentration.  Some of the substances transported in and out of cells by diffusion are oxygen and carbon dioxide in gas exchange, and of the waste product urea from cells into the blood plasma for excretion in the kidney. Factors which affect the rate of diffusion are:   * the difference in concentrations (concentration gradient) * the temperature * the surface area of the membrane. | 1 | Define diffusion.  Describe the factors that can influence diffusion. Demonstrate surface area by comparing a flat piece of A4 paper with a crumpled piece.  Describe how different substances are diffused in the human body including oxygen and carbon dioxide in the lungs and urea in the kidney. | Pupils can examine the difference in rates of diffusion of a potassium permanganate crystal in hot and ice cold water.  Pupils can perform a similar experiment to examine how rate of diffusion differs with concentration using potassium permanganate crystals in different volumes of water (or different amounts of potassium permanganate in similar volumes of water). |  |
| 4.1.3.1 | Surface area to volume ratio | A single-celled organism has a relatively large surface area to volume ratio. This allows sufficient transport of molecules into and out of the cell to meet the needs of the organism.  Students should be able to explain how the small intestine and lungs in mammals, gills in fish, and the roots and leaves in plants, are adapted for exchanging materials.  In multicellular organisms the smaller surface area to volume ratio means surfaces and organ systems are specialised for exchanging materials. This is to allow sufficient molecules to be transported into and out of cells for the organism’s needs. The effectiveness of an exchange surface is increased by:   * having a large surface area * a membrane that is thin, to provide a short diffusion path * (in animals) having an efficient blood supply * (in animals, for gaseous exchange) being ventilated. | 1 | Label a diagram of a plant leaf and root to describe how the tissues and cells are adapted to increase the rate of diffusion of different substances into and out of a plant.  Label a diagram to show the surfaces of gas exchange in an alveolus.  Compare the structure of the lung to the gills of a fish. Describe the similarities and differences between them.  Label a diagram of the villi in the small intestine to show how substances can diffuse into the blood stream.  Describe and explain how all these organs are adapted to allow an increased rate of diffusion. | Pupils can investigate NaOH agar cubes with phenolphthalein indicator in HCl (either size of cube or concentration of acid) to demonstrate the difference between the surface area to volume ratio in unicellular and multicellular organism.  Demonstrate a fish gill to pupils (or pupils may complete a fish dissection using a mackerel or similar bony fish). |  |
| 4.1.3.2 | Osmosis  **Required practical**: **Osmosis**  Investigate the effect of a range of concentrations of salt or sugar solutions on the mass of plant tissue.  AT skills covered by this practical activity: biology AT 1, 3 and 5. | Water may move across cell membranes via osmosis. Osmosis is the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane. | 1 | Define osmosis.  Label diagrams to show the movement of water through partially permeable membranes.  Describe where osmosis takes place in plants and animals. | Compare raisins that have been left in distilled water and concentrated sugar solution.  Use a microscope to compare the vacuole sizes of onion skins that have had distilled water added to those with a salt solution.  Required practical 1: investigate the effect of salt or sugar solutions on plant tissue.  Pupils can investigate the change in mass of potato cores in different solutions. |  |
| 4.1.3.3 | Active transport | Active transport moves substances from a more dilute solution to a more concentrated solution (against a concentration gradient). This requires energy from respiration.  Students should be able to link the structure of a root hair cell to its function.  Active transport allows mineral ions to be absorbed into plant root hairs from very dilute solutions in the soil. Plants require ions for healthy growth. It also allows sugar molecules to be absorbed from lower concentrations in the gut into the blood which has a higher sugar concentration.  Sugar molecules are used for cell respiration. | 1 | Define active transport.  Define isotonic.  Label a diagram to show how a kidney dialysis machine works to keep blood concentrations level.  Describe why people drink isotonic drinks and high energy drinks in sport.  Compare the similarities and differences between diffusion, osmosis and active transport. | Pupils can investigate the isotonic point of potato cells, suing their results from the previous investigation.  Concentrations of solution should be made more precise around the point where there was little change. |  |