Unit 9A Inheritance and selection

About the unit

In this unit pupils learn:
- that characteristics are inherited and how this is used in selective breeding
- why selective breeding is important
- about variations arising from environmental differences

In scientific enquiry pupils:
- decide what measurements are needed
- collect, organise and use large data sets relating to variation
- look for patterns in data
- evaluate the strength of evidence
- investigate the effect of selective breeding on a plant variety, taking account of variables that cannot be controlled

When teaching this unit, teachers should make reference to their school's sex education policy and PSHE scheme. Teachers will be aware of the need for sensitivity to the personal circumstances of individual pupils and their families.

This unit is expected to take approximately 7.5 hours.

Where the unit fits in

The unit builds on ideas introduced in unit 7A 'Cells', unit 7B 'Reproduction' and in unit 7D 'Variation and classification'. This unit provides opportunities to revisit and revise topics met in other units in years 7 and 8. With some pupils, teachers may wish to concentrate on some of the new topics, extending activities, and with others to spend more time on revision of previous work.

The unit is closely related to unit 9D 'Plants for food', which considers environmental influences on food production.

There are opportunities for citizenship, PSHE and sex education to be linked to this unit.

The historical impact of scientific discovery is covered in unit 20 'Twentieth-century medicine' and unit 21 'Scientific discoveries' in the history scheme of work.

This unit lays the foundation for work in key stage 4 on inheritance and genetics.

Expectations

At the end of this unit

in terms of scientific enquiry

most pupils will: select and make effective use of secondary sources of information about inheritance and selective breeding; plan how to collect, store and use data about a large number of individuals; use ICT to produce graphs and draw conclusions from these; evaluate the strength of evidence in relation to sample size and variation within the sample

some pupils will not have made so much progress and will: select information from secondary sources about inheritance and selective breeding; collect, store and use data about a large number of individuals; use ICT to produce graphs and identify patterns in these

some pupils will have progressed further and will: synthesise information about inheritance and selective breeding and identify limitations in the data assembled; decide whether the data collected about individuals is sufficient for firm conclusions

in terms of life processes and living things

most pupils will: identify some inherited characteristics and describe how some characteristics are influenced by environmental conditions; describe how sexual reproduction results in genetic information being inherited from both parents; identify characteristics in a plant or animal which are desirable in particular circumstances; outline how these characteristics might be passed on; suggest some of the issues to be considered in relation to selective breeding

some pupils will not have made so much progress and will: identify some inherited characteristics and some influenced by environmental conditions; describe sexual reproduction as the joining of two cells; identify some characteristics of an animal or plant which are desirable in particular circumstances

some pupils will have progressed further and will: describe how selective breeding can result in offspring with particular characteristics; recognise that asexual reproduction produces clones

Prior learning

It is helpful if pupils know that:
- individuals of a species show characteristics which may be environmentally determined or inherited
- sexual reproduction involves the fusion of a male and female cell

Health and safety

Risk assessments are required for any hazardous activity.

Model risk assessments used by most employers for normal science activities can be found in the publications listed in the *Teacher's guide*. Teachers need to follow these as indicated in the guidance notes for the activities, and consider what modifications are needed for individual classroom situations.

Language for learning

Through the activities in this unit pupils will be able to understand, use and spell correctly:
- words and phrases relating to inheritance, *eg clone, gene, genetic information, gamete, genetically modified, selective breeding*
- specialised words, *eg clone, gene, gamete*
- words with different meanings in scientific and everyday contexts, *eg cell, variety*
- words with similar but distinct meanings, *eg variety, breed, species*
- words and phrases relating to scientific enquiry, *eg data set*

Through the activities pupils could:
- appraise texts quickly and effectively for their usefulness
- write closely argued text where precise links and connections are made within sentences
- ask different sorts of questions to extend thinking and refine ideas

Resources

Resources include:
- pictures of large family groups from which inherited characteristics can be identified
- secondary sources giving information about variation, reproduction and selective breeding in animals and plants, including different varieties of plant
- graphics software for producing graphs illustrating variation in a sample
- CD-ROMs on plants, *eg a gardening reference work*
- software simulations or video clips showing gametes and fertilisation and how animal and plant cells pass on genetic information
- information leaflets about breeds of farm animal
- information about cloning and genetically modified organisms (GMOs) from environmental groups and farming and governmental organisations
- plant specimens, *eg common fruits and vegetables,* showing variation such as size, shape and colour
- wind- and insect-pollinated flowers and photomicrographs of pollen and ovules

Out-of-school learning

Pupils could:
- watch television programmes or read newspaper and magazine articles about cloning and cellular 'surgery' and the impact of GMOs on the environment, and evaluate whether such information is biased
- search the internet to explore issues relating to this topic
- visit farms, including urban farms, rare-breed centres or allotments to gain first-hand experience of the differences between particular breeds and varieties

