E-CONTENT

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Topic: Taxonomic Resources & Nomenclature

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UNIT-IA

1. Taxonomic Resources & Nomenclature

Components of taxonomy (identification, nomenclature, classification); Taxonomic resources; Herbarium-functions & important herbaria.

A. Components of Taxonomy

(Identification, Nomenclature & Classification)

TAXONOMYM IS

"THE SCIENTIFIC PROCESS OF ANALYSING THINGS INTO GROUPS"

"ONE PARTICULAR SYSTEM OF GROUPS THAT THINGS HAVE BEEN ARRANGED IN"

- **The Science of classification is called Taxonomy.**
- The literal meaning of taxonomy is lawful arrangement of things or arrangement by rules.
- **{The Greek meaning of Taxonomy is "Arrangement by Rules" & Systematics is, "To put together"}**
- **TAXONOMY= Gr.; Taxis=Arrangement/Division+Nomous=Law/Study ["Lawful arrangement" OR "Arrangement by Rules"]**

Other definitions:

- **Taxonomy deals with the Laws governing the arrangement or Classification of Plants or Animals or other Organisms.**
- **The theory and practice of Classification.**

➢ **Taxonomy deals with the Laws governing the classification.**

[Taxonomist is a classifier who names, describes, classifies and identifies the organism. Taxonomists arebasicallyinvolved with: 1. determining what is a species/subspecies, 2. distinguishing these species from others through keys and descriptions, and geographic boundaries and mapping their distributions, 3. Investigating their interrelationships, and 4. Determining proper names of species and higher order ranks (as genera or families) using international rules of nomenclature. In addition, some taxonomists investigate process of evolution that lead to the existing pattern of species and their interrlationships**].**

- **The study of the diversity of plants and their identification, naming, classification and evolution called Systematics, while Taxonomy is restricted to the study of Classification (Jones & Luchsinger, 1979).**
- **Abercrombie *et al.* (1980), "Taxonomy is the Science of classification of organisms according to their resemblances and differences".**
- **Taxonomy is the theory and practice of describing, naming, and classifying organisms (Lincoln, Boxshall, and Clark 1998)**
- **Stace (1989), "It is the study and description of the variation of organisms, the investigation of the causes and consequences of this variation and the manipulation of the data obtained to produce a system of classification".**
- **Rouhan and Gaudel (2014), defined taxonomy as the Science that explores, describes, names and classifies all plants and all living and extinct organisms".**
- **According to Shipman (2012), Taxonomy makes communicating biological information much easier because it facilitates categorizing organisms.**
- **Simpson (2021) defined taxonomy as "the theoretical study of classification including its bases, principles, procedures and rules".**

The term **"TAXONOMY"** was coined by a French Botanist**AUGUSTIN PYRAMUS DE CANDOLLE**in his book, *TheorieElementarie de la Botanique* (Theory of Elementary Botany) [1813], while the term **"SYSTEMATICS"** was coined by **LINNAEUS** in his book ***Systema Naturae*** in 1735.

Often Taxonomy is considered synonyms to Systematics, though the latter is much more inclusive.

Systematics is the grouping of organisms based on a set of rules (or system).

The word systematics is derived from the Greek word '*SYSTEMA*' applied to the system of classification developed by CAROLUS LINNAEUS in the 4th edition of his historical book *SYSTEMA NATURAE* (1735).

Panawala (2017) believes that the main difference between Taxonomy and Systematics is that **Taxonomy** is involved in the classification and naming of organisms whereas **Systematics** is involved in the determination of evolutionary relationships of organisms.

Carolus Linnaeus (Carl von Linne) is considered as Father of Taxonomy.

WILLIAM ROXBURGH: Father of Indian Taxonomy
[Father of IndianBotany, Linnaeus of India]

WHAT DO WE MEAN BY "**SYSTEMATICS**" ?

Taxonomy: Description, Classification, Identification &Nomenclature +
Evolution: Variation, Speciation

SYSTEMATICS

Systematics is the branch of science that includes and encompasses **traditional taxonomy** (description, identification, nomenclature and classification of organisms) and **phylogeny** (evolutionary history).
Plant systematic is studied by acquiring, analysing and synthesizing information about plants and plant parts.
Systematics is a related term to taxonomy, sometimes used synonymously, but involves a broader discipline of discovering phylogenetic relationships through modern experimental methods using comparative anatomy, cytogenetics, ecology. Morphology, molecular data, or other data (Stuessy, 1990). It also could be more generally defined as the science of developing methods and philosophies for the systematic grouping of organisms.

