CHAPTER 4

Genetic Resources in Agriculture

4.1 Origin and distribution of crop plants

A centre of origin means a geographical area where a plant species, either domesticated or wild, first developed its distinctive properties. Six independent centers of crop origin are recognized.

*Mesoamerica (Southern Mexico, and North Central America)*

<table>
<thead>
<tr>
<th>Crop Plant</th>
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<tbody>
<tr>
<td>Maize</td>
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<tr>
<td>Beans</td>
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<tr>
<td>Sweet Potato</td>
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<tr>
<td>Tomatoes</td>
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<td>Papaya</td>
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<td>Guava</td>
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<td>Pepper</td>
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<td>Sunflower</td>
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<tr>
<td>Strawberry</td>
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<td>Grapes</td>
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<td>Avocado</td>
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</table>
Andes and South America

- Tapioca
- Pineapple
- Groundnut
- Cotton
- Papaya
- Guava
- Pepper
- Rubber
- Cocoa

South East Asia

- Rice
- Peas
- Beans
- Yam
- Breadfruit
- Mango
- Nutme
- Brinjal
- Cucumber
- Banana
- Plantain
- Orange
- Lime
- Grapefruit
- Coconut
China

- Rice
- Peas
- Beans
- Grains
- Green
- Orange
- Apricot
- Peach
- Tea
- Cabbage
- Ginger
- Ginseng
- Rape seeds
- Chestnut
- Turnip
- Yam

Africa

- Sorghum
- Cowpea
- Brinjal
- Coffee
- Melon
- Watermelon
- Yam
- Oil palm
- Okra
- Kenaf
### 4.2 Origin and distribution of livestock, poultry and fish

Since domestication of livestock, several breeds or species of livestock, fish and poultry are reared mainly as sources of food and non-food products. These animals have been developed by breeders in many parts of the world. When men migrated from one place to another (e.g. from England or Europe to USA, Australia and New Zealand), they brought with them live animals to continue the farming activities in the new land.

Today, animal genetics in the form of live farm animals e.g. cattle, sheep, goats, camels, horses, buffaloes, fish and poultry (chickens and ducks) are still exported from the country where it is widely developed (bred) to another by land, sea and air transportation. With advancement of genetic engineering and reproductive biotechnology, genetic materials in the forms of frozen semen and embryos are commonly moved from one part of the world to another. Therefore, same breed of cattle, goats, sheep, fish and poultry are farmed globally. Development and selling of animal genetics has become a big agricultural business globally.

**Beef cattle** – These are cattle with characteristically high growth rate and excellent meat quality. Examples of some popular breeds are:

a) **Angus**: Originally from the highlands of northern Scotland. It is one of the finest beef cattle breeds. Today, it is farmed in many countries and therefore takes the name of the country e.g. Australian Angus, US Angus. In the US for example, this breed was first brought by the Scottish farmer in 1873 when they migrated to the US.

b) **Brahman**: This is a typical tropical breed, meaning that it is largely found in the hot and wet tropics. The breed has its original home in India. Today, it is also farmed in many parts of the world. For example, it was introduced in 1954 in the US. It is the first cattle breed developed and named as the American Brahman. We have Australian Brahman, Thai Brahman and Pakistan Brahman and others. Today,
Malaysia regularly imported this breed for the integrated cattle farming in oil palm plantations.

c) **Hereford**: The breed was established in a place called Hereford, England, 300 years ago. It is another well known beef cattle breed with brown body coat and white face. Today, this breed is farmed in many parts of the world.

**Dairy cattle** – The dairy cattle breeds are best known for its ability to produce high milk yield. There are many breeds of dairy cattle commercially farmed for fresh milk production. Dairying is also a big business as milk and milk products (dairy products) are important diet of human. Examples of popular breeds are:

a) **Jersey**: Originated from Jersey the largest Island in the Channel Islands (near France). Today, the breed is continued to be bred in many countries and also take the name of the country where it is bred e.g. Australian Jersey, New Zealand Jersey, French Jersey, English Jersey and American Jersey.

b) **Friesian**: Originally from the highlands of northern Scotland. First brought by the Scottish farmer to the US in 1873. It is one of finest and most popular dairy cattle breeds and is farmed in many countries. The Friesian cattle also carry the name of the country where it is further developed.

Some examples are: Australian Friesian, New Zealand Friesian, French Friesian, English Friesian and American Friesian and Thai Friesian.

c) **Holstein**: Originated in Holland close to 2,000 years ago. Currently farmed in many countries e.g. Australian Holstein, New Zealand Holstein, French Holstein, English Holstein, American Holstein and Italian Holstein

**Goats and sheep** – Goats and sheep are important and popular farm animals. They are reared for meat, skin and fiber (wool and hair). These animals originate from Western Asia.


