

# The Department of Agriculture, Fisheries & Food

## Why Preserve Genetic Resources for Food and Agriculture?

### What are Genetic Resources?

We can define *genetic resources* as material of plant or animal origin containing functional units of heredity (*genes*) of actual or potential use. This lesson focuses on Irish plant and animal genetic resources and their specific uses in agriculture and food production. *Plant Genetic Resources* are the raw material that farmers and plant breeders use to improve the quality and productivity of crops. The range of indigenous plant genetic resources in Ireland is relatively narrow, but the collection and preservation of these resources could make an important contribution to future crop research both at home and abroad. *Animal Genetic Resources* are those animal species and populations that can be used for the production of food and agriculture. The management and conservation of animal genetic resources in the form of older or rare breeds, along with more modern breeds, is important in order to maintain genetically diverse animal populations for the future.

### Historical Overview

Human beings originally gathered plants or hunted animals for food. Agriculture evolved as people first deliberately planted the seeds of certain plants and, in time, selectively planted the seeds of the more useful ones. Some animals were found to be suitable for domestication by humans as a source of food.

As agriculture evolved in different regions, plants and animals that were adapted to the local terrain and climate were cultivated and bred. They were often more resistant to the parasites endemic in their area. People had reliable sources of food, clothing and medicine. Pigs, for example, which were a source of meat, were also our original refuse disposal service. Geese had an aversion to broad-leaved crops, but grazed the competing grass and weeds. Animal waste provided crop fertiliser; the crops provided food and income.

Knowledge grew and farmers selected certain *species* for desirable characteristics. *Breeds* were developed and were sometimes crossed to get *hybrid vigour* in the offspring. The increased demand for food that accompanied the development of cities made productive animal breeds and crop strains more desirable. The less productive strains were abandoned. Adaptable local multipurpose animals, such as the Shorthorn cattle in Ireland, were cross-bred with more productive breeds such as the Holstein Friesian to try and increase milk production. Less than a century ago, there were 300 cattle breeds in Europe and North America, but today there are far fewer. Of the 10,000 wheat varieties in use in China in 1949, only 1000 were still being used by the 1970's. The *intensification* of agriculture, while making food production more efficient, has resulted in a loss of *biodiversity* globally.

### The Importance of Genetic Resources

Modern breeds of livestock and crops come from a narrow genetic pool. This can leave them vulnerable to catastrophic disease epidemics and failures, such as happened in the 1845 Irish potato blight or the 1970 coffee rust epidemic in Sri Lanka and Brazil. In these cases, the problem was addressed by using disease resistant strains of the crops.

Although *antibiotics* and chemical controls have been used to control animal and plant diseases, resistant *pathogens* can quickly emerge. Having genetically diverse populations can help to reduce the need for these interventions and can decrease the overall negative impact of such an event on our food supply.

Through genetic selection, animals with better milk and meat yields have been produced, mainly in response to consumer demand. However, such demand can change over time.

### How Are Genetic Resources Preserved?

There is global agreement amongst Governments worldwide that genetic resources need to be protected. The Food and Agriculture Organisation (FAO) of the United Nations co-ordinates and supports the activities of governments globally in their efforts to conserve genetic resources for food and agriculture.

The reality is that future requirements and demands cannot be accurately predicted and so the best policy is to have a large, and diverse, genetic bank of animals and plants. This has been recognised in Ireland and support is given by the Government to farmers to keep native breeds such as Kerry, Dexter and Irish Moiled cattle, Galway sheep, Irish Draught Horses, and Kerry Bog and Connemara Ponies. Support is also provided to collect and store genetic material such as semen, eggs and embryos from these animals. Government supported plant initiatives include measures to conserve native Irish varieties of numerous crop species including cereals, potatoes, forage grasses, apples and brassicas. The major advantage in preserving an intact breed or crop variety lies in the fact that it possesses characteristics that are adapted to the local environment.

Preserving genetic resources is also necessary because of effects that climate change may have on our food supply. The security of supply of food producing animals and crops will be of critical importance in the future. Current ryegrass varieties, which are a staple in the diet of our livestock, may not be as well adapted to our climate in the future. Long-stem cereals, which were once favoured as a source of straw for animal bedding, are no longer in common use. Now, farmers plant short-stem cereals to prevent lodging (leaning or bending) of the crop during severe rainfall.

It is also quite likely that the needs of farmers and consumers may change in the future. Farmers will have to produce food for a bigger global population, but essential resources, such as land and water, are finite. It is quite likely that consumer tastes and preferences will change over time. For example the food that we eat today is quite different from that consumed by our ancestors a hundred years ago.

*Gene banks* have been established around the world and represent a practical means of saving many species from extinction. Gene banks act as a reservoir of genetic material from both plant and

animal species. It is important that the material is stored in a suitable way. For example, seeds from different plant species require different storage conditions.

Sperm, egg and embryo banks exist for animals and have been used in artificial insemination (AI) and *in vitro fertilisation* (IVF) programs. The *Frozen Ark* project involves the preservation of animal material – DNA, tissues, gametes or whole organisms – with the aim of re-establishing species in the future.