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[TYPES OF TAXONOMY:

i. **Alpha Taxonomy (Descriptiontaxonomy):** Concerned with the description and designation of species based on morphological characters and developed in 19th century.
ii. **Beta Taxonomy (Macrotaxonomy):** Developed in 20th century, concerned with the arrangement of species into hierarchical systems of higher categories or taxa.
iii. **Gamma Taxonomy:** Related with the intraspecific population and with phylogenetic trends. To determine the origin of species a taxonomist has to

depend on the species of palaeobotany which include all taxa of extinct plant groups.

iv. **Omega Taxonomy:** It is based on all characteristics. (Alpha taxonomy forms the basis of biology while the final accumulation of all data is ultimately incorporated into Omega taxonomy).
Classification based on morphological characters is called Alpha taxonomy. Classification based on data from other branches, i.e. from embryology, cytology, palynology, phytochemistry and serology along with morphological characters is called Omega Taxonomy.]

- **Taxonomy mainly comprises of four components:**

-Description,
-Identification,
-Nomenclature, and
-Classification (often memorized as **DINC**).

1. **DESCRIPTION/CHARACTERISATION:**Characterisation lays the foundation ofthe science of taxonomy. It provides the basic data for identification of an organism.
It is the primary activity of a taxonomist.
Characterisation is the basic requirement for understanding the different part of the organisms. It is thus a description of the characters.
By comparing the characters of two or more organisms, it becomes possible to differentiate them. Which help to identify an organism or a plant.
When two or more organisms have been differentiated (identified) by their characters, it becomes necessary to group them into categories. Once the identified organisms have been classified, it becomes necessary to name them.

The Character of the Organisms

↓

Identification on the basis of an understanding their characters

↓

Identifying them into groups

↓

Providing them names

Description is the written account of features or attributes of ataxon. The features are called characters. **The characters can be qualitative or quantitative**. Two or more forms of a character are known as CHARACTER STATES. For example, petal colour (red and white), leaf shape (ovate, elliptic, lanceolate), and fruit type (achene, capsule, berry).

2. **IDENTIFICATION:**Identification is the process of associating an unknown taxon with a known one. In other words, **identification is the determination of a taxon as being identical with or similar to another and already known element.**
   Identification is the process of finding the taxon to which a specimen belongs, like identifying the medicinal plants, edible and poisonous mushrooms.
   A taxonomic key is used for identification of plants.Identification is a primary function in taxonomy and by applying nomenclature it performs an essential role as a means of communication.

   [The data base provided by characterisation leads to recognize or identify an unknown plant by direct comparing two or more plants on the basis of their characters helps the taxonomists to decide whether the plants being compared have similar or different characters. This may be achieved by visiting a herbarium and comparing the unknown specimen with already identified specimens arranged in the herbarium.
   Identification may also be done by sending the specimens to an expert or by using various types of literature like Floras, Monographs or Manuals.Taxonomists have prepared artificial keys to identify the unknown specimens.]

3. **NOMENCLATURE: Application of names to different taxaaccording to prescribed rules. The naming of groups of organisms and the rules governing the application of these names together form the nomenclature.**
   Plant nomenclature is concerned with accepted system, i.e., International Code of Nomenclature for algae, Fungi and Plants **(ICNafp).** Once the plant has been identified, it becomes necessary that it has a scientific name that provides universal applicability. The rules of ICNafp determine the application of name of the taxa.

4. **CLASSIFICATION: Classification is the placing of plants into groups or categories according to a particular plan.**
   It is a two-step process.

Step 1: Grouping objects based on similarities and differences; and
Step 2: Ranking these groups into a hierarchy (nested series of categories) based on some criteria.
Classification is thus the **placement of a plant (or group of plants) in categories based on their similarities and differences.** These groups are then arranged according to their levels into categories in a nested manner. Thus, similar individuals may be grouped under a "species", similar species under a genus "genus", similar genera under a "family" and so on.
[Classification is the arrangement of groups of plants with particular circumscriptions by rank and position according to artificial criteria, phonetic similarities, or phylogenetic relationships.]
{Classification is the arrangement of organisms into groups having common characteristics. These groups are then arranged according to a system.}

One Of the greatest assets Of a sOund classificatiOn is its predictive value.-Mayr (1969)

There are many rationales for biological taxonomy, including the need
(1). to understand the world about us and to conceptualize and order this through classifications; (2). to have classifications for identification and communication; (3). for a convenient information retrieval system; (4). to use stable names that maintain continuity of the literature; (5). to construct a predictive classification; and (6). to construct a useful framework to understand phylogenetic relationships. Taxonomy has special use for conservators including; (8). to aid germplasm collectors to plan expeditions based on gaps in a genebank (Warburton 1967; Mayr 1982; Stuessy 1990; Judd et al, 1999; Woodland 2000).

