B6 Inheritance, Variation and Evolution

What's the science story?

In this section we will discover how the number of chromosomes are halved during meiosis and then combined with new genes from the sexual partner to produce unique offspring. Gene mutations occur continuously and on rare occasions can affect the functioning of the animal or plant. These mutations may be damaging and lead to a number of genetic disorders or death. Very rarely a new mutation can be beneficial and consequently, lead to increased fitness in the individual. Variation generated by mutations and sexual reproduction is the basis for natural selection; this is how species evolve. An understanding of these processes has allowed scientists to intervene through selective breeding to produce livestock with favoured characteristics. Once new varieties of plants or animals have been produced it is possible to clone individuals to produce larger numbers of identical individuals all carrying the favourable characteristic. Scientists have now discovered how to take genes from one species and introduce them in to the genome of another by a process called genetic engineering. In spite of the huge potential benefits that this technology can offer, genetic modification still remains highly controversial.

Previous knowledge:

KS3: Genes, Organisms, Genes 2
KS4: B1 Cell Biology
B3 Infection and Response

Next steps…

N/A

Keywords

Gamete	Mutation	Mitosis	Eukaryota	Variation	MRSA
Gene	Plasmid	Haploid	Kingdom	Environmental	
Chromosome	Culture	Diploid	Class	Linnaean	
DNA	Archaea	Polydactyly	Dominant	Binomial	
Polymer	Bacteria	Cystic fibrosis	Recessive	Order	
Genetic		Carrier	Allele	Family	
Nucleotide		Embyro	Homozygous	Genus	
Genome		Traits	Heterozygous	Species	
Ethical		Selective breeding	Genotype	Antibiotics	
Survival of the fittest	meiosis	Phylum	Phenotype	Resistance	

Working scientifically skills:
WS1: Why theories change over time
WS2: Use models
WS4: Ethical arguments
WS6: Importance of peer review
WS8: Writing methods
WS10: Selecting the correct equipment and measuring time accurately.
WS11: Hazards

Assessments:

End of unit test (summative) (Out of 30)

AQA GCSE Combined Science Trilogy (8464)

Lesson No. and Title	Learning objectives	AQA Specification	Practical equipment
1. Sexual and Asexual Reproduction	4 – Describe sexual and asexual reproduction 6 – Compare sexual and asexual reproduction 8 – Explain why one type of reproduction leads to increased variation	**4.6.1.1 Sexual and asexual 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. 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.	
2. Cell Division and Sexual Reproduction	4 – State that gametes are formed by meiosis. 6 – Describe the processes of mitosis and meiosis. 8 – Explain in detail why gametes are genetically different from each other.	**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.	
3. DNA and the genome	4 – State that the genetic material in the nucleus of a cell is DNA. 6 – Describe the relationship between DNA, genes and chromosomes. 8 – Describe DNA as a polymer made up of repeating nucleotide units each consisting of a sugar, a phosphate and a base.	**4.6.1.3 DNA and the genome** Students should be able to describe the structure of DNA and define 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. Students should be able to discuss the importance of understanding the human genome. This is limited to the: • search for genes linked to different types of disease • understanding and treatment of inherited disorders • use in tracing human migration patterns from the past.	Practical: extracting DNA • Fruit • Masher • Washing up liquid • Salt • Ice • ethanol • Water bath • Filter paper • Funnel • Small beaker

4. Genetic Inheritance	4 – Recognise examples of inherited traits. 6 – Use a Punnett square diagram to predict offspring outcome. **8 – Construct Punnett squares and use them to predict the outcomes of monohybrid crosses.**	**4.6.1.4 Genetic inheritance** Students should be able to explain the terms: • gamete • chromosome • gene • allele • dominant • recessive • homozygous • heterozygous • genotype • phenotype. Some characteristics are controlled by a single gene, such as: fur colour in mice; and red-green colour blindness 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 organism 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. Students should be able to understand the concept of probability in predicting the results of a single gene cross, but recall that most phenotype features are the result of multiple genes rather than single gene inheritance. Students should be able to use direct proportion and simple ratios to express the outcome of a genetic cross. Students should be able to complete a Punnett square diagram and extract and interpret information from genetic crosses and family trees. **(HT only) Students should be able to construct a genetic cross by Punnett square diagram and use it to make predictions using the theory of probability.**	

5. Inherited disorders	4 – Describe the symptoms of polydactyly and cystic fibrosis 6 – Construct genetic diagrams to predict the inheritance of genetic disorders 8 – Evaluate the use of embryo screening for both conditions.	**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.	
6. Sex Determination	4 – State the chromosomes difference in males and females. 6 – Represent the genetic cross to show sex inheritance. 8 – Use a family tree to work out possibilities of offspring.	**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). Students should to be able to carry out a genetic cross to show sex inheritance. Students should understand and use direct proportion and simple ratios in genetic crosses.	
7. Variation	4 – List examples of human variation. 6 – Categorise variation as genetic or environmental. 8 – Discuss some of the issues scientists face when conducting twin studies.	**4.6.2.1 Variation** Students should be able to describe simply how the genome and its interaction with the environment influence the development of the phenotype of an organism. 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. Students should be able to: • state that there is usually extensive genetic variation within a population of a species • recall that all variants arise from mutations and that: most have no effect on the phenotype; some influence phenotype; very few determine phenotype. Mutations occur continuously. 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.	

