# Scheme of work

## Combined Science: Trilogy - Foundation

## Biology – Inheritance, variation and evolution

This resource provides guidance for teaching the Inheritance, variation and evolution 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.

Some minor changes have been made to the specification in sections 4.6.1.3 DNA and the genome, 4.6.1.4 Genetic inheritance, 4.6.2.1 Variation and 4.6.2.2 Evolution. 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.

### 4.6 Inheritance, variation and evolution

### 4.6.1 Reproduction

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes** *What most students 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*  |
| --- | --- | --- | --- | --- | --- | --- |
| 4.6.1.1 | Sexual reproduction | Students should understand that meiosis leads to non-identical cells being formed while mitosis leads to identical cells being formed.Sexual reproduction involves the joining (fusion) of male and female gametes:* sperm and egg cells in animals
* pollen and egg cells in flowering plants.

In sexual reproduction there is mixing of genetic information which leads to variety in the offspring. The formation of gametes involves meiosis. | 1 | Recap from KS3 the definitions of sexual reproduction, gametes (in both plants and animals), and fertilisation.Introduce the term mitosis and define.Label diagrams of plant and animal gametes.Introduce the term meiosis and define. | Demonstrate a lily and ask students to recall KS3 and determine the male and female parts. Identify the gametes on the flower. | [Exampro user guide Powerpoint](http://filestore.aqa.org.uk/resources/science/AQA-GCSE-SCIENCE-EXAMPRO-UG.PPTX) |
| 4.6.1.1 | Asexual reproduction | Asexual reproduction involves only one parent and no fusion of gametes. There is no mixing of genetic information. This leads to genetically identical offspring (clones). Only mitosis is involved. | 1 | Define asexual reproduction.Examine pictures of embryo development ie:[Baby center – Fetal Development week by week](http://www.babycenter.com/fetal-development-week-by-week) [Boots – Slideshow of foetal development month by month](http://www.webmd.boots.com/pregnancy/ss/slideshow-foetal-development) Determine that the development of cells is caused by mitosis as the cells are all similar.Discuss scars and how these are made from cells that are genetically identical to all the others in the body. | Students can use spider plantlets or Mexican hat plants to grow clones of the mother plant. |  |
| 4.6.1.2 | Meiosis | Students should be able to explain how meiosis halves the number of chromosomes in gametes and fertilisation restores the full number of chromosomes.Cells in reproductive organs divide by meiosis to form gametes.When a cell divides to form gametes:* copies of the genetic information are made
* the cell divides twice to form four gametes, each with a single set of chromosomes
* all gametes are genetically different from each other.