[A. W. Eichler, first proposed the idea of Phylogenetic (Phyletic) or Evolutionary System for classification].

{BIOSYSTEMATICS (coined by Camp & Gilly, 1941): It is the study of genotype and the phenotype variations of species in relation to the environment in which they occur.}

WHY TAXONOMY IS IMPORTANT

Taxonomy is important because it is
-a language of communication.
-an essential infrastructure for other activities in society.
-imagine if people and things didn't have a name…… or , if many names were Wrong.
-If a researcher does not have a reliable name on his study subject, is it possible to communicate?

Taxonomic knowledge is must in:

- Disease control,
- Management of medicinal plants,
- Monitoring and Conservation of Environment,
- Management of Invasive species,
- We still have no idea, how many species are there on earth.

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ROLE OF TAXONOMY

1. Taxonomy workout for us a vivid picture of the existing organic diversity of the earth.
2. Taxonomy provides much of the information permitting a reconstruction of the phylogeny of life.
3. Taxonomy reveals numerous interesting evolutionary phenomena.
4. Taxonomy supplies classifications which are of great experimental value in most branches biology and palynology.

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-JOHN LINDLEY (1830) used the term 'SYSTEMATIC BOTANY'

-J. HUXLEY (1940), given the term 'NEW SYSTEMATICS'

Taxonomy refers to the science of classifying and naming organisms based on hierarchical system. Taxonomists categorize living organisms into various ranks, such as domain, kingdom, phylum, class, order, family, genus, and species. The primary roles of taxonomy are:

1. **Classification:**It helps, categorize and organize species into hierarchical groups based on their characteristics, making it easier to study and understand the diversity of life.
2. **Nomenclature:**Taxonomy assigns scientific names (binomial nomenclature) to species, ensuring a standardized way to refer to organisms across languages and regions.

