# Scheme of work

Combined Science: Trilogy

## 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

Several useful resources can be found at [BBC Bitesize Science page](http://www.bbc.co.uk/schools/gcsebitesize/science/add_edexcel/cells/) .

Sexual reproduction links with 4.6.2.3, Selective breeding.

Asexual reproduction links with 4.1.2.2, Mitosis and the cell cycle.

There are also links with 4.1.1.4, Cell differentiation.

Chromosomes and Mitosis (4.1.2.1 and 4.1.2.2) should be reviewed when teaching Meiosis.

Protein synthesis links with enzyme action in 4.2.2.1.

It would be sensible to teach Sex determination, 4.6.1.6, after sexual and asexual reproduction and before DNA and genes, in 4.6.1.3. This would begin the story at the level of chromosomes, which have been introduced in meiosis, and also leads on from single chromosomes coming together as pairs at fertilisation.

4.6.1.5, Inherited disorders links with 4.6.2.4, Genetic engineering to treat genetic disorders.

4.6.2.4, Genetic engineering, could be taught after inheritance, rather than with 4.6.2 Variation and evolution.

| **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 apply practical and enquiry skills** | **Self/peer assessment**  **Opportunities and resources**  *Reference to past questions that indicate success* |
| --- | --- | --- | --- | --- | --- | --- |
| 4.6.1.1  4.6.1.1 | Sexual and asexual reproduction  Sexual reproduction involves the joining (fusion) of male and female gametes, sperm and eggs in animals and pollen and ovule cells in flowering plants. This mixing of genetic information leads to variation in the offspring. Gametes are produced by meiosis.  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. | Explain why sexual reproduction produces variation in the offspring, but asexual reproduction does not.  Describe sexual reproduction in animals and plants. Define the term clone. | 1 | Recap of reproduction through group work to discuss and share answers to questions:   * Do we really need males? * Is sex necessary? * Can scientists solve the world food shortage? * Do hermaphrodites lead a solitary existence?   Watch BBC video clips of fertilisation in humans and pollination of flowers (see resources).  Observe exhibition showing asexual reproduction in different organisms.  Give examples of sexual and asexual reproduction in different organisms.  View the BBC guide to sexual and asexual reproduction (see resources). | Appreciate how scientific developments can be used to control reproduction. | [BBC Bitesize – Human fertilisation](http://www.bbc.co.uk/education/clips/zth87ty)  [BBC Two – Science Clips – Pollination and Transportation](http://www.bbc.co.uk/programmes/p0128z6q)  Exhibition:   * strawberry runners * carrot top growing on damp blotting paper * potato sprouting * spider plant producing runners * bulb * amoeba * yeast.   [BBC Bitesize –Asexual and sexual reproduction](http://www.bbc.co.uk/education/guides/zykp34j/revision/1)  [BBC Bitesize – Reproduction and cloning activity](http://www.bbc.co.uk/schools/gcsebitesize/science/21c/genes/cloning_stem_cellsact.shtml) |
| 4.6.1.2 | Meiosis  Cells in reproductive organs divide by meiosis to form gametes.  When a cell divides to form gametes: copies of the genetic information are made and 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, and as the embryo develops cells differentiate. | Explain the term gametes and describe their genetic material.  Explain why sexual reproduction results in variety.  Draw diagrams to explain how gametes are formed in meiosis.  Explain the number of chromosomes in the gametes during meiosis and fertilisation.  Describe how an embryo is formed.  Compare mitosis and meiosis (links with 4.1.2.1 and 4.1.2.2). | 1 | Consider fusion of sex cells at fertilisation and explain why gametes have only one set of chromosomes – use models or diagrams.  Make models to show what happens during fertilisation (‘Play-Doh’ is ideal) – this could be extended to a stop frame animation if ICT is available.  Watch BBC video clip and access information on mitosis and meiosis (see resources).  Produce a poster to compare mitosis and meiosis. | Use bio-viewers, video clips or images to show chromosomes and meiosis. | Mitosis and meiosis: [BBC Bitesize – The building blocks of cells](http://www.bbc.co.uk/schools/gcsebitesize/science/add_edexcel/cells/)  Knowledge and understanding of the stages in meiosis are not required. |