1	Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What characteristics can be inherited?				
	• that offspring are similar but not identical to their parents • that some characteristics are inherited • that these variations occur in both plants and animals	• Review pupils' ideas on variation from earlier work by asking them about ways in which humans differ from each other. Ask pupils which of these variations are likely to have been inherited from their parents, prompting them initially by showing pictures of large family groups used in unit 7D 'Variation and classification'. Extend the work to other organisms, *eg farm animals, garden flowers,* and ask pupils to identify characteristics that might be inherited.	• describe similarities between parents and offspring • identify some inherited characteristics in plants and animals	• This activity is designed to find out what pupils know about inheritance and variation. Teachers will need to bear this in mind in later work. • Pictures of large family groups in which inherited characteristics can be identified are available in many textbooks.
Why are offspring of the same parents similar but not identical?				
	• that cells have nuclei which contain information that is transferred from one generation to the next • that during fertilisation genetic information from male and female parents is combined • that the fusion of male and female sex-cell nuclei in both animals and plants produces a new individual that is genetically unique • how sperm and egg cells are specialised • that fertilisation is similar in plants and animals	• Ask pupils to suggest how offspring inherit characteristics from their parents, reminding them of the work on reproduction in unit 7B 'Reproduction' and unit 7A 'Cells'. Establish, *eg using video clips, software simulation or diagrams*, that during fertilisation animal and plant cells pass on 'information' in the nuclei from one generation to another. Introduce the terms 'gene' and 'genetic information' and explain them in simple terms, *eg Genes are instructions that control the characteristics that develop, The nucleus contains the thousands of genes needed to produce an individual.* Help pupils to associate genes with particular inherited characteristics. • Ask pupils questions to check understanding, *eg* – *Why are brothers and sisters similar?* – *How are identical twins formed?* – *Why are identical twins more similar than brothers and sisters?* – *Can identical twins be different sexes?* – *Will multiple births, when eggs are fertilised outside the body and then implanted, produce identical or similar offspring?* – *How does fertilisation occur in plants?* • Ask pupils to record this discussion by producing a sequence of diagrams to illustrate the processes of production and fertilisation of the sex cells in both plants and animals, annotated to describe what is happening. • Remind pupils of the structure of sperm and egg cells and how they are specialised for their functions. • Elicit pupils' ideas about whether identical twins really are identical and how any differences between them arise.	• produce a sequence of diagrams showing the process of sex-cell formation and fertilisation, and show, *eg by annotations,* how genetic information is transferred • describe, *eg in annotated drawings,* some ways in which sperm and egg cells are adapted • summarise similarities in fertilisation in plants and animals	• Teachers will be aware of the need for sensitivity to the circumstances of pupils and their families. • Pupils will have considered adaptations of sperm and egg cells in unit 7A 'Cells' and unit 7B 'Reproduction'. This provides an opportunity for revision, if appropriate. • Environmental variation is covered more fully in the next activity. • Details of genetics and inheritance are not required, but since pupils will be familiar with terms such as 'gene' from the media, it is worth introducing them and explaining their meaning simply, so that pupils can learn to use them correctly when talking about inheritance. Similarly, no detail of meiosis is required. • Extension: some pupils could be asked to use the internet to find out about the human genome project.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How do differences between offspring with the same parents compare with differences between offspring of different parents?			
• to decide which observations and measurements to make • to design tables to record data • to use spreadsheets to analyse data and draw graphs • to draw conclusions about variation within and between varieties	• Show pupils specimens of the same variety of crop, *eg tomatoes, garden beans, potatoes,* and ask them to investigate variation within the variety. Ask pupils to suggest characteristics that vary, *eg mass, length, diameter*, and make measurements of a sample, tabulating data and presenting results, *eg as a frequency graph.* • Ask pupils to compare the distribution and spread of results obtained from one variety with those obtained from another variety of the same species, and to decide whether the variation within a variety is greater or less than that between varieties. Point out to pupils that many varieties differ in ways that are not immediately observable, *eg resistance to disease, flavour, ripening time*, and ask them to think about why these factors might be important in growing crops.	• make and record appropriate measurements • present data in tables and use spreadsheet software to produce appropriate graphs • explain how evidence supports conclusions, *eg variation between varieties is greater than variation within varieties*	• Plants that show observable variation should be used in this work. Food bought in many supermarkets and other outlets is less likely to provide an observable range because it has often been presorted to produce individuals of similar quality, size, etc. Home-grown food is likely to produce the best results. • Groups could measure features in a number of specimens, *eg 10,* and pool results for analysis. • Different groups of pupils could investigate the same feature in different varieties of the same species. • The data could be saved as a spreadsheet and graphs produced from this.
• that variations can arise from environmental differences	• Remind pupils of the earlier discussion on twins and of the results of the previous investigation. Challenge pupils to explain why there is variation between individuals with identical or very similar genetic information and to list environmental factors that may lead to variation.	• identify some characteristics that are influenced by environmental factors • identify environmental factors that influence characteristics of an individual	• Pupils sometimes think that variation arises for either environmental or genetic reasons. They may need help to see that some characteristics, *eg height,* may be influenced by both. It may also be helpful to establish that environmental differences do not alter an individual's genes.
How are new breeds of animal produced?			
• that selective breeding involves choosing individuals with particular inherited characteristics to mate • that different breeds of animal have been produced by selective breeding • that selective breeding results in new varieties of plants and animals	• Show pupils images, *eg photographs, video clips,* of different breeds, *eg of dog.* Ask them to identify why they are considered to be separate breeds, using questions, *eg What are their unique features? What features do they share? How do breeders ensure they get the right kind of puppy? What happens if you cross a labrador with a dalmatian?* Expand the discussion by asking how these breeds came about. Develop the ideas by building on pupils' notions that breeds have been produced by humans selecting dogs with particular inherited characteristics for breeding, and relate these ideas to pupils' knowledge about cells. • Ask pupils why humans have gone to this trouble. Explain that although some varieties were bred for decorative features, most were originally functional in nature. Ask pupils to use secondary sources to find out the reasons different varieties were bred. Help pupils to summarise key points.	• identify some characteristics that breeders wish to pass on • explain why breeders may wish animals to have these characteristics • describe in terms of cells how desired characteristics are passed on	• Teachers may wish to extend the discussion to ethical questions surrounding selective breeding which are of interest and concern. • Extension: pupils could find out whether animals can breed across species, *eg donkey and horse.*