Gametes join at fertilisation to restore the normal number of chromosomes. The new cell divides by mitosis. The number of cells increases. As the embryo develops cells differentiate.Knowledge of the stages of meiosis is not required. | 1 | Define meiosis and draw a diagram to show what happens to chromosome numbers.Illustrate diagrams the joining of chromosomes to make a full set during fertilisation.Compare and contrast mitosis and meiosis. | Make models to illustrate the process of meiosis in gamete formation.Model a numbers of chromosomes in somatic body cell with a gamete using plasticine of different colours. Determine that pairs would join during fertilisation and the offspring would be different from both parents. |  |
| 4.6.1.3 | DNA and the genome | The genetic material in the nucleus of a cell is composed of a chemical called DNA. DNA is a polymer made up of two strands forming a double helix. The DNA is contained in structures called chromosomes.A gene is a small section of DNA on a chromosome. Each gene codes for a particular sequence of amino acids, to make a specific protein.The genome of an organism is the entire genetic material of that organism. The whole human genome has now been studied and this will have great importance for medicine in the future. | 1 | Give students a diagram of a chromosome and ask them to recap KS3 by labelling the chromosome, DNA and genes. Describe the structure of DNA and how it related to a chromosome. An analogy is a chromosome is a ladder, DNA is the material the ladder is made from and the genes are the rungs.Define the function of DNA.Describe the human genome and why it has been studied. Describe the diseases that have been linked to genetic research (eg PKU, Huntington’s disease, Down’s syndrome, sickle cells) and why it is important to find out about them in terms of their inheritance and treatment. Describe how the Human Genome project has been used in tracing human migration patterns from the past. | Students model the structure of DNA using cocktail sticks, jelly tots and mini marshmallows.Extract DNA from a kiwi or strawberry.Students can illustrate a timeline of discoveries that have led to our understanding of the human genome. They could include: Darwin, Mendel, Miescher, Fleming, DeVries, Sutton, Johannsen, Hunt Morgan, Astbury, McClintock, Crick and Watson, Hin Tjio, Nirenberg, Sanger, the GenBAnk database, PCR, the human genome project. [DNA – timeline](http://www.dnai.org/timeline/) [DNA Worldwide – The history of DNA Timeline](https://www.dna-worldwide.com/resource/160/history-dna-timeline) |  |
| 4.6.1.4 | Genetic inheritance | Some characteristics are controlled by a single gene, such as: fur colour in mice and pendulous or attached ear lobes in humans.Each gene may have different forms called alleles.The alleles present, or genotype, operate at a molecular level to develop characteristics that can be expressed as a phenotype.A dominant allele is always expressed, even if only one copy is present. A recessive allele is only expressed if two copies are present (therefore no dominant allele present).If the two alleles present are the same the person is homozygous for that trait, but if the alleles are different they are heterozygous.Most characteristics are a result of multiple genes interacting, rather than a single gene.  | 2 | Discuss pedigree dogs and what pedigree means about the future offspring of the animals.Define: allele, genotype, phenotype, zygote, dominant, recessive heterozygous and homozygous.Complete Punnett square diagrams for black and white mice for two generations. Students can practise working out genetic crosses using a range of different parental gametes (hetero- and homozygous crosses).Label parental gametes and resulting crosses on Punnett square diagrams. Calculate the percentage probability for different offspring.Examine the royal family tree to find out how haemophilia was so prevalent and how the family have ‘bred out’ to prevent it. | Give pairs of students sets of dominant and recessive genetic traits. Roll dice to choose various traits for different characteristics. Make resulting models out of marshmallows, cocktail sticks, and cake decorating balls, pipe cleaners and similar components.Students should then pair with another group and determine the possible offspring by using a Punnett square. |  |
| 4.6.1.5 | Inherited disorders | Some disorders are inherited. These disorders are caused by the inheritance of certain alleles:* Polydactyly (having extra fingers or toes) is caused by a dominant allele.
* Cystic fibrosis (a disorder of cell membranes) is caused by a recessive allele.

Students should make informed judgements about the economic, social and ethical issues concerning embryo screening, given appropriate information. | 2 | Describe the symptoms for polydactyly.Draw a genetic cross diagram to illustrate how it is inherited.Describe the symptoms for cystic fibrosis and how it is treated.Draw a genetic cross diagram to illustrate how it is inherited.Discuss how some people might define traits such as deafness as a disability whereas others would not.What might happen if science discovers a gene for ‘intelligence’ or violent behaviour?Describe the process of embryo screening and why some people might want or not want to be tested.List the advantages and disadvantages of embryo screening.  | Give students different scenarios and ask them to present to the class the reasons they would or would not decide to have embryo screening. Reasons may include: * cost of IVF and risk of having a disabled child
* a child already born with a deadly genetic disease
* the perspective of someone with Down’s syndrome
* people with a history of Huntington’s disease in the family
* two deaf parents choosing to have a deaf baby.
 |  |
| 4.6.1.6  | Sex determination | Ordinary human body cells contain 23 pairs of chromosomes.22 pairs control characteristics only, but one of the pairs carries the genes that determine sex.In females the sex chromosomes are the same (XX).In males the chromosomes are different (XY). | 1 | Describe the numbers and pairs of chromosomes in normal human body cells of men and women.Distinguish between XY male and XX females.Draw a Punnett square diagram to illustrate the probabilities of have boy verses girl offspring. |  |  |