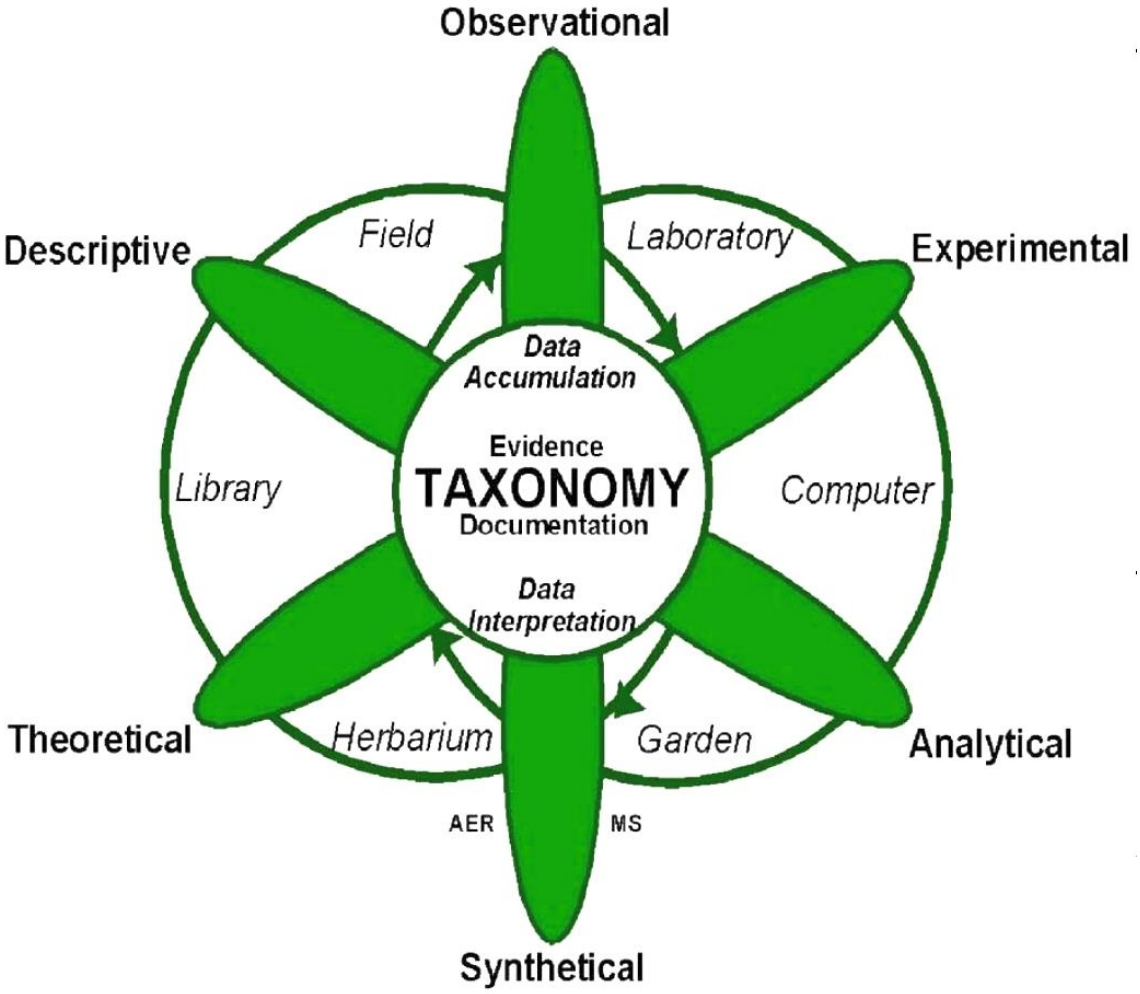
3. **Identification:**Taxonomy aids in the identification of species, helping scientists, researchers, and even the general public distinguish between different organisms.
4. **Evolutionary Understanding:** It provides insights into the evolutionary relationships between species, as organisms within the same taxonomic groups are assumed to share a common ancestry.
5. **Biodiversity Conservation:** Taxonomy is essential for conservation efforts, as it helps in recognizing and protecting endangered or unique species.
6. **Research and Communication:** Taxonomy forms the basis for biological research and facilitates communication among scientists by providing a common language and framework.
7. **Agriculture and Medicine:** In fields like agriculture and medicine, taxonomy is crucial for identifying pests, pathogens, and beneficial organisms, aiding in pest control and disease management.
8. **Environment Management:** It assists in environmental impact assessments and the monitoring of ecosystems by tracking changes in the abundance and distribution of species.

Overall, taxonomy is fundamental to our understanding of the natural world and has practical applications in various scientific disciplines and everyday life.

Taxonomy is important for several reasons:

a. **Organizing Diversity:** It provides a systematic way to categorize and organize the incredible diversity of life on Earth, making it easier to study and understand.
b. **Communication:** Taxonomy provides a common language for scientists to communicate about different species. Using standardized names and classifications helps avoid confusion.
c. **Biological Research:** It aids in biological research by helping scientists identify relationships between species, study evolutionary history, and understand the distribution of traits.
d. **Conservation:** Taxonomy plays a crucial role in conservation efforts. By identifying and classifying species, we can prioritize and implement conservation strategies to protect endangered or threatened organisms.
e. **Agriculture and Medicine:** It is important in agriculture for crop breeding and pest control, as well as in medicine for understanding diseases and developing pharmaceuticals.
f. **Environmental Management:** Helps in managing ecosystems, understanding invasive species, and monitoring environmental changes.
g. **Education:** Taxonomy is fundamental in teaching biology and helping students grasp the concepts of biodiversity.
h. **Historical Context:** It provides a historical context for life on Earth, helping us understand how species have evolved over time.

In summary, taxonomy is crucial for understanding and managing the natural world, facilitating scientific research, and preserving the planet's biodiversity.



B. Taxonomic Resources

Documentation : Taxonomic Resources [Taxonomic Literature]

The written documents, specimens, etc., used as an evidence or a source of information in taxonomic studies is called Documentation or Taxonomic Literature or Taxonomic Resources.

Taxonomy has one of the oldest and most voluminous literature because it is oldest among different disciplines of science.