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
Checking progress			
• to bring together ideas about inherited characteristics and fertilisation • to identify reasons for variation between individuals • that selective breeding can produce individuals with particular characteristics	• Provide pupils with a series of true/false statements about individual characteristics, inherited and environmental variations, fertilisation and genes. Ask pupils in groups to agree whether they are true or false, providing an explanation for their decision. Discuss pupils' decisions with them, using those they found particularly challenging as a way of identifying difficulties. Use the outcomes to summarise work so far.	• relate characteristics to genetic information passed from both parents • explain why individuals from the same parents may vary • explain why individuals with the same genetic information may vary • suggest why particular inherited characteristics are important in animals	• Teachers will be aware of the need to ensure that material used in this activity is sensitive to the possible circumstances of pupils.
Why do farmers produce new breeds of animals?			
• to appraise texts quickly and effectively for their usefulness • to make precise links and connections within their own writing • that domestic farm animals have been bred to possess 'desirable' characteristics	• Explain to pupils that modern farm animals have been bred by humans to have characteristics that are desirable for stock management, or in the food produced. Ask pupils to suggest what particular features may have been desirable in breeding, *eg dairy cattle, pigs, beef cattle, sheep, poultry.* • Remind pupils, *eg by showing some examples of pupils' work,* how to make precise links between ideas when they are putting together an explanation or argument, and about skimming texts to see whether they are useful or not. • Provide secondary sources of information for pupils to use to find out more about breeds of domestic and farm animals. They could be asked to focus on specific issues, *eg* – *how 'desirable' features have changed through the ages* – *the origins of domesticated farm animals* – *how desirable features may be very local depending on the environment, such as short-legged sheep for upland hills* – *how some breeds are now no longer used on farms but are still protected to ensure that useful genes are not lost* • Ask pupils to write an account of their findings about one of the questions, supported by pictures and/or diagrams.	• identify useful sources of information • select information relevant to the question • describe and explain 'desirable' characteristics in a breed of animal, making clear links between the description and the reasons it is desirable	• Teachers will be aware, in choosing examples, of the need to be sensitive to the religious beliefs of some groups and to attitudes to eating meat. • Literature on breeds of farm animals and their particular characteristics may be obtained from sources such as farming organisations and the Ministry of Agriculture, Fisheries and Food. • A good example is the mating of Hereford bulls with Friesian cows to improve the meat quality of offspring, which also bear the white face of the Herefords as an identification mark. Details of genetics of the cross are not required at this level. • Extension: organise a visit to a farm or rare-breeds centre, where animals can be observed.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
How are new varieties of plant produced?			
• that plant breeders select healthy plants with particular characteristics to breed from	• Show pupils sets of varieties of food crops, *eg plum, beefsteak and cherry tomatoes; curly, cos and iceberg lettuces,* and explain that selective breeding is also used to produce new plant varieties. Ask pupils to think about less obvious characteristics which may be important to plant breeders, *eg resistance to cold, so crops can be planted early; sweetness, colour and texture in fruit crops; long shelf life for supermarket trade and overseas shipping.* Help pupils to produce a list of characteristics that selective breeding of plants might achieve.	• identify differences in visible characteristics in varieties of food crops • suggest other characteristics that might be desirable	• A detailed genetic treatment is not needed at this stage. • Extension: pupils could find out more about one example of selective breeding, *eg the development of winter wheat, the many generations of cross required and how this affects the price of seed.*
• that fertilisation of an ovule by a pollen cell produces a new individual • to suggest how selective pollination could be brought about	• Review pupils' understanding of the process of pollination in a flowering plant and what happens during fertilisation, prompting if necessary by showing pupils specimens of flowering plants and images of pollen and ovules, *eg photomicrographs or microscope slides.* • Ask pupils to suggest how a plant breeder could ensure that pollen from one particular flower was used to pollinate another flower, ensuring that no other pollen could be involved, and taking account of the fact that pollen and ovules may not ripen at the same time. Ask pupils to work in groups to produce a set of instructions for the process for use by a trainee breeder. • Ask groups to share and evaluate each other's ideas. Provide pupils with an account of how a plant breeder ensures selective pollination.	• describe pollination in terms of male and female cells • identify problems to be overcome in selective pollination • suggest how to ensure that a flower is pollinated by the selected pollen	• Investigation of the formation of pollen tubes is included in unit 7A 'Cells'.
Are varieties produced by selective breeding different from each other?			
• to frame questions to be investigated • to choose an appropriate sample size • to decide what methods and apparatus to use • to draw conclusions and evaluate these	• Ask pupils to investigate effects of selective breeding in plants, *eg by comparing the characteristics of garden peas of different varieties in terms of size, mass, colour, taste, cooking time*. Ask pupils to report on variation within each variety and to provide comparisons between the varieties. Different groups could investigate different questions and pool the results. Invite pupils to make value judgements on the 'best' type of pea.	• decide on a question or questions to investigate, *eg Do frozen peas weigh less than fresh peas?* • decide on a suitable sample, *eg 50 peas* • choose a method appropriate to the question • state conclusions, indicating the strength of the evidence, in terms of a comparison of variation within and between varieties and in terms of sample size	• Frozen peas and fresh peas could be used to provide different varieties. • A comparison of two varieties of potato could be used as an alternative. • Teachers may wish to extend the work to consider GMOs, explaining that this is a form of breeding where the genetic information carried by the parents is modified by inserting a different gene. This results in particular characteristics thought desirable, but long-term effects on other organisms are not clear.

