CHAPTER 5

GENETIC RESOURCES IN AGRICULTURE
TOPIC 1: ORIGIN and DISTRIBUTION of CROP PLANTS

• Centre of origin: Geographical area where a plant species, either domesticated or wild, first developed with special characteristics

• 6 independent centres recognized
1. **Mesoamerica** (Southern Mexico, and North Central America).
2. Andes and South America.

- **Pseudocereals:**
  - amaranth, chenopodium

- **Pulses:**

- **Roots & tubers:**
  - arracacha, achira, cassava, jicama, *oca*, potato, *aïn*, *yacon*, ullucu, *mashua*, *unchua*

- **Oil crops:**
  - peanut, cotton

- **Fiber:**
  - cotton

- **Fruits & nuts:**
  - cashew, pineapple, guanabana, charimoya, Brazil nut, papaya, avocado, guava

- **Vegetables & spices:**
  - pepper, squash

- **Stimulant:**
  - coca, *mate*

Cereals:
Asian rice

Pulses:
pigeon pea, jack bean, winged bean, moth bean, rice bean

Roots & tubers:
yams, arrowroot, taro
cassava
coconut

Fruits & nuts:
breadfruit, orange, lime, tangerine, grapefruit, mango, banana

Vegetables & spices:
cucumber, nutmeg, eggplant, plantain

Fiber plants:
coconut, jute

Cereals:
- Asian rice, proso and foxtail millets

Pulses:
- soybean, adzuki bean

Root & tuber crops:
- turnip, yams

Oil crops:
- rape seed

Fruits & nuts:
- Chinese hickory, chestnut, quince;
- persimmon, litchi, apricot, peach

Vegetables & spices:
- Chinese cabbage, ginger

Stimulants:
- tea, ginseng, camphor
5. **Africa** (Sahel Region including Ethiopian Highlands).

- **Cereals:**
  - African rice, pearl millet, sorghum
  - teff, fonio

- **Pulses:** cowpea, Bambara groundnut, hyacinth bean, Karating’s groundnut

- **Roots & tuber crops:**
  - yam

- **Oil crops:**
  - oil palm, castor bean

- **Fruits & nuts:**
  - baobab, watermelon, melon

- **Vegetables & spices:**
  - okra, *Sesamum* sp. (leaves), *Solanum* spp.

- **Fibers:**
  - kenaf

- **Stimulants:**
  - coffee

Cereals:
wheat, barley, rye, oat

Pulses:
pea, chickpea [garbanzo], lentil, lupine

Root & tuber crops:
turnip, carrot, radish

Oil crops:
rape seed, safflower, flax, olive

Fruits & nuts:
fig, walnut, date palm, almond, grape, apple, pear, plum

Vegetables & spices:
onion & relatives, lettuce, saffron, parsley

Stimulants:
poppy, digitalis, belladonna, licorice
TOPIC 2: ORIGIN and DISTRIBUTION of LIVESTOCK, POULTRY AND FISH
• Migration led to live animals brought from one place to another, eg. Europe to USA

• Animal genetics follows the migration pattern via land, sea and air transportation

• Gene engineering and reproductive biotechnology resulted in materials like frozen semen and embryos moved across the world – same breed formed globally
BEEF CATTLE

High growth rate and excellent meat quality eg:

• **Angus**

  Originated in northern Scotland. Among finest breeds, farmed in Australia, US
• Brahman
Tropical breed, originated in India. Now found everywhere, eg American Brahman, Thai Brahman, etc.

In Malaysia, regularly imported for integrated cattle farming in oil palm plantations
• **Hereford**
  Originated in Hereford, England 300 years ago.
  Farmed in many parts of the world. Brown body coat and white face.
DAIRY CATTLE

Produce high milk yield. Big business as milk is important human diet

• Jersey

Originated from Jersey, Channel Islands UK, near France. Bred in many countries eg Australian Jersey, English Jersey, French Jersey,
• Friesian
Originated from northern Scotland.

One of finest and most popular breeds. Found all over the world eg English Friesian, Australian Friesian, Thai Friesian
• Holstein

Originated in Holland nearly 2000 yrs ago.