A taxonomist must be fully acquainted and should have a thorough knowledge of taxonomic literature, as it is a very essential part of identification of an unknown plant, solution of a nomenclatural problem, or a monographic or revisionary or floristic study. There is no single source dealing exclusively with taxonomic literature; it would occupy several volumes.

Taxonomic literature has an international character as plants have been named and described in books and periodicals in many languages.

Important On Line Resources For Taxonomy are as follows

- **Biodiversity Heritage Library,** Australia: A collection of digitized taxonomic literature from a consortium of natural history and botanical libraries. Includes local collections for Europe, China, Australia, and Brazil.
- **Encyclopaedia of Life,**Alexandria: Information on all organisms. Community experts are consulted to find out which organisms have an immediate impact on humans. These include commercially valuable species, invasive pests and disease organisms, charismatic and familiar animals, popular ornamental plants, newly discovered species, and plants, animals and fungi on which we rely for **food, among other groups.**

- **Integrated Taxonomic Information Society(ITIS):**Authoritative taxonomic information on plants, animals, fungi, and microbes of North America and the world. This group works in the U.S., Canadian, and Mexican agencies (ITIS-North America); other organizations; and taxonomic specialists. ITIS is also a partner of **Species 2000** and the Global Biodiversity Information Facility (**GBIF**).
- **The Plant List:**The Plant List is a working list of all known plant species. It aims to be comprehensive for species of Vascular plant (flowering plants, conifers, ferns and their allies) and of Bryophytes (mosses and liverworts).
- **Tree of Life:**The Tree of Life Web Project (**ToL**) is a collaborative effort of biologists and nature enthusiasts from around the world. On more than 10,000 World Wide Web pages, **the project provides information about biodiversity,the characteristics of different groups of organisms, and their evolution.** The tree of life Web Project (ToL) is a collaborative effort of biologists and nature enthusisasts from around the world. On more than 10,000 WWW pages, **the project provides information about biodiversity, the characteristic of different groups of organisms, and their evolutionary history (phylogeny).**
- **Common Names for Plants:**This common name look-up lists about 25,000 common names for plants from a number of different languages.
- **GRIN Taxonomy for Plants** (**Germplasm Resource InformationNetwork, USDA**): GRIN taxonomic data provide the structure and nomenclature for accessions of the National Plant Germplasm System (NPGS), part of the National Genetic Resources Program (NGRP) of the United States Department of Agriculture's (USDA's), Agricultural Research Service (ARS). **In GRIN Taxonomy for Plants all families and genera of vascular plants and 52,262 species from throughout the world are represented, especially economic plants and their relatives. Information on scientific and common names, classification, distribution, references, and economic impacts are provided.**
- **Index to Organism Names (ION):**ION contains the organism names related data gathered from the scientific literature for Thomson Reuters'. Viruses, bacteria and

plant names will be added from other Thomson Reuters databases such as BIOSIS **Previews®.**

- **The International Plant Names Index(IPIN):**The International Plant Names Index (IPNI) is a database of the names and associated basic bibliographical details of seed plants, ferns and lycophytes. **Its goal is to eliminate the need for repeated reference to primary sources for basic bibliographic information about plant names.** The data are freely available and are gradually being standardized and checked. **IPNI provides nomenclatural information (spelling, author, types and first place and date of publication) for the scientific names of Vascular Plants from Family down to infraspecific ranks.**For plant names, authors or publications in the search box. New records are added daily, and the IPNI team are continuously working to improve data standardization.IPNI provides links to protologues in online articles or page scans from the Biodiversity Heritage Library as well as links to taxonomic data (synonymy and native distribution) through the Plants of the World Online.
- **NCBI Taxonomy Database[National Centre for Biotechnology Information]:**The Taxonomy Database is a curated classification and nomenclature for all of the organisms in the public sequence databases. This currently represents about 10% of the described species of life on the planet.The National Centre for Biotechnology Information advances science and health by providing access to biomedical and genomic information.
- **PLANTS Database,** USDA: The PLANTS Database provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the U.S. and its territories.
- **Tropicos:**Tropicos, **the world's largest botanical database, contains 1.2 million published names, information on more than 361,000 type specimens (the specimen used to establish the name for a plant species), more than two million distribution records, nearly 660,000 synonyms, over four million specimen records and more than 230,000 plant images. Literature reports on chromosome counts are also included, as well as information on the ways plants have been used by or had an effect on humans.** The Tropicos database links over 1.37M scientific names with over 5.01M specimens and over 996K digital images. The data includes over 160K references from over 54.2K publications offered as a free service to the world's scientific community.