**Poultry** - Poultry refers to chicken, ducks and turkeys. Humans first domesticated chickens (fowl) of Indian origin for the purpose of cockfighting in Asia, Africa, and Europe and little attention was given to egg or meat production. From India, the domesticated fowl moved to western Asia and then to Europe in the 5th century BC.


In modern day farming, chicken is divided into two groups; (a) Layers (production of eggs) and (b) broiler (production of tender meat). In today’s commercial world, chicken is genetically selected and farmed for their fast growing ability (for broiler chicken) and produces high yield of eggs (for layers). Both groups of chicken must also be efficient in using feed. These chickens are commonly referred as commercial lines (breeds). However, there are many native (original breeds), some of these breeds are:

a) Plymouth Rocks, (b) Leghorns, (iii) Cornish, (iv) Sussex and (v) Langshans

**Fish** – The Egyptians and the Chinese started aquaculture (rearing of fish) in around 2500 BC. However, the growth of modern aquaculture is new with most of the species currently farmed having been domesticated since the beginning of the 20th century. Many
breeds: freshwater (examples are catfish or Keli and carp (Lampam) and marine or saltwater (examples are grouper, Mackerel and Pomfret or bawal).

Presently, aquaculture is a big business in Malaysia. It covers rearing of freshwater and marine (saltwater) fishes, shells, shrimps, crabs, seaweed and others. Fish are reared in cages along river banks, lakes and sea. It can be reared in ponds and tanks. Ornamental fish (e.g. aquarium fish) is also another business and Malaysia is one of the largest breeder and exporter of ornamental fishes in the world.

4.3 Germplasm and biodiversity

4.3.1 Germplasm

It is a term used to describe the genetic resources, or more precisely the DNA of an organism and collections of the materials. The term germplasm was first used by August Weismann to describe a component of germ cells that he proposed were responsible for heredity. It involves any material of plant, animal, microbial or other origin containing functional units of heredity.

There are worldwide collections of plant, animal and bacterial germplasms for use in breeding new organisms and the conservation of existing species.

4.3.2 Biological diversity

Biological diversity is often shortened to biodiversity, as meaning the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

There are three aspects of biodiversity:

*Genetic diversity*

This term refers to the variation (diversity) of genes within a species.

*Species diversity*

This term refers to diversity among species in an ecosystem. “Biodiversity hotspots” are excellent examples of species diversity.

*Ecosystem (habitat) diversity*

This term refers to diversity at a higher level of organization, the ecosystem. This has to do with the variety of ecosystem on earth habitat, topography, elevation, natural vs agroecosystem, etc.

If the gene is the fundamental unit of natural selection, the real biodiversity is genetic diversity.
4.3.3 Significance of biodiversity

a) It is a global resource being the underpinning factor for the healthy functioning of the earth's many ecosystems.

b) It provides humans with substantial economic benefits with respect to crops, livestock, medicines, natural products (wildlife, fish, timber) with some 10,000 species of plants and animals exploited industrially.

c) It provides humans with aesthetic benefits.

4.4 Genetic resource applications

Agriculture production is increased through the use of improved genetic resources (new variety) created by altering the genetic constitution.

Yield

Examples can be seen in the dramatic increase of crop yield from 1930 to 2000. Crops yield of rice, wheat, barley, soybeans, cotton and sugarcane has doubled, of tomato and rubber has tripled, and of corn, sorghum, potato has quadrupled.

Pest and disease resistance

Resistance against pest and disease by plants and fruits is influenced by their genetic make-up. Genes from resistant plants or fruits are used in breeding programme to produce hybrids with stronger resistance. Example is in the breeding of tomatoes where the genes have been sourced from the wild relatives of the cultivated tomatoes producing tomato plants with resistance to several major diseases.

Insect resistant genes have also been bred. An added phenomenon is introduction of foreign genes such as Bacillus thuringiensis (Bt), which produces an insect killing toxin, into the crop, as seen in maize.

Ecological tolerance

New varieties with genes sourced from wild relatives have been developed which are tolerant to temperature extremes, salinity, drought and water logging.

Green revolution examples

A cultivar of wheat, Norin 10, from Japan has been developed which was shorter in height than the typical varieties of wheat through the introduction of two genes, Rht1 and Rht2 that caused dwarfing (short). These genes were derived from a Japanese landrace Shiro Daruma. These genes not only reduced lodging through reduced heights, they directly increased the yield via a more efficient nutrient uptake and enhanced tillering.