Now farmed in many countries eg Australian Holstein, Italian Holstein, etc
GOATS AND SHEEP

• Reared for meat, skin and fibre (wool and hair)

• Originated from Western Asia
Sheep breeds

- Merino
- Dorper
- Damara
- Cheviot
- Dorset
- Border Leicester

Merino
Goat breeds

- Alpine
- Saanen
- British Alpine
- Anglo-Nubian
- Boer
- Kacang
  (local Malaysian)
POULTRY

• Refers to Chicken (Fowls), Ducks and Turkeys

• Chicken first domesticated from India for cockfighting in Asia, Africa and Europe, not for eggs or meat

• From India, fowl moved to western Asia, then Europe in 5th Century BCE.
• Broad classes of chicken are:
  - American
  - Asiatic
  - Mediterranean
  - English
  - Continental
  - French
  - Orientals
American chicken - Dominique
Asiatic chicken - Bantam
Continental chicken
Chicken divided into:

- **Layers** - egg production. Selected for high yield of eggs

- **Broiler** - meat. Selected for rapid growth

- Both groups must be efficient in using feed. Referred to as commercial lines (breeds)
There are many native (original breeds) eg

- Plymouth Rock
- Leghorn
- Cornish
- Sussex
- Langshans
FISH

• Aquaculture (rearing of fish) started by Egyptians and Chinese around 2500 BCE

• However modern aquaculture involves species domesticated since beginning 20th Century.
Divided into:

- Freshwater - catfish (Keli), carp (Lampan)
- Marine or saltwater – grouper, mackerel and pomfret (Bawal)
• Aquaculture is big business in Malaysia

• Rearing of fresh and salt water fishes, shells, shrimps, crabs, seaweed and others

• Reared in ponds and tanks

• Ornamental fish is also an important item
TOPIC 3: GERmplasm & Biodiversity

- **Germlasm**: genetic resources, or more precisely the DNA of an organism and collections of that material.

- Worldwide there are collections of plant, animal and bacterial germplasm for use in breeding new organisms and the conservation of existing species.
Evolution

The first cells originated by chemical evolution on a young Earth at the beginning of time billions of years ago.

They developed from nonliving materials that became ordered into molecular aggregates that eventually could reproduce.
New fossils shed light on this part of the family tree.
THEORY OF NATURAL SELECTION:
Charles Darwin

• Over time, these early cells mutate to create new life forms.

• If these new forms are favoured by the environment, they will be selected and retained.

• Accumulated mutations over thousands of years will result in a new species. This gives rise to the biodiversity of life we see today.
Biological Diversity (Biodiversity)

• Refers to the “variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems
Biodiversity of life
Charles Darwin
Three aspects of biodiversity:

- **Genetic diversity**
  Variation of genes within a species

- **Species diversity**
  Variation of species within an ecosystem. Example: Biodiversity hotspots

- **Ecosystem (habitat) diversity**
  Variation of ecosystems on earth

- Since gene is fundamental unit of natural selection, real biodiversity is **genetic diversity**
Genetic diversity in a vole population

Species diversity in a coastal redwood ecosystem

Community and ecosystem diversity across the landscape of entire region
Significance of biodiversity

• Global resource
  – biodiversity is the underpinning of the healthy functioning of the earth's many ecosystems

• Biodiversity provides humans with substantial economic benefits
  • crops
  • domestic animals
  • Medicines
  • natural products: wildlife, fish, timber
  • some 10000 species of plants and animals are exploited industrially

• Biodiversity provides humans with esthetic benefits
Genetic Resource Applications

Agriculture production increased through improved genetic resources (new varieties)
• YIELD of many crops increased dramatically in the half century from 1930 to 2000.

Examples:
Rice, barley, soybeans, wheat, cotton, and sugarcane - DOUBLED

Tomato and Rubber - TRIPLED
Corn, sorghum, potato – QUADRUPLE
2. PEST AND DISEASE RESISTANCE:

Eg. In tomato

- Resistance to at least 16 major tomato diseases have been discovered in wild relatives. Genes bred into commercial cultivars.

- Insect resistance genes have also been bred.

In maize:

Foreign genes such as *Bacillus thuringiensis* (Bt) which produces an insect-killing toxin has been introduced
3. ECOLOGICAL TOLERANCE

New varieties with genes sourced from wild relatives have been developed which are tolerant to:

- temperature extremes
- salinity
- drought
- waterlogging.
4. **Green Revolution example:**

A cultivar of wheat, "Norin 10," from Japan was shorter than typical varieties because of two dwarfing genes.