| 4.6.1.6 | Sex determination  Human body cells contain 23 pairs of chromosomes.  22 pairs control characteristics only. The 23rd pair carries the genes that determine sex. In females the sex chromosomes are the same (XX); in males the chromosomes are different (XY). | Explain using a Punnett square and genetic diagram how sex is determined in humans.  Explain the probability of having a child that is a boy or a girl. | 0.5 | Look at male and female karyotypes and identify the number of pairs of chromosomes and each pair of sex chromosomes.  Use ‘Making Reebops’ game to demonstrate variation (see resources).  Watch BBC video clip about Sex chromosomes (see resources).  Use a Punnett square and a genetic cross diagram to illustrate the inheritance of sex; evaluate the chance of producing a male or female. | ‘Making Reebops’ practical. | Video clip:  [BBC Bitesize – Sex chromosomes](http://www.bbc.co.uk/education/clips/zhx4wmn)  [Nuffield Foundation | Making Reebops: a model for meiosis](http://www.nuffieldfoundation.org/practical-biology/making-reebops-model-meiosis) |
| 4.6.1.3 | DNA  DNA is a polymer made up of two strands forming a double helix.  DNA is found in chromosomes.  A gene is a small section of DNA.  Each gene codes for a sequence of amino acids to form a particular protein.  The genome is all the genetic material of an organism.  The human genome has been studied and will be important for medicine in the future. | Describe the structure of chromosomes, DNA and genes.  Explain that a gene is a small section of DNA that codes for a particular sequence of amino acids to make a specific protein**.**  Describe what the genome is.  Explain how knowledge of the human genome will help medicine in the future, eg identifying genes linked to cancers, understanding and treating inherited disorders. It will also help trace human migration patterns.  Explain the ethical issues related to DNA sequencing. | 1 | Recap key ideas by asking students to reorder by size: cell, nucleus, DNA, chromosome, gene, nucleotide.  Debate: research and discuss ‘DNA profiling’ for health.  Research roles of Franklin, Watson and Crick in the discovery of the structure of DNA.  Demo or practical to extract DNA. | Appreciate the power and limitations of science and consider any ethical issues.  Extract DNA from fruits such as onions or kiwi fruit. Observe the long strands which are the polymer. | [Wellcome trust – Interactive Human Genome](http://genome.wellcome.ac.uk/interactive/browser/start.html?t=1431513810294&remotechr=0&remotegen)  [BBC Bitesize – What is DNA?](http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel_pre_2011/genes/dnarev1.shtml)  Ethical issues: [ABPI – Genetics and the pharmaceutical industry](http://www.abpischools.org.uk/page/modules/hgenome/hgp5.cfm?coSiteNavigation_allTopic=1)  [Nuffield Foundation/ Extracting DNA from living things](http://www.nuffieldfoundation.org/practical-biology/extracting-dna-living-things) |
| 4.6.1.4  4.6.1.5  4.6.1.4  4.6.1.5  4.6.1.4  4.6.1.5 | Genetic inheritance and Inherited disorders  Some characteristics are controlled by a single gene. Each gene may have different forms called alleles.  The genes present, or genotype, operate at a molecular level to develop characteristics that are expressed as a phenotype.  A dominant allele is expressed if only present on one chromosome.  A recessive allele is only expressed if present on both chromosomes.  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.  Some disorders are inherited, eg polydactyly and cystic fibrosis.  A Punnett square can be constructed to predict the outcome of a monohybrid cross. | Give examples of characteristics controlled by a single gene and describe their alleles.  Give examples of characteristics controlled by multiple genes.  Define and use the terms:gametes,genotype, phenotype, dominant recessive, homozygous and heterozygous.  Complete a Punnett square to show the outcomes of genetic crosses.  Interpret the results of a genetic cross diagram and use direct proportion and simple ratios to express the outcomes. Describe the genotypes and phenotypes of the offspring.  