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❖ **Flora**: Species content of a particular area in published form.

❖ **flora** is species found in a particular area.

(a). Local Flora:e.g. Flora of Varanasi
(b). Regional Flora: Flora of Madras Presidency

(c). Continental Flora: Flora of Europea
(d). Electronic Flora (e-floras): Digitized form of Flora published online. e.g. Flora of China

- **Taxonomic Inventory:** Ataxonomic inventory typically refers to a comprehensive list of organisms categorized into various taxonomic groups, such as species, genera, families, orders, and more. These lists are commonly used in fields like biology, ecology, and conservation to document and study the diversity of life in a particular ecosystem or region.

- **Monograph: "**The complete account as can be made at a given time of any one family, tribe or genus nothing being neglected of it".
  It is worldwide in its scope and application. It reviews all taxonomic treatments that have been made in particular taxon. It synthesizes all available cytological, genetical, morphological, anatomical, palaeobotanical, geographical and ecological studies of the taxon by author.
  (a). Maheshwari, P and Konar, RN: *Pinus*: Botanical monograph, CSIR,N Delhi
  (b). The Family Lentibulariaceae by Peter Tylor

- **Revisions:** Taxonomic revisionis carried out for familyor genus. Taxonomic revisions are usually less comprehensive than a Monograph.
  Revisions usually contain taxonomic keys, short descriptions, distribution maps and a classification.
  Illustrations mostly in the form of line drawings are included both in monographs and revisions.
  Example: (a). Malvaceae of India by TK Paul;
  (b). *Strobilanthes* (Acanthaceae) in Peninsular India.

- **Catalogues:** Catalogues are the books of libraries rich in botanical titles. They have special value in taxonomic studies.
  To refer a catalogue, one should know full name of the author, exact title of the book, exact title of the book, exact date of publication and edition.
  Example: Catalogue of the library of British Museum (of National History), Catalogue of the library of Massachusetts, Horticultural Society.

- **General Taxonomic Indexes:**
  The indexes serve as an aid to locate quickly the source of original publication of a name.
  This helps us to learn if a particular name has been applied to a plant or to know to which order, family, subfamily or tribe a plant of a given name may belong. Important Indexes to Vascular plants are as follows:
  (i).Index Kewensis Plantarum Phanerogamarum: 2 vols. (1893-1995) and 20 supplements, Oxford.
  This work/book/publication is corner stone to the literature on systematics of flowering plants.

The compilation of original work was made possible by gift of money by Charles Darwin. It compiled at the Royal Botanic Garden, Kew by BD Jackson and JD Hooker.

Index Kewensis is the reference employed to determine the source of the original publications of a generic name or binomial of a seed plant.

The original two volumes of the Index Kewensis listed 400,000 names of plant species published since 1753 to 1895. About 6000 names added every year.

(ii).Gray Herbarium Card Index: Published by Harvard University, Cambridge, Massachusetts, USA. It has database account of the flowering plants and pteridophytes of the Western Hemisphere. It has covered 287225 cards for taxa published since 1873.

(iii).Genera Siphonogamarum: (Berlin, 1900-1907). The work edited by CG Dalla Torre & H Harms, accounts for the names published for families and genera of spermatophytes in one volume. Orders and families are arranged according to Engler & Prantl's System of classification.

(iv).Index NominumGenericorum [ING], Botany: A compilation of generic names for organisms covered by the ICN: "International Code of Nomenclature for Algae, Fungi and Plants".

Details of valid publication, precise date of publication, type specimen, basionym(s), of each organism is maintained as a card. Every card has name of genus, serial number, and the designation of person who prepared the card. The first issue published in 1955.

- **Periodicals:** A periodical is a publication appearing at regular intervals.Each issue is called a number (Band/Heft/Fascicle in German) and collectively called a Volume. Some Periodicals are as follows:

-Annals of Royal Botanic Garden, Kolkata.
-Journal of Linnean Society , Botany, London.
-Tropical Ecology, Varanasi
-TAXON Berlin, Germany
-Nelumbo, Kolkata

- **Manuals:**

A manual is a book that contains information on the area of coverage and keys and descriptions to the families, genera and species alongwith ecological and distributional data and common names.

Examples:

-Fernald, ML, 1850 (8th Edition): Gray's Manual of Botany, American Biological Company, NY.
-Fassett, NC, 1940: A Manual of Aquatic Plants. McGraw Hill, NY.
-Bailey, LH, 1949: Manual of Cultivated Plants. McMillan, NY.

- **Some Important Websites:**
  a. **www.ipni.org**
  b. **http://plants.jstor.org**
  c. **www.kew.org**
  d. **www. Tolweb.org/tree**

TAXONOMIC RESOURCES

Taxonomic resources are tools or references that help researchers and scientists classify and categorize living organisms based on their evolutionary relationships. These resources include:

1. **Taxonomic Databases:** Online databases like the Integrated Taxonomic Information Systems (ITIS) and catalogue of life provide comprehensive information on the classification of various species.
2. **Field Guides:** Printed or digital guides with detailed descriptions, illustrations, and keys for identifying organisms.
3. **Herbaria:** Collection of preserved plant specimens, often with associated taxonomic information, used for plant identification and research.
4. **Museums:** Natural history museums house extensive collections of preserved specimens and can be valuable resources for taxonomic research.
5. **Scientific Journals:** Peer reviewed journals contain taxonomic research articles, species descriptions, and updates on nomenclature.
6. **DNA Sequencing:** **Molecular techniques such as DNA barcoding and phylogenetics aid in determining evolutionary relationships and classifying species.**
7. **Taxonomic Experts:** Taxonomists with expertise in specific group of organisms provide valuable insights expertise in classification.
8. **Online Communities:** Websites, forums, and social media groups where taxonomists and enthusiasts discuss and share their findings.

These resources collectively support the ongoing efforts to understand and document the diversity of life on Earth.

TAXONOMIC TOOLS

Taxonomic tools are instruments or resources used by biologists and taxonomists to classify and categorize living organisms. They include:

1. **Field Guides:** These are books or digital resources that help identify species based on their physical characteristics, habitat, and distribution.
2. **Dichotomous Keys:** A series of paired statements or questions that lead to the identification of an organism based on its characteristics.
3. **DNA Barcoding:** Molecular techniques that use specific DNA sequences to identify and classify species.
4. **Herbaria and Museums:** Collections of preserved specimens for studying and comparing species.
5. **Taxonomic Databases:** Digital platforms that provide information on species descriptions, distributions, and classifications.
6. **Phylogenetic Software:** Tools for constructing evolutionary trees and analyzing relationships between species.
7. **Taxonomic Literature:** Scientific papers and publications that describe and classify new species.
8. **Citizen Science Apps:** Apps that allow the public to contribute to taxonomic research by recording observations of species.

These tools are essential for the organization and understanding of the Earth's biodiversity.

Taxonomic Documentation

Taxonomic documentation refers to the detailed record-keeping and classification of organisms in the field of biology, particularly in the context of taxonomy.

Taxonomic documentation typically includes:

A. **Scientific Names:** Assigning a unique scientific name to each species based on the rules of binomial nomenclature, which involves a genus and species name (e.g. *Rosa indica* for Rose)
B. **Description:** Detailed written descriptions of the characteristics, habitat, and habit of plant.
C. **Specimen Collection:** The collection and preservation of plant specimens, such as Herbarium specimens, which serve as reference material.
D. **Classification:** Placing plants into hierarchical groups, from the broadest categories like domains down to specific species.
E. **Key Characteristics:** Identifying and documenting unique characteristics or traits that distinguish one group or species from another.
F. **Molecular Data:**Genetic and molecular analysis to supplement traditional classification methods.
G. **Historical Records:** Tracing the historical understanding of the taxonomy of a group of organisms.
H. **Distribution:** Documenting the geographic range of species and their ecological interactions.
I. **Taxonomic Keys:** Developing keys or guides to help identify species.

Taxonomic documentation is essential for understanding biodiversity, conducting biological research, and conservation efforts. It helps scientists and researchers communicate about specific organisms and contributes to our overall knowledge of life on Earth.

[Some important references:

- **Plant Systematics: WS Judd; CS Campbell, EA Kellogg, PF STEVENS. 2002**
- **Plant Systematics: GS SINGH, 2004**
- **Plant Systematics: AKPandey& S Kasana; 2021.]**

C. Herbarium-functions & Important Herbaria:

HERBA, a Latin word which was originally meant for grass/pasture was derived from the Greek term ***'forb'*** which in turn appears to have been derived from the Sanskrit root: ***'bhar'*** (meaning pasture/forage).

The term 'Herbarium' was first used by **Tournefort** as an equivalent to 'Hortus Siccus' to describe a collection of dried plants in ca. 1700, which was later adopted by Carolus Linnaeus.

The **first hebarium** was established in the University of Padua, Italy (1545).

Lucca Ghini (1490-1556) was the first person to dry plants and mount them on paper.

HERBARIUM (plural: Herbaria) is a collection of dried/preserved plant specimens arranged according to some accepted system of classification.

According to Fosberg and Sachet (1965), "A modern herbarium is agreat filing system for information about plants, both primarily in the form of actual plant specimens and secondarily in the form of published information, pictures and recorded notes".

Herbaria are standard reference centres for identification and verification of new plant material and provide basis for taxonomic studies which include identification, classification, distribution etc.

Herbarium is the documentation of earth's diversity through dried reference specimens kept in collections and are rightly called as the **'gold mine of information'.**

FUNCTIONS:

1. **A store house of reference material:** the specimens deposited in a herbarim provide a verifiable documentation of the past and present distribution as well as geographical range of plant species. They can give valuable information about plant biology including flowering time, habitat preferences and associated species.
2. **A means of identification:** Herbaria provide a means of identification of new plant specimens by effective matching with named specimens in the collections. For this, the specimens should be correctly identified and must be placed in such a way that the arrangement bears some relation to their overall similarities.
3. **Confirming the identity of known species:** Classification is a dynamic and evolving science. Species concepts and species delimitations often change when new evidence becomes available. Consequently, the names applied to plants may change. Herbarium specimens enable previous identification to be verified or altered when the taxonomy changes, unlike the situation with identification based on sight records, where it is often impossible to establish the current name in the absence of a specimen.
4. **An arbiter of correct names:** Printed floras soon become out of date and it is up to the herbarium to maintain nomenclatural standards. This entails keeping the names in line with current revisionary work, maintaining type collections, and organizing exchange of specimens with other institutions.
5. **A comprehensive data-bank:** Herbarium specimens provide a permanent record for confirming the occurrence of a species at a specific locality and time for conservation and research needs, including the cataloguing of

biodiversity. Ideally the collections should fully represent the diversity and distribution of the regions vegetation.

6. **As a source of plant material:** Samples from herbarium specimens are routinely used for leaf anatomy, phytochemical screening, pollen studies, DNA extraction, preparation of Floras, field guides and monographs. Herbarium specimens thus provide a source of plant material for taxonomic and botanical research.
7. Herbarium specimens can be used for developing morphological data by measuring the parts of the plants housed at various herbaria.
8. Serves as a fundamental resource for identification of newly discovered taxa.
9. A large number of 'type' specimens housed in the form of herbarium specimens can help to stabilize the nomenclature.
10. Provides information about the past and future location of plants through the use of Geographical Information System (GIS) mapping.
11. Adds in assessment of conservation status of a taxon.
12. Gives information about the rare, endangered or extinct taxa.
13. Detailed illustrations about plant specimens can be drawn by using the herbarium specimens. May also act as a repository of viable seeds for rare species (Seed bank).
14. Herbarium specimens constitute an invaluable resource for the study of genetic diversity of plants.

IMPORTANT HERBARIA:

According to recent census there are about 3990 recognized herbaria in the world. The International Association for Plant Taxonomy (IAPT) published 'Index Herbarium' the directory of world herbaria.

Herbarium	**Acronym**	**Country**	**Number of specimens**
Herbarium, Royal Botanic Gardens, Kew	**K**	United Kingdom	8,000,000
Herbarium, Botany Department, The Natural History Museum, London	**BM**	-do-	5,200,000
William and Lynda Street Herbarium, New York Botanical Garden, New York	**NY**	USA	7,200,000
Herbarium, Missouri	**MO**	USA	68,50,000

Botanical Garden, Missouri, Saint, Louis			
Herbarium, V L Komorov Botanical Institute, Saint Peterburg	**LE**	Russia	7, 160, 000
Central National Herbarium	**CAL**	Howrah	2500000
Indian Council of Forest Research & Education, Dehra Dun	**DD**	Dehra Dun	3,30,000
Blatter Herbarium, St. