

## UNIT 8: Inheritance and Evolution

**Recommended Prior Knowledge:** Knowledge Basic knowledge of cell structure is required, and also an understanding of the processes involved in sexual reproduction.

**Context:** This Unit builds on the topic of sexual reproduction, covered in Units 6 and 7.

**Outline:** The Unit begins with the introduction of several new terms, before moving on to genetics and inheritance. Variation, affected by both genotype and phenotype, is investigated, before considering the ideas of natural selection and evolution.

	Learning Outcomes	Suggested Teaching Activities	Online Resources	Other resources
III 3.1	Define the following terms: <i>chromosome; gene; allele; haploid and diploid nuclei</i>	<p>Students should know that a chromosome is a length of DNA, and that each chromosome carries a large number of genes. They may be interested to discuss the human genome project, which is mapping all the genes on the human chromosomes.</p> <p>They may already have met the terms haploid and diploid when considering the processes involved in sexual reproduction. A haploid cell is one with a single set of chromosomes (for example a gamete) while a diploid cell has two complete sets. Meiosis produces haploid cells from diploid. It is important to use the terms 'gene' and 'allele' correctly right from the start. If this is done, students find them easy to use, and there is no reason for confusion! At IGCSE level, it is enough to define a gene as a length of DNA giving instructions for a certain characteristic. However, you may prefer to say that a gene carries instructions for making a particular protein. An allele is a variety of a gene, and many genes have many different alleles.</p>	<p>The Human Genome Project  <a href="http://www.genome.gov/page.cfm?pageID=10001694">http://www.genome.gov/page.cfm?pageID=10001694</a></p> <p>Introduction to chromosomes  <a href="http://gslc.genetics.utah.edu/units/basics/tour/">http://gslc.genetics.utah.edu/units/basics/tour/</a></p>	
III	Define the following terms: <i>genotype;</i>	It is best to consider the meanings of these	Genotype and phenotype	

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3.4	<i>phenotype; homozygous; heterozygous; dominant; recessive</i>	<p>terms before thinking about inheritance. They can best be illustrated and explained with reference to a particular characteristic. Choose something simple, and that is likely to appeal to students, such as coat colour of an animal. The example does not have to be real. It should involve a gene with two alleles, one dominant and one recessive. Students should learn that one letter is used to represent these alleles, with an upper case letter for the dominant allele and a lower case letter for the recessive allele.</p> <p>They will already know that most cells are diploid, so should be able to understand that they therefore carry two copies of each gene. They can work out for themselves the three possible combinations of alleles, and think about what colours will result from them. Hence the terms genotype, phenotype, homozygous and heterozygous can be introduced and defined.</p> <p>It is a good idea to spend some time with such examples, and ensure that students are thoroughly confident using the terminology, before beginning to think about how inheritance occurs.</p>	<a href="http://www.brooklyn.cuny.edu/bc/ahp/BioInfo/GP/Definition.html">http://www.brooklyn.cuny.edu/bc/ahp/BioInfo/GP/Definition.html</a>	
III 3.4	Calculate and predict the results of monohybrid crosses involving 1 : 1 and 3	One or more of the examples used to illustrate the meanings of the above terms	The genetics of PKU <a href="http://www.ess.sunysb.edu/tr">http://www.ess.sunysb.edu/tr</a>	

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		will have four children!		
III 3.4	Explain codominance and inheritance of A, B, AB, O blood groups ( $I_A$ , $I_B$ and $i$ ).	<p>Codominance is, in many ways, easier to deal with than dominance. It is easy for students to imagine that a combination of two different alleles will produce an effect that is a mixture of both of them. The correct use of symbols should be encouraged; where codominance exists, the gene is shown with an upper case letter, with superscripts to represent the different alleles.</p> <p>The genetics of the A, B, AB and O blood groups is a good example of codominance, but it is also more complex than what has gone before because there are now three different alleles of the gene to consider, rather than just two. It is therefore helpful to write down a list of all the possible genotypes and the resulting phenotypes before attempting to deal with any crosses. Ensure that the correct symbols, as used in the syllabus, are automatically used by students. They should not take the easy way out by writing A and B instead of <math>I_A</math> and <math>I_B</math>.</p>	<p>Coat colour in Great Danes  <a href="http://www.greatdanerescueinc.com/PrimaryColor.html">http://www.greatdanerescueinc.com/PrimaryColor.html</a></p> <p>ABO genetics  <a href="http://www.people.virginia.edu/~rjh9u/abo.html">http://www.people.virginia.edu/~rjh9u/abo.html</a></p>	
III 3.1	Describe the inheritance of sex in humans (XX, XY).	The inheritance of sex can be dealt with in the same way as the inheritance of genes, but this time the symbols X and Y are used to indicate whole chromosomes, not alleles of a gene. Students should be able to draw genetic crosses to show that you would expect equal numbers of males and females to be born.		
III 3.5	Describe continuous and discontinuous variation as influenced by the environment and genes, illustrated by height and A, B, AB and O blood groups in humans.	Extension students will already be familiar with the A, B, AB and O blood groups, but these will need introducing for Core students. They are a good example of discontinuous variation. Students can draw bar charts to show the relative proportions	Variation – continuous and discontinuous <a href="http://www.bbc.co.uk/scotland/revision/biology/inheritance/variation_and_genetics_and_society_rev.shtml">http://www.bbc.co.uk/scotland/revision/biology/inheritance/variation_and_genetics_and_society_rev.shtml</a>	