Describe the inherited disorders polydactyly and cystic fibrosis.  Use genetic cross diagrams to explain inheritance and carriers.  Make informed judgements about the economic, social and ethical issues concerning embryo screening.  Discuss the use of genetic modification to treat genetic disorders (links with 4.6.1.4).  HT: Construct Punnet squares and genetic crosses. | 2 | Discuss variation in families and why offspring have some characteristics of their mother and some of their father and often strongly resemble their grandparents.  Complete Punnett squares.  BBC activity Inheritance showing genetic crosses (see resources).  Show images of polydactyly. Interpret family trees to determine chance of inheriting disorders.  Watch a video to explain what cystic fibrosis is, how it is inherited and to illustrate the severity of the disorder (see resources).  Evaluate genetic modification to treat cystic fibrosis.  Produce notes and complete genetic diagrams to explain how polydactyly and cystic fibrosis are inherited.  Interpret genetic diagrams relating to these disorders.  Role play – choices for parents of a cystic fibrosis sufferer who would like another child. To involve experts explaining cystic fibrosis and the screening procedure; the child with the disorder; parents to discuss what they would do if the foetus had the disorder.  Or  Watch a video of the process and describe issues to be considered re embryo screening. | Complete Punnett squares and genetic crosses. Interpret the results and describe the offspring. | [BBC Bitesize – Inheritance activity](http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/celldivision/inheritanceact.shtml)    Video clip: [BBC Bitesize – Gene therapy and cystic fibrosis](http://www.bbc.co.uk/education/clips/zh8fgk7)  Video clip: [Embryo chromosome screening](http://www.bing.com/videos/search?q=++embryo+screening&FORM=HDRSC3#view=detail&mid=61A90B74189B20130D2B61A90B74189B20130D2B) |
| 4.6.2.4  4.6.2.4 | Genetic engineering  Genetic engineering involves modifying the genome of an organism to introduce a desired characteristic.  Genes can be cut from the chromosome of a human or other organism and transferred into the cells of other organisms.  HT: enzymes are used to cut the gene from a chromosome; gene is inserted into a vector, eg bacterial plasmid or virus; vector is used to insert gene into cell; cell then makes a new protein to produce the desired characteristic.  Examples of genetic engineering.  Concerns about GM crops, eg effect on populations of wild flowers and insects, and uncertainty about safety of eating them. | Define the term genetic engineering.  Describe the process of genetic engineering and its advantages.  HT: Describe in detail the process of genetic engineering.  Evaluate the use of genetic engineering in medicine, eg in gene therapy and production of hormones and some vaccines.  Interpret information about genetic engineering techniques.  Make informed judgements about the economic, social and ethical issues concerning genetic engineering and GM crops.  Explain advantages and disadvantages of genetic engineering. | 1–2 | Brainstorm what the terms genetic engineering, genetic modification and gene therapy mean.  List examples of genetic engineering.  Produce a leaflet for a doctor’s surgery to explain how human insulin is produced by bacteria and discuss the advantages of this over porcine insulin.  Interpret information about genetic engineering techniques.  Research advantages and disadvantages of GM crops. What characteristics may be modified? Produce a web page or a table of benefits versus concerns for homework.  Produce short, headline paragraphs to represent the views of organic farmers, Food-Aid organisers, GM Research scientists and students.  Research the use of genetic engineering in medicine. | Use a model to describe genetic engineering techniques.  Evaluate the use of genetic engineering in agriculture and medicine. | [UPD8 – GM decisions](http://www.upd8.org.uk/activity/359/GM-decisions.html)  Information on genetically modified food can be found at [curriculumbits.com](http://www.curriculumbits.com/)  [PPT B1.7 Genetic variation and its control](http://filestore.aqa.org.uk/subjects/gcsescienceassessment/B1-7-GENETIC-VARIATION-AND-ITS-CONTROL.PPT) |