These genes bred into Mexican wheat and reduce lodging (breaking). Also improved yield.
Genetic Resources: 6 types

1. Wild relatives
   - Other species from the same genus of the plant/animal

2. Weedy relatives
   - Bridge between wild relatives and crops. Neglected crop varieties (plant) that evolved to adapt to the natural growing environment – they become more hardy and good competitor as the wild type

3. Primitive cultivars/land-races
   - Cultivated varieties in earlier times
4. **Modern cultivars**
   Improved strains bred from primitive cultivars

5. **Advanced breeding lines**
   Selected germplasm from modern cultivars

6. **Genes form other crops, genera, and kingdoms**
   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!
Biodiversity Hot Spots

• The areas that contain higher:
  – range or number of species or subspecies found in a particular area.
  – 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.
  – variety of life forms that inhabit the earth. Biodiversity includes the genetic diversity of a population or species as well as the diversity of species and ecosystems.
Diversity Hot Spots

There are 25 Diversity hot spots in the world:

- **North and Central America**
  - Caribbean
  - California Floristic Province
  - Mesoamerica

- **South America**
  - Tropical Andes
  - Choco-Darien-Western Ecuador
  - Atlantic Forest
  - Brazilian Cerrado
  - Central Chile

- **Europe and Central Asia**
  - Caucasus
  - Mediterranean Basin
– **Africa**
  - Madagascar and Indian Ocean Islands
  - Eastern Arc Mountains and Coastal Forests
  - Guinean Forests of West Africa
  - Cape Floristic Region
  - Succulent Karoo

– **Mainland Asia**
  - Mountains of Southwest China
  - Indo-Burma
  - Western Ghats

– **Asia-Pacific**
  - Philippines
  - Sundaland
  - **(Malaysia, Indonesia)**
  - Wallacea
  - Southwest Australia
  - New Zealand
  - New Caledonia
  - Polynesia & Micronesia
TOPIC 3:

GENETIC VARIATION & CONSERVATION OF GENETIC RESOURCES
Genetic Variation and Evolution

• **Sources of Genetic Variation**
  – All genetic variations originate from mutations. Mutations are rare and random.
  
  – Genetic variation is essential for evolution.
  
  – For evolution to occur, the genetic variation must be expressed in the phenotype and selected
  
  – Large amount of variation present in natural populations
To date 1.7 million species have been identified and named:

- about 1,000,000 animals (750,000 insects)
- about 250,000 plants
- about 69,000 fungi

Each species is given a binomial (double) name:

- *Zea mays* = corn
- *Homo sapiens* = humans
- *Elais guineensis* = oil palm
• **New Species are Discovered Every Day**
  – about 10,000 reported every year
  – most large species are known but new ones still appear

• **Species Diversity Increases as You Move Towards the Equator**

Species are not evenly distributed on the Earth's surface
  – much more diversity at the Equator than towards the poles. Reasons:
    • more land near the Equator
    • more sunlight at Equator, much more growth
    • species at Equator were not wiped out by glaciers
Techniques for conservation of genetic resources

• There are two major alternatives for the conservation of genetic resources
  – in situ conservation
  – ex situ conservation
• **In situ conservation**
  – refers to the conservation of important genetic resources in wild populations and land races, and often associated with traditional subsistence agriculture.
• Combines *nature reserves* focused on protection of wild races and wild relatives with traditional agricultural practices. However traditional farmers may not want the new approach although substantial economic benefits might be obtained by switching to elite varieties.
  
  This may require direct economic subsidy or conservation of traditional varieties in some other way.
• Examples: *Forest Reserve, National Park, herbal gardens, 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, i.e., difficult or impossible to store for long periods.

Many crop plants are clonally propagated but tissue culture techniques for long-term storage are not well-developed.
Threats to Diversity and Loss of Genetic Resources
Dying species are caused by:

1. Domestication and use of modern varieties.

Wild species → Early domesticates → Modern varieties
2. Wanton, irresponsible and thorough wide spread, and often concentrated habitat destruction. Natives species often lost and habitat invaded by exotic weeds.

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