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		<p>of people with these four blood groups. They will not find it difficult to understand that everyone fits into one of these four categories, with no in-betweens, and this is therefore an example of discontinuous variation. They could then be asked to think of other examples of discontinuous variation, and may think of gender.</p> <p>Continuous variation can be illustrated by almost anything that is measurable on a human - height, length of middle finger or wrist circumference will each give a good range of results and not cause any embarrassment! Leaves or other plant material can also be used to generate a range of results. Students will realise that they are dealing with something that behaves differently from blood groups; now there are no clear-cut categories, but a whole range of values. To show them graphically, they will need to decide on 6 or 7 ranges and then draw up a tally chart to show how many values fit into each range. These can then be plotted on a histogram. A common misconception is that 'continuous variation' means something that changes through your life. Although this is true of the measurements students are likely to have made to illustrate this, it is not the correct meaning of the term. Use other features, such as hair or eye colour, to emphasise the real meaning of continuous variation.</p> <p>Students should be able to work out for themselves that, while discontinuous variation is caused purely by genes, continuous variation often involves influence by the environment as well.</p>		
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<p><b>III</b> <b>3.5</b></p>	<p>Define <i>mutation</i>.</p> <p>Describe mutation as a source of variation, as shown by Down's syndrome.</p> <p>Outline the effects of radiation and chemicals on the rate of mutation.</p>	<p>Mutation can be defined as an unpredictable change in the DNA content of a cell. It can affect a single gene, or whole chromosomes, and can happen at any stage, not only during cell division. Ionising radiation and mustard gas can be given as examples of factors that may cause mutations.</p> <p>Down's syndrome is used to illustrate a mutation that occurs during cell division, and that affects the number of chromosomes in a cell. Students could look at karyotypes of people with Down's syndrome, and compare them with karyotypes of males and females with the normal number of chromosomes.</p>	<p>Down's syndrome as an example of mutation  <a href="http://www.bbc.co.uk/scotland/revision/biology/inheritance/variation_and_genetics_and_society_rev.shtml">http://www.bbc.co.uk/scotland/revision/biology/inheritance/variation_and_genetics_and_society_rev.shtml</a></p>	
<p><b>III</b> <b>3.5</b></p>	<p>Describe sickle cell anaemia and explain its incidence in relation to that of malaria.</p>	<p>Sickle cell anaemia can be explained as the result of a mutation in the gene that codes for the production of haemoglobin. The effects of this on the carriage of oxygen, and the consequences for respiring cells in body tissues, can be discussed. Its inheritance can also be considered. Students will need to know a little about malaria. They can then look at maps showing the distribution of malaria and of sickle cell anaemia, and begin to think of why these should be so similar. The story is not a simple one, and will give plenty of food for thought for Extension students. It is a good way to introduce the ideas of selection pressures, and natural selection.</p>	<p>Sickle cell disease  <a href="http://www.cuhk.edu.hk/med/paf/slides/hematolo/xv-19.htm">http://www.cuhk.edu.hk/med/paf/slides/hematolo/xv-19.htm</a></p> <p>Inheritance of sickle cell anaemia  <a href="http://www.sicklecellsociety.org/education.htm">http://www.sicklecellsociety.org/education.htm</a></p>	

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<b>III 3.6</b>	Describe the role of artificial selection in the production of varieties of animals and plants with increased economic importance.	Students are already aware that variation occurs within populations of organisms, and they will not find it difficult to think how humans may choose a particular variety of an animal or plant, and use this to breed from. Real or imaginary examples can be used to illustrate this. It should be made clear that this selection needs to continue for many generations, and does not produce immediate results.		
<b>III 3.6</b>	<p>Define natural selection as the passing on of genes by the best adapted organisms</p> <p>Assess the importance of natural selection as a possible mechanism for evolution</p> <p>Describe variation and state that competition leads to differential survival of, and reproduction by, those organisms best fitted to the environment</p>	If students have already considered the sickle cell anaemia story, they will already have thought about the ideas of differential survival and selection. Here, they can think a little more widely, perhaps using imaginary examples to think about how competition for scarce resources could lead to some individuals being more likely to survive and breed than others. These will pass on their alleles to their offspring, so that the alleles that confer the advantageous characteristics gradually become more common. Over time, this could lead to a change in the overall characteristics of the species.	Simulated evolution <a href="http://home.pacbell.net/s-max/scott/simevol.html">http://home.pacbell.net/s-max/scott/simevol.html</a>	
<b>III 3.6</b>	Describe the development of strains of antibiotic resistant bacteria as an example of natural selection	The development of antibiotic-resistant strains of bacteria makes a good example to illustrate the ideas in the previous section.	Antibiotic resistance <a href="http://www.hpa.org.uk/infections/topics_az/wfhfactsheets/WFHantib.htm">http://www.hpa.org.uk/infections/topics_az/wfhfactsheets/WFHantib.htm</a>	
<b>III 3.7</b>	<p>Define genetic engineering as taking a gene from one species and putting it into another species</p> <p>Explain why, and outline how, human insulin genes were put in to bacteria using genetic engineering</p>	<p>Use simple diagrams of bacteria containing circular DNA to show how a section of human DNA can be inserted into the bacterial DNA.</p> <p>Explain that DNA can be cut in certain places using different restriction enzymes to select the correct gene. If the same</p>	Description of human insulin production <a href="http://www.tiscali.co.uk/reference/encyclopaedia/hutchinson/m0007839.html">http://www.tiscali.co.uk/reference/encyclopaedia/hutchinson/m0007839.html</a>	

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		restriction enzyme is used to cut the bacterial DNA then the ends of the human and bacterial DNA will stick together.		
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