### 4.6.2 Variation and evolution

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes** *What most students 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*  |
| --- | --- | --- | --- | --- | --- | --- |
| 4.6.2.1 | Variation | Differences in the characteristics of individuals in a population is called variation and may be due to differences in:* the genes they have inherited (genetic causes)
* the conditions in which they have developed (environmental causes)
* a combination of genes and the environment.
 | 1 | Recall the definition of variation from KS3.Measure variation of middle finger length and plot a line graph to show it is continuous variation.Record eye colour and plot a bar graph to show it as discontinuous (or categoric) variation.Compare inherited and environmental variation, and describe where there might be a combination of both. | Examine pictures of different people from around the world. Discuss the variation and how we can find out how closely related they are.Students can investigate variation within the class. If this has been completed in KS3, students can choose different characteristics to investigate ie foot size, freckles or dimples, head circumference.  |  |
| 4.6.2.1 | Mutations | Mutations are continuous changes in the DNA code. Very rarely a mutation will lead to a new phenotype. If the new phenotype is suited to an environmental change it can lead to a relatively rapid change in the species. | 1 | Define phenotype.Define mutation and compare it to variation within a population.Describe what changes in the environment might allow different mutations to become common and others to disappear. | Groups can investigate the effect of mutation by selecting a letter which represents their mutation. Each letter corresponds with a mutation, such as: taping lolly sticks to fingers, no fingers, hands clasped together, tunnel vision (use blacked out goggles), and blind folded etc, shoelaces tied together). Mutated individuals then have to collect food (ie beads) from one side of the room and deposit in a pot. When all the food has been collected, groups can compare amount of food in the pots to identify which mutation will survive, who will die out and what adaptions in behaviour occurred.  |  |
| 4.6.2.2 | Evolution | Students should be able to explain how evolution occurs through natural selection.The theory of evolution by natural selection states that all species of living things have evolved from simple life forms that first developed more than three billion years ago.Evolution occurs via natural selection:* individual organisms within a particular species may show a wide range of phenotype variation because of differences in their genes
* individuals with characteristics most suited to the environment are more likely to survive to breed successfully
* the genes that have enabled these individuals to survive are then passed on to the next generation.

If two populations of one species become so different in phenotype that they can no longer interbreed to produce fertile offspring they have formed two new species. | 1 | Ask students to recall KS3 and write a definition for a species.Recapping from KS3, ask students if they can write their own definition of the theory of evolution by natural selection.Examine a ‘tree of life’ and how all organisms occured from simple ones a long time ago.Describe the peppered moth and how populations differ in polluted compared to non-polluted areas. | Examine pictures of animals that have been artificially bred together, such as liger and tigrons and mules. Students can colour in butterflies or similar insects so they are camouflaged and stick around the classroom. The teacher ‘predator’ needs to find as many of them as possible. The best camouflage will survive to breed. |  |
| 4.6.2.3 | Selective breeding | Selective breeding (artificial selection) is the process by which humans breed plants and animals for particular genetic characteristics.Humans have been doing this for thousands of years since they first bred food crops from wild plants and domesticated animals.Selective breeding involves choosing parents with the desired characteristic from a mixed population. They are bred together. From the offspring those with the desired characteristic are bred together. This continues over many generations until all the offspring show the desired characteristic.The characteristic can be chosen for usefulness or appearance:* disease resistance in food crops
* animals which produce more meat or milk
* domestic dogs with a gentle nature
* large or unusual flowers.

Selective breeding can lead to ‘inbreeding’ where some breeds are particularly prone to disease or inherited defects. Some breeds of dogs suffer from frequent defects. | 1 | Define selective breeding.Describe how the process selective breeding of plants and animals is used to produce organisms with desired traits.Describe different plants and animals that have been selectively bred and give the characteristics that have been selected for. Establish that dogs can be bred as they are all the same species. Draw and label the characteristics on the selectively bred puppy including which features were inherited from each parent.Discuss some of the issues that might arise if the resulting puppies were bred with each other and how deformities might arise.Ask students to apply the ideas of breeding in dogs to other contexts:* disease resistance in food crops
* animals which produce more meat or milk
* domestic dogs with a gentle nature
* large or unusual flowers.