8. Evolution	4 – State what a mutation is. 6 – Describe the steps of natural selection. 8 – Apply the theory of natural selection to suggest how a specific organism evolved.	**4.6.2.2 Evolution** Students should be able to describe evolution as a change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of a new species. 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. Students should be able to explain how evolution occurs through natural selection of variants that give rise to phenotypes best suited to their environment. 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.	
9. Selective Breeding	4 – Describe what selective breeding is. 6 – Explain why humans have used selective breeding. 8 – Compare and contrast natural selection and artificial selection.	**4.6.2.3 Selective breeding** Students should be able to explain the impact of selective breeding of food plants and domesticated animals. 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.	

10. Genetic Engineering	4 – Give examples of GM organisms and describe why they are useful. 6 – Describe steps in genetic engineering to produce GM organisms. 8 – Explain how genetic engineering could be used to cure people with inherited disorders.	**4.6.2.4 Genetic engineering** Students should be able to describe genetic engineering as a process which involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic. Plant crops have been genetically engineered to be resistant to diseases or to produce bigger better fruits. Bacterial cells have been genetically engineered to produce useful substances such as human insulin to treat diabetes. Students should be able to explain the potential benefits and risks of genetic engineering in agriculture and in medicine and that some people have objections. In genetic engineering, genes from the chromosomes of humans and other organisms can be 'cut out' and transferred to cells of other organisms. 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. 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. Modern medical research is exploring the possibility of genetic modification to overcome some inherited disorders. **(HT only) Students should be able to describe the main steps in the process of genetic engineering.** **(HT only) In genetic engineering:** **• enzymes are used to isolate the required gene; this gene is inserted into a vector, usually a bacterial plasmid or a virus** **• the vector is used to insert the gene into the required cells** **• genes are transferred to the cells of animals, plants or microorganisms at an early stage in their development so that they develop with desired characteristics.** **(HT only) Interpret information about genetic engineering techniques and to make informed judgements about issues concerning cloning and genetic engineering,**	

11. Evidence for Evolution	4 – Describe what a fossil is and give an example. 6 – Describe how fossils are formed and evidence of evolution. 8 – Evaluate the use of fossils as evidence for evolution by natural selection.	**4.6.3.1 Evidence for evolution** Students should be able to describe the evidence for evolution including fossils and antibiotic resistance in bacteria. 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. **4.6.3.2 Fossils** Fossils are the 'remains' of organisms from millions 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 minerals 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. Students should be able to extract and interpret information from charts, graphs and tables such as evolutionary trees.	Practical Making fossils: • Plaster of paris • Objects to mould • water • small beaker • Modelling clay • Paper cups • Plastic Rod
12. Fossils and Extinction	4 – Order fossil diagrams to show the evolution of the horse. 6 – Describe how other organisms can cause extinction of another species. 8 – Evaluate the need to conserve endangered plants.	**4.6.3.2 Fossils** We can learn from fossils how much or how little different organisms have changed as life developed on Earth. Students should be able to extract and interpret information from charts, graphs and tables such as evolutionary trees. **4.6.3.3 Extinction** Extinctions occur when there are no remaining individuals of a species still alive. Students should be able to describe factors which may contribute to the extinction of a species.	

13. Resistant bacteria	4 – State what is meant by antibiotic resistant bacteria. 6 – Explain why we need to develop new antibiotics. 8 – Explain how a fast reproduction rate is linked to the development of antibiotic resistant strains.	**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 agricultural use of antibiotics should be restricted. The development of new antibiotics is costly and slow. It is unlikely to keep up with the emergence of new resistant strains.	
14. Classification	4 – Classify animals into groups based on their characteristics. 6 – Identify genus and species from a scientific name. 8 – Suggest why hybrids are not assigned names using the binomial system.	**4.6.4 Classification of living organisms** Traditionally living things have been classified into groups depending on their structure and characteristics in a system developed 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. Students should be able to use information given to show understanding of the Linnaean system.	

15. New Systems in Classification	4 – Name the three domains. 6 – Describe how organisms are divided into the three domains. 8 – Compare and contrast the Linnaean system with the three domain system.	**4.6.4 Classification of living organisms** Students should be able to describe the impact of developments in biology on classification systems. 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.	