Its current focus is on threatened wildlife species but it could eventually include endangered agricultural breeds. One problem is that stored seeds and tissues may not have the same gene frequencies as those found in thriving populations, and so it is important to keep updating gene banks with new material. The security of storage facilities cannot be guaranteed into the future and stored genes cannot evolve with changing conditions as would happen with living organisms.

The best option for preserving genetic resources for agriculture is to preserve as many species as possible in viable numbers. As an insurance against disease or other catastrophe, a species needs to be preserved in geographically distinct locations. Technology such as AI can help prevent excessive *inbreeding* and help preserve and increase populations, especially those with low numbers, or where populations exist in different parts of a country or continent. Financial subsidies may be necessary where a breed or plant species is currently uneconomic for farmers to maintain, but is important to preserve for future use.

Diverse agriculture is an adaptable and varied source of food and other products for humankind. For example, goats survive on *marginal land* and successfully challenge predators; they can be used for milk and meat production. Beekeeping helps crop pollination. Cows' milk contains useful proteins as well as fat. Pigs, while used for meat production are also a source of raw materials for pharmaceuticals.

Maintaining a broad base of plant and animal genetic resources for food and agriculture underpins today's production and provides the raw material needed to ensure continuing supplies tomorrow, in a rapidly changing world.

## The Department of Agriculture, Fisheries & Food

The Department of Agriculture, Fisheries & Food (DAFF) provides financial aid to research and development projects aimed at the conservation and sustainable use of plant and animal genetic resources e.g.

- Funding and support for rare and endangered indigenous Irish breeds such as Irish Draught Horses, Connemara and Kerry Bog Ponies, Kerry, Irish Moiled and Dexter Cattle and Galway Sheep.
- Conservation options offered to farmers under the Rural Environment Protection Scheme (REPS) – see below
- Certification of the quality of Irish cereal seeds
- Maintenance of a collection of approximately 400 potato varieties (some of which date back to pre-famine times) in the Department's Potato Centre, Raphoe, Co Donegal
- Funding for biodiversity research projects, e.g. studies on genetic diversity or on the wild relatives of commercial crops.

The **Rural Environmental Protection Scheme** compensates farmers for protecting and enhancing field margins and hedgerows as important habitats for a variety of plants and animals; planting traditional orchards to help conserve native Irish apple varieties; growing traditional hay meadows that benefit wildlife and help maintain valuable genetic resources; conserving rare breeds of animals native to Ireland that are in danger of being lost to farming.

You can learn more about this and other Department of Agriculture, Fisheries & Food lessons on [www.sta.ie](http://www.sta.ie).

Further information on DAFF's actions to conserve agriculturally important plant and animal genetic resources can be found on [www.agriculture.ie](http://www.agriculture.ie) under the headings Farmer Schemes & Payments/Other Farmer's Schemes/Conservation of Genetic Resources for Food and Agriculture.

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### Teaching Notes

#### Syllabus References

The relevant syllabus references are:

##### Leaving Certificate Biology

Section 1.4.9. Human impact on ecosystems.

Section 2.5. Genetics.

##### Leaving Certificate Agricultural Science

Farm crops- cereals and root crops, grassland.

Farm animals- cow, sheep, horse, pig.

Principles of genetics.

#### Learning Outcomes

On completion of this lesson, the student should be able to:

- Appreciate the historical development of agriculture
- Realise that some agricultural methods have reduced the genetic diversity of crops and farm animals
- Appreciate why protection of genetic resources is vital to agriculture
- Be aware that active measures are underway both nationally and internationally to protect agricultural genetic resources.

#### General Learning Points

The following information can be used to revise the lesson content and to inform discussion.

- Traditionally, agriculture used crops and animal breeds that were adapted to their environment and fulfilled a community's specific needs.
- Improved breeding techniques selected animals and plants with desirable characteristics.
- Intensive agricultural methods have led to mass production of less genetically diverse crop varieties and animal breeds; this can lead to overall loss of genetic resources.
- Species may in future require different characteristics due to climate change, changes in consumer demand or needs as yet unforeseen. Therefore, preservation of genetic resources is essential.
- Active programs and new farming methods are required in order to promote agricultural biodiversity.
- Farm species are part of the world's genetic heritage and contribute to biodiversity.
- It is preferable to preserve intact breeds and species rather than desirable genes alone.

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### Exercises

#### Investigation

- Obtain seeds of a particular plant. Plant 50 of them and record the percentage that germinate. Store the remainder, putting batches in different storage conditions. Repeat the germination experiment after intervals of time. Decide if seed viability declines over the period of investigation.
- In Ireland, there are programs to preserve Kerry, Dexter and Irish Moiled cattle, Galway sheep, Irish draught horses, Connemara and Kerry Bog ponies and Irish native plants. Find out about these programs and others. List any characteristics of these species that make them worth preserving for agriculture.
- Extinct cattle include the Irish and Suffolk Duns, both dairy breeds. Extinct sheep include the Scottish Cladagh. Make a list of extinct farm breeds and, if possible, find out some of their characteristics and why their use was discontinued.
- Survey local farms. What livestock breeds and crops are being used? What breeds and crops were used 30 or 60 years ago? Assess the effect of the European Common Agricultural Policy on agriculture. What current rules and programs are impacting positively or negatively on the preservation of genetic resources?
- Compare the operation of an organic farm with that of an intensive production farm.
- What are the advantages and disadvantages of GM technology in preserving genetic resources?