Genetic resources

Genetic resources are categorized into six types:

(i) **Wild relatives:** These are species in the wild from the same genus of the crop or livestock.
(ii) **Weedy relatives:** There are bridge or link between wild relatives and domesticated species. In the case of crops, they are neglected varieties that evolved to adapt to the natural growing environment. They become more hardy and as good a competitor as the wild types.

(iii) **Primitive cultivars or landraces:** are the cultivated varieties during earlier times.

(iv) **Modern cultivars:** are improved strains bred from primitive cultivars

(v) **Advanced breeding lines:** These are superior germplasm selected from modern cultivars

(vi) **Genes from other species** advanced lines which contain specific desired genes from other species. For example, 90% of the genes in rice could also be found in corn, wheat and barley.

4.5 **Biological diversity hotspots**

These hotspots are the sites where many types of biological organisms exist and constitute invaluable genetic resources. They contain:

(i) Higher range or number of species or subspecies found in a particular area.

(ii) Higher variety of life, including the genetic diversity among members of a population or species, the species themselves, and the range of communities and ecosystems present on earth.

(iii) Higher variety of life forms that inhabit the earth.

Much of the Earth's species diversity is concentrated into a few small areas. Twenty-five regions are identified and this cover only 1.4% of the Earth's land surface, but contain nearly half of all plant species and a third of all terrestrial vertebrate species. All are under
pressure from human activities. Recognized biodiversity hot spots in the world are as follows:

i. **North and Central America** that is made up of the Caribbean, California Floristic Province, and Mesoamerica;

ii. **South America** that is made up of the Tropical Andes, Choco-Darien-Western Ecuador, Atlantic Forest, Brazilian Cerrado, and Central Chile;

iii. **Europe and Central Asia** that is made up of the Caucasus, and the Mediterranean Basin;

iv. **Africa** that is made up of the island of Madagascar and Indian Ocean Islands, Eastern Arc Mountains and Central Forests, Guinean Forests of West Africa, Cape Floristic Region, and Succulent Karoo

v. **Mainland Asia** that is made up of the Mountains of Southwest China, Indo-Burma, and the Western Ghats; and

vi. **Asia-Pacific** region that constitutes the Philippines, Sundaland, Wallacea, Southwest Australia, New Zealand, Polynesia and Micronesia, and New Caledonia.

### 4.6 Genetic variation and conservation of genetic resources

#### 4.6.1 Genetic Variation

All genetic variation originates from mutations and is increased by sexual recombination. Mutations are rare and random. Genetic variation is essential for evolution. For evolution to occur, the genetic variation must be selected for and expressed in the phenotype. Large amounts of variation are present in natural populations.

To date, 1.7 million species have been identified and named. About 1 million are animals (750,000 are insects), 250,000 are plants, and 69,000 are fungi.

A species name consists of two words (binomial system), for example, *Zea mays* (corn), and *Homo sapiens* (human). New species are discovered everyday with about 10,000 reported every year.

Species are not evenly distributed on the earth’s surface with diversity increasing with convergence towards the equator. The reasons are there are more land and sunlight (much more growth) near the equator, and greater survival of species due to disruptive glaciers are not present.

#### 4.6.2 Techniques to Conserve Genetic Resources

There are two major alternatives for the conservation of genetic resources, namely *in situ* and *ex situ*.

**In situ conservation** refers to the conservation of important genetic resources in wild populations and landraces, often associated with traditional and subsistence agriculture. This involves combining nature reserves, focusing on the protection of wild races and wild relatives with traditional agricultural practices. Botanical reserve is one such approach. However, it is expected that traditional farmers would not forego the substantial economic
benefits that may accrue by conserving elite varieties. As such this may require direct economic subsidy or conservation of traditional varieties in some other ways. Examples include forest reserves, national parks, agricultural parks, botanical gardens, herbal collections, and zoos.

**Ex situ conservation** refers to the conservation of genetic resources off-site in gene banks, often in long-term storage as seed. However, seeds of many important tropical species are recalcitrant which means it is difficult or impossible to store for long periods. Many of these crop plants can also be clonally propagated. Nonetheless, tissue culture and cryopreservation techniques have not been fully developed.

### 4.6.3 Threats to diversity and loss of genetic resources

Dying species are caused by:

i. Domestication and use of modern varieties.

- [Diagram showing evolution of species from wild to domesticated to modern varieties]

ii. Wanton, irresponsible and thorough wide spread, and often concentrated habitat destruction. Native species are often lost and habitat is invaded by exotic weeds.

iii. Natural extinctions as a result of competition and natural disasters.