### 4.6.2 Variation and evolution

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

The content of these two sections is closely related.

These sections link with 4.6.1.1, Sexual and asexual reproduction.

4.6.2.4, Genetic engineering, and 4.6.2.5, Cloning, could be taught after 4.6.1.6, Genetic inheritance, as described above, rather than with Variation and evolution.

All sections of the specification related to evolution have been linked together here, to include 4.6.2.2, Evolution, 4.6.3.1, Theory of evolution, 4.6.3.2, Speciation, and Evidence for evolution - Fossils, and Resistant bacteria, 4.6.3.4, 4.6.3.5 and 4.6.3.7. Extinction, 4.6.3.6, completes the story.

Resistant bacteria, 4.6.3.7, links with 4.3.1.8, Antibiotics and painkillers.

There are lots of good BBC activities and video clips about evolution, evidence for the theory and extinction.

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| --- | --- | --- | --- | --- | --- | --- |
| 4.6.2.1 | Variation  Differences in the characteristics of individuals may be due to:   * genes they have inherited * environmental causes * a combination of genetic and environmental causes. | Classify characteristics as being due to genetic, environmental or a combination of these causes.  Give examples of continuous and discontinuous variation.  Decide the best way to present information about variation in tables and charts. | 1–2 | Discuss why organisms of the same species show variation. Use the terms: genetic and environmental variation, continuous and discontinuous variation.  Class survey of characteristics – collate results in a table and produce a display of the results in appropriate format.  Discuss how continuous data should be displayed.  Include in the table whether each characteristic is due to genetic or environmental causes, or both.  Measure variation in plants, eg leaf length in areas of sun/ shade.  Would you want to know if you had a genetic predisposition to illness that could be linked to environment? Eg, high cholesterol levels in family.  Discuss the benefits of knowing how genes can be linked to diseases. | Class survey and presentation of results.  Measure variation in a plant species growing in different areas of school grounds. | [BBC Bitesize – Variation](http://www.bbc.co.uk/education/guides/z9gk87h/revision/1)  [PPT B1.7 Genetic variation and its control](http://filestore.aqa.org.uk/subjects/gcsescienceassessment/B1-7-GENETIC-VARIATION-AND-ITS-CONTROL.PPT) |
| 4.6.2.3  4.6.2.3 | Selective breeding  Selective breeding (artificial selection) is the process by which humans breed plants and animals for useful characteristics.  The steps involved in selective breeding.  Selective breeding of food plants has produced disease or weather resistant crops, more attractive or better flavoured fruits and crops that are easier to harvest.  Selective breeding of animals has produced cows that produce more milk, animals that produce more, better flavoured or leaner meat.  Selective breeding can lead to ‘inbreeding’ where some breeds are particularly prone to disease or inherited defects. Some breeds of dogs suffer from inbred defects. | Explain why humans selectively breed plants and animals.  Describe selective breeding as a type of sexual reproduction.  Describe the process of selective breeding and give examples.  Explain the benefits and risks of selective breeding in plants and animals. | 1 | Images of different dogs. Students ‘breed’ and name a new dog from selecting any 2 – draw a picture of their new breed.  Draw a flow diagram to explain the steps involved in selective breeding.  Give examples of characteristics that are selectively bred in plants and animals.  Discuss the advantages and risks of selective breeding in plants and animals.  Debate: Should people be allowed to breed dogs? | Produce a model to describe selective breeding.  Consider the social, economic and ethical implications of selective breeding. | Video clips:  [BBC Bitesize – Selective breeding in dogs](http://www.bbc.co.uk/education/clips/zyq9wmn)  [BBC Bitesize – Natural and artificial selection in racehorses](http://www.bbc.co.uk/education/clips/zch76sg)  [BBC Bitesize – Species and selective breeding](http://www.bbc.co.uk/education/guides/zw4wjxs/revision/1)  [BBC Bitesize – The development of artificial selection in farming](http://www.bbc.co.uk/education/clips/z29br82) |
| 4.6.2.2  4.6.2.2 | Evolution  Darwin’s theory of evolution by natural selection states that all species evolved from simple life forms that first developed more than three billion years ago.  The main stages of natural selection.  Mutations are changes in the DNA code. They may lead to more rapid evolution, although mutations that result in a new phenotype are rare.  Organisms of the same species can interbreed to produce fertile offspring. | Describe Darwin’s theory of evolution by natural selection.  Describe the main stages of natural selection as:   * 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.   Define the term mutation.  Explain why mutation may lead to more rapid change in a species.  Define the term species.  Identify organisms that are of different species.  