Unit-I: Introduction

1. Concept of Species

A biological species is a group of organisms that can reproduce with one another in nature and produce fertile offspring. Species are characterized by the fact that they are reproductively isolated from other groups, which means that the organisms in one species are incapable of reproducing with organisms in another species. The term species can also be defined as the most basic category in the system of taxonomy. Taxonomy is a scientific system that classifies organisms into categories based on their biological characteristics. Species can also be defined based on a shared evolutionary history and ancestry. This method of defining species is called phylogenetics, which is the study of the evolutionary relationships among organisms. The evolutionary process by which a new species comes into being is called speciation.

2. Variation

Variations are the differences in the genetic makeup or phenotype of various organisms. Variations arise due to mutation, recombination at the time of gamete formation or due to environmental factors. Variations can be categorised into two types:

1. Genotypic variations are caused due to changes in the chromosome or genes or due to various alleles of the same gene. They are inheritable variations. These are caused due to mutation, recombination, etc.
2. Phenotypic variations are caused due to food supply, climate change or by conscious efforts. They are mostly not inherited and are acquired and may change during their lifetime. They do not play a significant role in evolution.

The genetic and phenotypic variation can occur between different species or within a single species:

A. Interspecific variation is the variation between species.

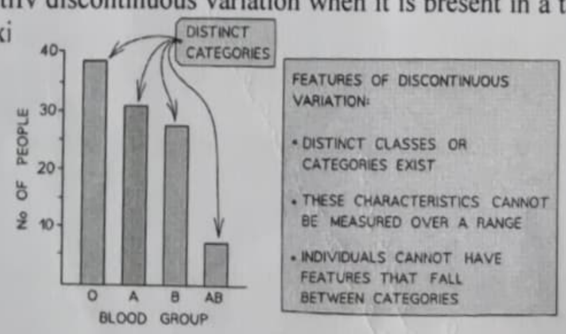
- Interspecific variation can be useful in identifying and classifying different species.
- Even between species that look very similar to each other, there are usually forms of phenotypic variation that can help differentiate them. For example, Bactrian and dromedary camels are highly similar but show one very obvious variation in their phenotypes, as Bactrian camels have two humps whereas dromedaries have one
- Other species that look very similar will have slightly different niches, occupying slightly different habitats or fulfilling slightly different roles if present within the same habitat. This can be used to help distinguish between them
- Some species have such similar phenotypes that they can be very difficult to distinguish. In these cases, there will always be some level of genetic variation between the species, so their genotypes can be used to help identify them

B. Intraspecific variation is the variation within species.

- In relation to natural selection, variation refers to the differences that exist between individuals of the same species. This may also be referred to as intraspecific variation
- Variation observed in the phenotypes of individuals from the same species can be due to qualitative or quantitative differences

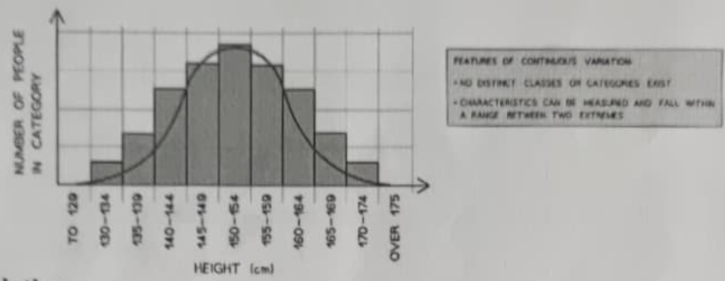
Discontinuous variation

- Qualitative differences in the phenotypes of individuals within a population give rise to discontinuous variation.
- Qualitative differences fall into discrete and distinguishable categories, usually with no intermediates (a feature can't fall in between categories).
- For example, there are four possible ABO blood groups in humans; a person can only have one of them
- It is easy to identifv discontinuous variation when it is present in a table or graph due to the distinct categories that exi



Continuous variation

- Continuous variation occurs when there are quantitative differences in the phenotypes of individuals within a population for particular characteristics.
- Quantitative differences do not fall into discrete categories like in discontinuous variation.
- Instead for these features, a range of values exist between two extremes within which the phenotype will fall.
- For example, the mass or height of a human is an example of continuous variation.
- The lack of categories and the presence of a range of values can be used to identify continuous variation when it is presented in a table or graph.