Learning objectives Pupils should learn:	Possible teaching activities	Learning outcomes Pupils:	Points to note
What is a clone?			
• that, in cloning, all genetic information comes from one parent • to consider some of the ethical issues relating to cloning • to ask questions to extend their thinking and refine ideas	• As an extension, ask pupils what they understand by the term 'clone' and where they have heard it, *eg science fiction, Dolly the sheep.* Explain the principles of cloning, emphasising that it differs from sexual reproduction in that all genetic information comes from one parent. Ask pupils to describe the consequences of this for variation between parents and offspring. • Establish with pupils that methods of asexual reproduction, *eg cuttings, grafting,* have been used for many years with plants. • Ask pupils to suggest five questions that they would ask a scientist about cloning, given the opportunity, and to explain why they think they are important. Help pupils to evaluate and refine their questions and to use some of the many internet sites providing information on the process to find the answers. Ask pupils what they have found and make a brief summary.	• explain why clones are genetically identical • describe how asexual reproduction has been used to produce new plants • identify ethical issues relating to cloning of animals • use the internet to answer their questions and interpret what they have found	• Asexual reproduction producing clones is covered in the key stage 4 programme of study. However, most pupils will have heard of cloning and teachers may wish to discuss it here. • As an alternative, teachers could invite a scientist to talk about their work and answer pupils' questions. • Media reports may contain excellent explanations and graphics of the process of cloning for the 'general reader'. The internet can also be a valuable resource. • Extension: pupils could plant cuttings, *eg of geranium,* and show that they grow into new plants.
Reviewing work			
• to bring together ideas about inherited characteristics, fertilisation and selective breeding	• Provide pupils with a set of structured questions covering the work in this unit. Ask them to use their books and other sources of information to answer the questions. • Discuss their answers with them, identifying particular difficulties and, if appropriate, provide a set of exemplar answers.	• use ideas and concepts accurately in answering questions	