#### True/False Questions

- |   |   |   |
|---|---|---|
| a) The increased demand for food that accompanied the development of cities made productive animal breeds and crop strains more desirable.                | T | F |
| b) Having genetically diverse populations can help to reduce the need for antibiotics.  | T | F |
| c) In Europe, about half the livestock breeds that existed in 1900 are extinct and a third of the remaining breeds are threatened.                        | T | F |
| d) Native Irish bees are well adapted to the parasitic varroa mite which arrived with introduced species.   | T | F |
| e) Pigs bred for lean meat are poorly adapted to outdoor production because they do not have sufficient insulating fat.                                   | T | F |
| f) Seeds are normally planted deeper in the ground than would happen naturally. Domestication has therefore favoured seeds with large endosperm reserves. | T | F |
| h) GM technology has removed the need for preservation of genetic resources.  | T | F |
| i) Monoculture contributed to U.S. southern corn leaf blight outbreaks.   | T | F |

Check out your answers to these questions on [www.sta.ie](http://www.sta.ie).

#### Examination Questions

##### Leaving Certificate Biology (HL) 2009, Q.10

- (a)
- State Mendel's Law of Segregation.
  - Name two cell organelles, other than the nucleus, that contain DNA.
- (b)
- In guinea pigs the allele for black hair (B) is dominant to the allele for brown hair (b) and the allele for short hair (S) is dominant to the allele for long hair (s). The alleles governing hair colour are located on a different chromosome pair to those governing hair length.
- Explain the terms alleles and dominant.
  - What term is used to describe alleles that lie on the same chromosome?
  - Why is it significant that the two pairs of alleles, mentioned above in relation to guinea pigs, are located on different chromosome pairs?
  - Determine all the possible genotypes and phenotypes of the offspring of a cross between the following guinea pigs:  
Brown hair, heterozygous short hair × Heterozygous black hair, long hair
- (c)
- Explain the term species.
  - Within a species a considerable degree of variation is usually seen.
    - What is meant by variation?
    - State two causes of variation.
  - What is the significance of inherited variation in the evolution of species?
  - State two types of evidence used to support the theory of evolution.

#### Did You Know?

- There have been attempts to re-create extinct species. In 1991, after collecting sperm/egg samples, the New Zealand government exterminated feral cattle on Enderby Island. All efforts to produce offspring from the samples failed. Fortuitously, a lone cow was discovered to have escaped the cull. She was successfully impregnated with the sperm. This near-disaster shows that technology alone may not bring back species. In Germany, Heck cattle are the result of an attempt to back-breed aurochs from cattle with auroch characteristics. Nobody knows the aurochs' original niche so there is controversy about the program.
- Charles Darwin recognised that domestication imposed selection pressures on animals & plants. He devoted a major

work 'Variations of plants and animals under domestication' to the topic.

3. Horses are used by ranchers and police. In logging operations, they are used because they can climb slopes where machinery cannot operate and can remove selected felled trees with minimal ecological disruption.

## Biographical Notes

### Nikoloy Vavilov (1887-1943)

The Russian botanist and geneticist, Nikoloy Vavilov is recognized as the foremost plant geographer of his time.

He was born in 1887 into a merchant family. He studied in the Moscow Agricultural Institute, graduating in 1910. He transformed Moscow's Bureau for Applied Botany into the world's largest crop research institute and, during his lifetime, took part in over 100 "missions" worldwide, collecting almost 500 plant species. His research contributed enormously to the knowledge of plant genetics and breeding in areas such as disease resistance, origination of species and taxonomy.

The crater Vavilov on the Moon is also named after him and his younger brother, physicist Sergey Ivanovich Vavilov.

### Robert Bakewell (1726-1795)

Robert Bakewell, a farmer who was born in Leicestershire in 1726, had a significant influence on the world of animal breeding. Prior to the development of new methods of breeding by Bakewell, farmers

practiced the breeding of unrelated animals and prevented the mating of animals that were of close relationship. He demonstrated with his Leicester sheep and his long-horned cattle that animals of close relationship could be mated, and if rigid culling was practiced, desirable characteristics could thereby be fixed much more rapidly than by mating unrelated animals. He also identified that male and female lines carried the characteristics for different traits separately. Today Robert Bakewell is affectionately referred to, as the "Father of Animal Breeding". It is thought that the theories developed by Bakewell were the foundation of Darwin's work on natural selection.

## Revise the Terms

Can you recall the meaning of the following terms? Reviewing terminology is a powerful aid to recall and retention.

AI, antibiotic, biodiversity, breed, frozen ark, gene bank, hybrid, hybrid vigour, inbreeding, intensive agriculture, in vitro fertilisation (IVF), marginal land, monoculture, organic farming, pathogens, species.

**Check out the Glossary of Terms for this lesson at [www.sta.ie](http://www.sta.ie).**