Interpret evolutionary trees. | 2 | Look at exhibition to show the wide variety of organisms that live, or have lived, on Earth.  Discuss how they were all formed.  BBC activity about Evolution.  Watch BBC video clip illustrating survival of the fittest (see resources).  Watch video clip about ancestor of horses from BBC Walking with Beasts.  Draw a flow diagram to explain natural selection.  Natural selection role play activities.  Peppered moth game; explain in terms of natural selection.  Look at pictures of Darwin’s finches and match up with the Galapagos Island they lived on based on food available there.  Discuss how you could show that a donkey and a horse are different species.  Interpret evolutionary trees. | Use a model to explain natural selection.  Describe how to gather evidence for an evolutionary tree to describe relationships between organisms. Include the time scales involved in evolution. | [BBC Bitesize –Evolution activity](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/evolution/evolutionact.shtml)  Video clip  [BBC Bitesize - Natural selection and survival of the fittest](http://www.bbc.co.uk/education/clips/z4wd7ty)  Horse ancestor: [BBC Nature – Propalaeotherium videos, news and facts](http://www.bbc.co.uk/nature/life/Propalaeotherium)  [BBC Bitesize –Evolution, extinction and biodiversity](http://www.bbc.co.uk/education/guides/zw9jq6f/revision/1)  Darwin and evidence for evolution; extinction: [BBC Bitesize – Charles Darwin](http://www.bbc.co.uk/schools/gcsebitesize/science/aqa_pre_2011/evolution/evolutionrev1.shtml)  [BBC Nature – Species](http://www.bbc.co.uk/nature/species) |
| 4.6.3.1  4.6.3.2  4.6.3.4  4.6.3.1  4.6.3.2  4.6.3.4  4.6.3.1  4.6.3.2  4.6.3.4 | Evidence for evolution – Fossils and Resistant bacteria.  The theory of evolution by natural selection is now widely accepted.  The evidence to support Darwin’s theory.  Fossils  Fossils are the ‘remains’ of organisms from many years ago, which are found in rocks.  Scientists cannot be certain about how life began on Earth because many early forms of life were soft-bodied, so few traces remain. What traces there were have been destroyed by geological activity.  Fossils show how much, or how little, organisms have changed over time.  Resistant bacteria  Bacteria can evolve rapidly because they reproduce at a fast rate.  Mutations produce new strains. Resistant strains are not killed by antibiotics, so they survive and reproduce. Resistant strains spread because people are not immune and there is no effective treatment.  MRSA is resistant to antibiotics.  How to reduce the development of resistant strains.  Problems associated with the development of new antibiotics. | Describe the evidence for the theory of evolution by natural selection.  Define the term ‘fossil’.  Describe how 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, eg footprints, burrows and rootlet traces.   Explain why scientists cannot be certain how life began on Earth.  Explain how fossils provide evidence for evolution.  Explain what we should do to slow down the rate of development of resistant strains of bacteria.  Describe the impact of antibiotic resistance. | 1 | Discuss the evidence we have to support Darwin’s theory and present in a suitable format.  Observe fossils or pictures of fossils.  Model how a fossil can be formed.  Discuss how fossils provide evidence for evolution.  Consider theories of how life on Earth began.  Explain how bacteria can become resistant to antibiotics.  Explain how antibiotic resistance has impacted on cleaning practices in Britain’s hospitals.  Interpret data about antibiotic resistance.  Role play: life without antibiotics.  Research MRSA and C. difficile infections and treatment.  Discuss how the rate of development of resistant bacteria could be slowed down.  Discuss why there are few new antibiotics being developed, and suggest how drug companies might be encouraged to develop some. | Draw fossils.  Model how a fossil can be formed. | Fossils and pictures of fossils.  Fossil formation:   * shells * leaves and other artefacts * sand * plaster of Paris.   [BBC News – Q&A: Antibiotic resistance](http://www.bbc.co.uk/news/health-21739378) |
| 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. | Define the term extinction.  Explain how extinction may be caused.  Explain that organisms become extinct because something changes and the species cannot adapt quickly enough to the new circumstances. | 0.5 | Give a list of extinct organisms and ask students to print images. Suggest reasons to explain why they died out.  Produce a poster of pictures of extinct organisms. Discuss the evidence we have that they looked like this.  Explain why some organisms are endangered. Give examples. Give reasons why it is important to prevent species from becoming extinct.  Research causes of extinction and write a report/ PowerPoint presentation to present to the class. |  | [PPT 1.8 Evolution](http://filestore.aqa.org.uk/subjects/gcsescienceassessment/B1-8-EVOLUTION.PPT)  [BBC Bitesize – Evolution, extinction and biodiversity](http://www.bbc.co.uk/education/guides/zw9jq6f/revision/3)  [BBC News – In pictures: 100 most threatened species](http://www.bbc.co.uk/news/science-environment-19558442) |