Ask students to describe the desired characteristics and give reasons why. Describe the less desirable ones and give any potential long term undesirable effects. | Look at some of the dogs entered for the Crufts Dog Show and describe the characteristics that make them ‘that type of dog’.Examine breeds of dog and what certain traits have been selected for. Students should chose types of traits (including those for different jobs like retrieving, hunting, companionship, guarding, assistance) and then select dog breeds to produce a puppy with the features they have selected.Use pictures of dog breeds to artificially select traits for their ideal breed. Different puppies will be produced but will inherit different traits from each parent. Students need to decide which puppy would be most suitable. |  |
| 4.6.2.4 | Genetic engineering | Genetic engineering involves modifying the genome of an organism by introducing a gene from another organism to give the desired characteristic.Plant crops have been genetically engineered to be resistant to diseases or to produce bigger better fruits.Fungus cells have been genetically engineered to produce useful substances such as human insulin to treat diabetes.In genetic engineering, genes from the chromosomes of humans and other organisms can be ‘cut out’ and transferred to cells of other organisms.Modern medical research is exploring the possibility of genetic modification to overcome some inherited diseases. | 1 | Define genetic engineering.Draw a flow diagram to illustrate the process of genetic engineering in order.Label a diagram to show the process of genetic engineering fungi to produce human insulin.Give some advantages and disadvantages of genetic engineering. | Examine pictures of different organisms that have been created using genetic engineering. [Enkivillage – Genetically modified animals](http://www.enkivillage.com/genetically-modified-animals.html)  |  |
| 4.6.2.4 | GM crops | Crops that have had their genes modified in this way are called genetically modified (GM) crops.GM crops include ones that are resistant to insect attack or to herbicides.GM crops generally show increased yields because of the characteristics chosen such as larger fruits, disease resistance or herbicide resistance.Concerns about GM crops include the effect on populations of wild flowers and insects. Some people feel the effects of eating GM crops on human health have not been fully explored. | 1 | Define GM and describe how they can be used to help grow plants in inhospitable areas to feed the human populations on the Earth.Give examples of different GM crops and how they can produce more food. Produce a letter to MP/ campaign advert script/blog taking a side on the debate but including both pros and cons of GM crops. | Demonstrate to students the tiny amount of land available for farming the skin peeled from 1/32 of an apple (this is the amount available for farming, when the oceans, mountains, deserts, polar areas, rocky, dry wet, steep, cold, urban areas etc. have been removed).Show students an image of the fictional bird, the jabberjay from the Hunger Games. These were used to spy on rebels but then bred with mockingbirds to become the mockingjay, which then become the symbol for the rebellion. |  |

### 4.6.3 The development of understanding of genetics and evolution

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes** *What most students 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*  |
| --- | --- | --- | --- | --- | --- | --- |
| 4.6.3.2 | Fossils | Fossils are the ‘remains’ of organisms from hundreds of thousands of years ago, which are found in rocks.Fossils may be formed:* from parts of organisms that have not decayed because one or more of the conditions needed for decay are absent
* when parts of the organism are replaced by other materials as they decay
* as preserved traces of organisms, such as footprints, burrows and rootlet traces.

Many early forms of life were soft-bodied, which means that they have left few traces behind. What traces there were have been mainly destroyed by geological activity. This is why scientists cannot be certain about how life began on Earth.We can learn from fossils how much or how little different organisms have changed as life developed on Earth. | 1 | Define a fossil.Describe the process of fossilisation in a cartoon strip, including the conditions required for fossilisation to occur.Describe why some organisms might be fossilised and others not.  | Students can examine different fossils and determine what the actual animal or plant may have looked like.Make model fossils using plaster of Paris and plasticine moulds.Alternatively, use smarties or jelly babies squashed in between sliced bread to form casts.Ask students to describe the models and what is good/not so good about them. Ask students how they would improve the models to reflect real fossils.Give students print outs of fossils of horses or whales in various stages of their evolution and ask students to put along a timeline on the wall (from Holocene to Palaeocene) (ie [ExpertsMind.com – Evolution of the horse](http://www.expertsmind.com/questions/fossil-history-of-horse-30116610.aspx) [Understanding Evolution – The Evolution of Whales](http://evolution.berkeley.edu/evolibrary/article/evograms_03) Make a poster of the different kinds of human that have lived during the evolution of modern humans. |  |
| 4.6.3.1 | Evidence for evolution | The theory of evolution by natural selection is now widely accepted.Evidence for Darwin’s theory is now available as it has been shown that characteristics are passed on to offspring in genes. There is further evidence in the fossil record and the knowledge of how resistance to antibiotics evolves in bacteria. | 1 | Label a diagram of different depths of the earth and how the deeper the layer, the further back in time it represents.Revisit the peppered moth and antibiotic resistant bacteria as evidence for evolution.Link back to fossils as one source of evidence for evolution. |  |  |
| 4.6.3.3 | Extinction | Extinction may be caused by:* changes to the environment over geological time
* new predators
* new diseases
* new, more successful, competitors
* a single catastrophic event, eg massive volcanic eruptions or collisions with asteroids.
 | 1 | Ask students to recap KS3 and write their own definition of extinction. List the reasons why animals can become extinct.Examine pictures of animals and plants that are endangered species and describe why they may become extinct:[WWF – Critically Endangered list](https://www.worldwildlife.org/species/directory?direction=desc&sort=extinction_status)[BBC Earth – The 9 rarest plants in the world](http://www.bbc.com/earth/story/20141121-the-rarest-plants-in-the-world)  [The Sixth Extinction – The most recent extinctions](http://www.petermaas.nl/extinct/lists/mostrecent.htm) [Pixable – Here's every single animal that became extinct in the last 100 years (photos)](http://www.pixable.com/article/heres-every-single-animal-that-became-extinct-in-the-last-100-years-photos-67674)Describe the changes that occurred to the Earth following the KT impact and how this may have contributed to the extinction of the dinosaurs. | Students can examine pictures of the geologic timescale, ie: [Geology.com – Geologic Time Scale](http://geology.com/time.htm). Examine pictures of the KT event crater.[National Geographic – Asteroid terminated dinosaur era in a matter of days](http://voices.nationalgeographic.com/2010/03/04/asteroid_terminated_dinosaur_era_in_days/). [Video – Impact visualisation – end of cretaceous period](https://www.youtube.com/watch?v=5qJPTjMnwNk)  |  |
| 4.6.3.4 | Resistant bacteria | Bacteria can evolve rapidly because they reproduce at a fast rate.Mutations of bacterial pathogens produce new strains. Some strains might be resistant to antibiotics, and so are not killed. They survive and reproduce, so the population of the resistant strain rises. The resistant strain will then spread because people are not immune to it and there is no effective treatment.MRSA is resistant to antibiotics.To reduce the rate of development of antibiotic resistant strains:* Doctors should not prescribe antibiotics inappropriately, such as treating non-serious or viral infections.
* Patients should complete their course of antibiotics so all bacteria are killed and none survive to mutate and form resistant strains.