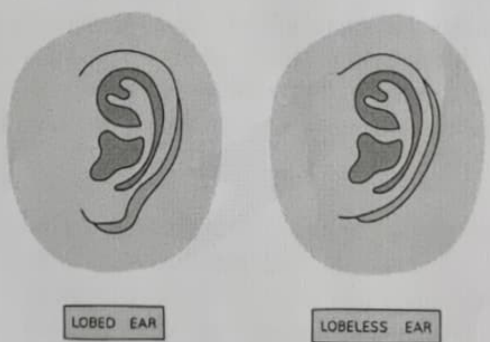


Causes of variation

Variation can be explained by genetic factors, environmental factors or a combination of the two.

Causes of discontinuous variation:

- This type of variation occurs solely due to genetic factors.
- The environment has no direct effect i.e. Phenotype = Genotype.
- At the genetic level, different genes have different effects on the phenotype.
- Different alleles at a single gene locus have a large effect on the phenotype.
- Remember diploid organisms will inherit two alleles of each gene, these alleles can be the same or different
- A good example of this is the F8 gene that codes for the blood-clotting protein Factor VIII. The different alleles at the F8 gene locus dictate whether or not normal Factor VIII is produced and whether the individual has the condition haemophilia.



Causes of continuous variation

- This type of variation is caused by an interaction between genetics and the environment.
- Phenotype = genotype + environment
- At the genetic level:
    - Different alleles at a single locus have a small effect on the phenotype.
    - Different genes can have the same effect on the phenotype and these add together to have an additive effect.
    - If a large number of genes have a combined effect on the phenotype they are known as polygenes

Environmental factors

- In some cases, phenotypic variation is explained by environmental factors alone
    - For example, clones of plants with exactly the same genetic information (DNA) will grow to different heights when grown in different environmental conditions.

- Different environments around the globe experience very different conditions in terms of the:
    - Length of sunlight hours (which may be seasonal)
    - Supply of nutrients (food)
    - Availability of water
    - Temperature range
    - Oxygen levels
- Changes in the factors above can affect how organisms grow and develop
    - For example, plants with a tall genotype growing in an environment that is depleted in minerals, sunlight and water will not be able to grow to their full potential size determined by genetics
- Variation in phenotype caused solely by environmental pressures or factors cannot be inherited by an organism's offspring
    - Only alterations to the genetic component of gametes will ever be inherited
- Other examples of environmental variation include:
    - An accident may lead to scarring on the body
    - Eating too much and not leading an active lifestyle will cause weight gain
    - Being raised in a certain country will cause you to speak a certain language with a certain accent

Introduction to Major Plant Groups

Plant classification is the process of grouping and categorising plants based on their features. Because the usage of generic names can be extremely erroneous, a system of plant categorization is necessary to prevent problems or confusion in recognising a plant's identity. The Linnaean system, which is regarded as the international language for naming plants, evolved into the binomial system that we use today.

There are around 374,000 plant species that exist today. Plants are immensely diverse and complex, and there are thousands of species that have yet to be fully found and investigated. Botanists must develop a means to categorise the numerous distinct species to continue studying and organising plants. Major classifications of plants and their salient features:

1) Classification based on Tissue structure: They are divided into two groups based on tissue structure: non-vascular (mosses) and vascular (plants) (all others):-

- **Vascular Plants-** During the Silurian epoch, the first vascular plants evolved. Now, there are about 3, 08,312 species of vascular plants in the world. Xylem, a specialised supporting and water-conducting tissue, and Phloem, a food-conducting tissue, are found in these plants. Lignin, a hardening chemical that strengthens the cellulose cell wall, stiffens non-living cells (tracheids and vessel components) in the Xylem.

Features of vascular plants –

a) Vascular tissues are found in vascular plants and are in charge of transferring nutrients throughout the plant. Xylem and phloem are the two forms of vascular tissue found in plants.

b) The sporophyte, which releases spores and is diploid, is the first generation or phase of vascular plants.

c) Even if some groups have lost some of these characteristics, vascular plants have real roots, leaves, and stems.

- **Non-vascular plants-** Internal water and food conduction and support are not provided by these plant's vascular tissue (xylem and phloem).

Features of non-vascular plants:-

a) The majority of bryophytes lack vascular structures, as well as genuine leaves, seeds, and flowers.

b) They have hair-like rhizoids instead of roots to bind them to the earth and absorb water and minerals.

c) Bryophytes inhabit moist ecological niches, however, they are inefficient at absorbing water due to their lack of vascular structure.

2) Classification based on Seed structure:

Seed plants

Seed Plants are further split into the following categories:

a) Gymnosperms- Gymnosperms generate both a female and a male cone, known as seed and pollen cones.

Features of Gymnosperms:-

- The lack of blossoms and the existence of bare, open seeds distinguishes them. As they can not have flowers, resultantly, fruits also are absent in these kinds of plants
- The source of both pollination and dispersal is wind. These are mostly medium to large trees, with a few shrub species thrown in for good measure
- As with conifers, the leaves look like needles having a thick cuticle and depressed stomata. This feature aids in the decrease of transpiration-related water loss

b) Angiosperms- Angiosperms are flowering plants whose seeds are protected by an outer covering called a 'Fruit.' The Angiosperms Phyla has about 2, 95,383 flowering plant species, making this the most diversified of any Plant Phyla. Angiosperms are classified into two groups namely, monocots and dicots. These names refer to how many seed leaves, or Cotyledons, a plant has when it germinates.

Features of Angiosperms:-

- For the transport of water, minerals, and nutrients, every angiosperm plant has a vascular bundle comprising xylem and phloem tissues
- Angiosperms can be located in a range of locations and a variety of sizes
- Based on the habitat in which they thrive, these plants have several adaptations in their roots, stems, and leaves

Seedless Plants

Seedless Plants are those that do not generate seeds. Spores are used to propagating this plant group. Ferns, for example, produce spores on the bottom of their fronds.

Features of Seedless plants-

- These sorts of plants do not produce seeds
- They proliferate using spores
- Some of them have stems, leaves, and roots, but the individual parts may be difficult to recognise
- The xylem and phloem, for example, are complex tissues found in plants

3) Classification based on Stature structure –

This is classified into:-

a) Cacti (Cactus) – By retaining water in their succulent stems, cactus plants are well adjusted to hot and dry environments.

b) Biennials – A Biennial Plant requires 2 years to mature from seed to fruition, bloom, and die, or one that lasts two years.

c) Perennials are flowering plants that live for a long time and continue to bloom. It takes most of them two years to reach flowering age.

4) Classification based on Phylum structure

This is further classified into any parts, the main ones being;

a) Bryophyta – The most primitive group of plants, lacking vascular tissues for water transport. Bryophytes are plants without a root, leaves, or stalks. Liverworts, Hornworts, and Mosses are popular names for these plants. There are around 25,000 Bryophyta species.

b) Psilophyta – Psilophyta is a basic Vascular Plant that lacks genuine roots and, in some cases, leaves. Spores are used for replicating. Whisk Ferns is its common name.

Plant taxonomy is the science that finds, identifies, describes, classifies, and names plants. Plant taxonomy is closely allied to plant systematics. The "plant systematics" involves relationships between plants and their evolution. Classification systems serve the purpose of grouping organisms by characteristics common to each group. Three goals of plant taxonomy are the identification, classification and description of plants. The distinction between these three goals is important:

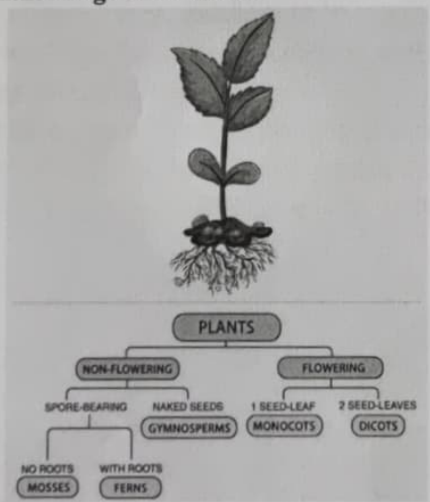
1. **Plant identification** is a determination of the identity of an unknown plant by comparison with previously collected specimens or with the aid of books or identification manuals. The process of identification connects the specimen with a published name. Once a plant specimen has been identified, its name and properties are known.

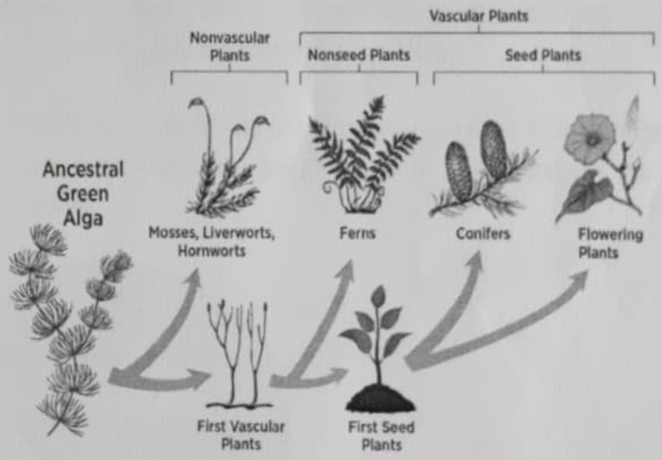
2. **Plant classification** is the placing of known plants into groups or categories to show some relationship. Scientific classification follows a system of rules that standardizes the results, and groups successive categories into a hierarchy. The basic unit of classification is species, a group able to breed amongst themselves and bearing mutual resemblance, a broader classification is the genus. Several genera make up a family, and several families an order. For example, the family to which the lilies belong is classified as follows:

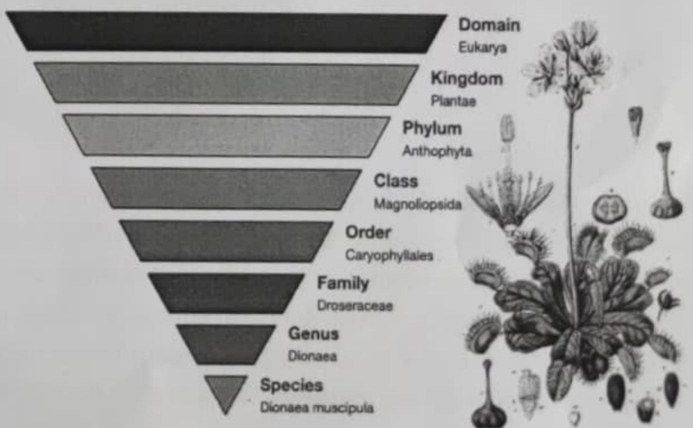
- Kingdom: Plantae
- Division: Magnoliophyta
- Class: Liliopsida
- Order: Liliales
- Family: Liliaceae

The classification of plants results in an organized system for the naming and cataloging of future specimens, and ideally reflects scientific ideas about inter-relationships between plants. The set of rules and recommendations for formal botanical nomenclature, including plants, is governed by the International Code of Nomenclature for algae, fungi, and plants abbreviated as ICN.

Plant Kingdom: Plantae







The **domain** classification is the highest level of taxonomic classification in the organism classification system. The domain can be broken down into three types: Archaea domain, Eukaryotic domain, and the (Eu)Bacteria domain.

The **kingdom** classification is the second-highest ranking in the taxonomic groupings of organisms. There are five kingdoms consist of the animals, plants, fungi, protists, and monerans.

The next classification is **phylum**. This taxonomic rank, sometimes termed as "*division*" lies after the kingdom and further classifies based on phenetic and phylogenetic. Phenetics is based on the number of shared characteristics using a numerical system and phylogenetics is based on evolution and shared relationships but using a systematic study. Each kingdom is broken down into numerous phyla. This can range from as few as four like in Kingdom Protista to as many as the nine phyla that kingdom Animalia contains.

The **class** falls just between the phylum and order classifications. Just like kingdoms contain multiple phyla, each phylum can contain multiple classes. These generally end with the suffix "*ae*" when they are named. Sometimes, if classes are very large, they may be divided into subclasses.

Order is the classification that consists of several families. Orders above the family classification and below the ranking of classes. An order consists of multiple families that share many characteristics and evolutionary traits.

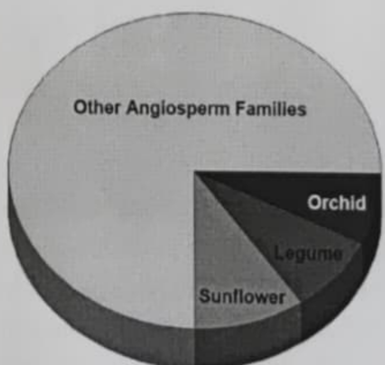
When a group of genera with similar characteristics and traits are pulled together it is called a **family**. The family is the ranking between orders and genus in the Linnean classification. Multiple genera make up a family group.

Genus is the systematic unit in the organism classification that helps determine the species of organisms as the genus groups multiple species together. A genus could also consist of one unusual species whose attributes are so unique it is classified on its own.

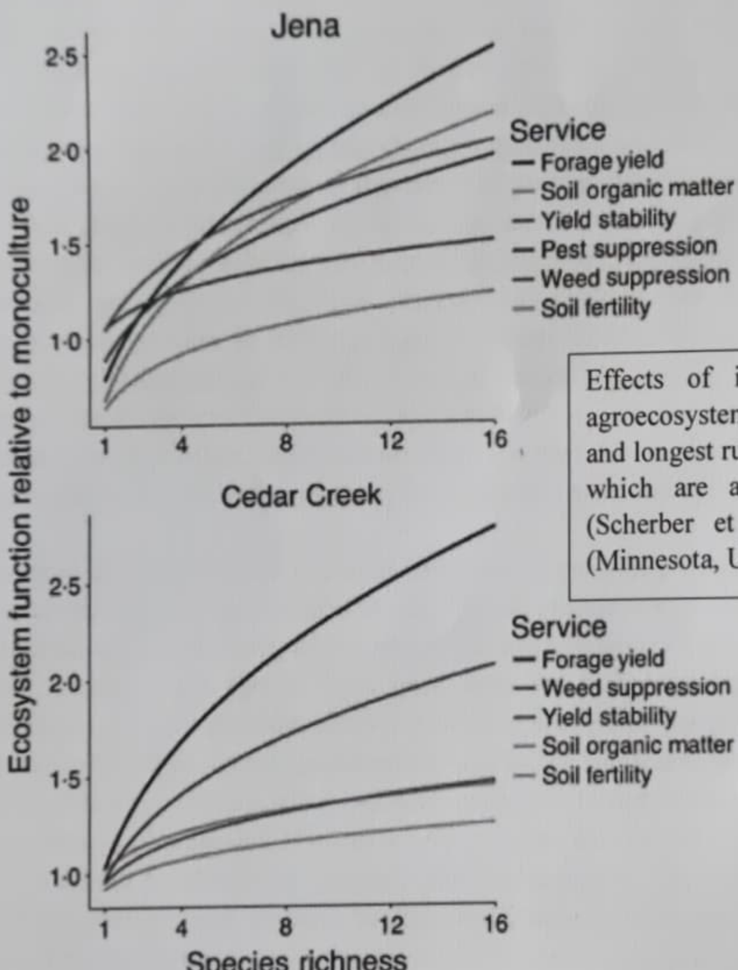
Species classification is the final ranking for the biological classification of living things. A species is defined as a group of organisms with similar characteristics that are able to procreate or interbreed with one another. The offspring they produce must be sustainable and also being able to create a new generation of the species as well. Sometimes, species can form evolve into another, this is known as speciation.

Plant Diversity Application

The three largest flowering plant families containing the greatest number of species are the sunflower family (Asteraceae) with about 24,000 species, the orchid family (Orchidaceae) with about 20,000 species, and the legume or pea family (Fabaceae) with 18,000 species.



Croplands, rangelands and pastures, and production and multiuse forests, which together occupy about 55% of Earth's ice-free land surface, provide humanity with food, feed, fibre, fuel and other wood products. These provisioning services often come, however, at the expense of biodiversity and many other ecosystem services. Specifically, about 40% of the species in 47 taxonomic groups have already been lost from the most intensively managed agroecosystems, which are often monocultures receiving high levels of chemical inputs and pastures and with high stocking rates. Even in the most extensively managed rangelands and plantations, about 20% of the species have already been lost. There is now considerable interest not only in preventing further loss of biodiversity but also in the strategic diversification of simplified agroecosystems and production forests through enhancing crop genetic diversity, mixed plantings, rotating crops and diversifying field margins and surrounding landscapes. Recent research suggests that the diversification of agroecosystems and production forests provides multiple benefits (Fig. 1). There is consistently strong evidence that strategically increasing plant diversity increases crop and forage yield, wood production, yield stability, pollinators, weed suppression and pest suppression. Increasing plant diversity influences the production of crops, forage, and wood, yield stability, and several regulating and supporting agroecosystem services.



Effects of increasing plant diversity on agroecosystem services in two of the largest and longest running biodiversity experiments, which are at Jena (Thuringia, Germany) (Scherber et al. 2010) and Cedar Creek (Minnesota, USA) (Tilman et al. 2001)

Restoration of coal mining areas

In most countries, open pit mining, commonly used in commercial coal mining, remains a rather acute issue. This resulted in irreversible degradation and a complete change in the ecological system. The natural landscape has been disrupted and damaged, including the destruction of biodiversity in ecosystems by eliminating natural soils, plants, animals, and microorganisms. Since coal is extracted at least shortly after work stops, a decision must be taken on how the site will be rehabilitated with all mine waste. Remediation of the site following mining is essential and becomes the responsibility of all mine operations. Mine landfill rehabilitation should be as similar as possible to earlier natural forms. However, quarry breeds have challenging conditions for the rooting and growth of plants because of their low organic matter content, heavy metal content, and other adverse physicochemical features.

Nitrogen-fixing legumes are recognized as crucial components in natural succession. These species are critical since the associated rhizobial symbioses are a source of nitrogen in the ecosystem. All affected woody legumes are also symbiotic with mycorrhizal fungi. Fungal mycelium, which stretches from mycorrhizal roots, forms a three-dimensional network that connects the roots with the soil environment. It is an effective system for absorbing nutrients (particularly phosphorus) and eliminating them under low-nutrient conditions. Mycelium also promotes the formation of water-resistant aggregations required for good tillage.

Plant succession following external disturbance associated with open-pit mining has ecological and practical interests. During plant rooting at different stages of succession, the recolonisation of varying plant species plays an essential role in the soil-forming process, promoting vegetation succession by improving soil conditions. The effectiveness of ecosystem restoration can be assessed in terms of the rate of natural or spontaneous restoration of vegetation and the status of nutrients in soils. To some extent, fertilizers meet plant nutrient needs). However, fertilizers (mainly applied in the long term) can cause environmental problems and damage ecosystems, such as groundwater pollution, greenhouse gas emissions, changes in soil physicochemical properties, and implication of soil food chains. Concerning these issues, the introduction of legumes into quarries is considered a sustainable land use practice. Due to their ability to fix nitrogen, many legumes are cultivated to improve soil fertility. In addition, they are commonly used to enhance net primary productivity, including grain, timber, and forage yields, in anthropogenic ecosystems. The presence of legumes has also been reported to increase soil carbon sequestration. In addition, deposition from nitrogen-rich legume crops is more readily degraded by soil microorganisms, and this effect can reach high trophic levels through bottom-up control. To restore the resiliency of a disturbed ecosystem, it is important to address as many aspects of spontaneous vegetation as possible. Consequently, there is a need to periodically study and monitor the diversity of spontaneous recolonization of plants in reclamation areas and how they survive.

Invasive alien species are currently identified as the primary threat to global biodiversity, ecosystem functions, economy, and human health. This is an increasingly serious management issue in parks and reserves, and it often complicates restoration and rehabilitation projects. In the past, and to some extent now, foreign plant species have been used for land rehabilitation, land stabilization, and rapid development of the plant community. However, due to their toxicity and habitat characteristics, invasive alien species often emerge spontaneously and invade landscapes severely disrupted by mining, making it difficult to restore natural plants. As such, awareness raising and appropriate management of spontaneous emergence and expansion of invasive plant communities should be encouraged.

A successful rehabilitation program aims to accelerate the spontaneous restoration of fertility in rehabilitated soils and increase biodiversity. Comparative studies of spontaneous plant succession in disturbed areas provide crucial information on vegetation dynamics to ensure the success of a future reclamation program. However, information on the process of spontaneous plant succession in post-coal reclamation areas remains limited.