The development of new antibiotics is costly and slow and is unlikely to keep up with the emergence of new resistant strains. | 2 | Links to the Infection and Response section 4.3.Describe how antibiotic resistant strains of bacteria can evolve due to people not completing the course of antibiotics.Draw a cartoon strip to show how the populations of non-antibiotic resistant and antibiotic resistant strains can change during the course of an antibiotic course.Develop a leaflet to hand out to doctors and patients explaining the way to use antibiotics courses properly, not to always expect them, and for doctors not to overprescribe them. Explain why all this is important.Link resistant bacteria back to being evidence for evolution, alongside fossils. |  |  |

### 4.6.4 Classification of living organisms

| **Spec ref.** | **Summary of the specification content** | **Learning outcomes** *What most students 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*  |
| --- | --- | --- | --- | --- | --- | --- |
| 4.6.4 | Classification | Traditionally living things have been classified into groups depending on their structure and characteristics in a system described by Carl Linnaeus.Linnaeus classified living things into kingdom, phylum, class, order, family, genus and species. Organisms are named by the binomial system of genus and species.As evidence of internal structures became more developed due to improvements in microscopes, and the understanding of biochemical processes progressed, new models of classification were proposed.Due to evidence available from chemical analysis there is now a ‘three-domain system’ developed by Carl Woese. In this system organisms are divided into:* archaea (primitive bacteria usually living in extreme environments)
* bacteria (true bacteria)
* eukaryota (which includes protists, fungi, plants and animals).

Evolutionary trees are a method used by scientists to show how they believe organisms are related. They use current classification data for living organisms and fossil data for extinct organisms. | 2 | Define the Linnaean system of classification.Describe a human through all the levels of the Linnaean classification system. Classify a range of different living things into one of the two correct kingdoms based on the Linnaean system.Compare the kingdom of the Linnaean system to the system devised by Woese in 1977. Describe why microbes are now seen so important compared to when Linnaeus devised his system in 1735.Draw out an evolutionary tree to show how humans are related to the great apes.[Understanding Evolution – The emergence of humans](http://evolution.berkeley.edu/evolibrary/article/evograms_07) Provide evolutionary trees of different formats and ask students to interpret them by asking questions such as:How many species are shown in the X family?What is the common ancestor of A and B?How many of the Z family are now extinct?[Earthsky – Clues to the rapid rise of birds](http://earthsky.org/earth/dino-study-clues-to-the-rapid-rise-of-birds) [Hooper Museum – Mammoth Evolution](http://hoopermuseum.earthsci.carleton.ca/PleistoceneWebsite/mammoth04.htm) [Hooper Museum – Smilodon Evolution](http://hoopermuseum.earthsci.carleton.ca/PleistoceneWebsite/smilodon04.htm)[La Crosse University – Evolution of the Cat](https://bioweb.uwlax.edu/bio203/s2014/barbara_josh/classification.htm)  | Give students collections of different pictures of living things and ask them to sort them into groups. Discuss how they sorted them out.Examine pictures of bacteria and fungi, including some of the extremophiles (Archaea).Determine there are more types of microbe on Earth than any other living thing. |  |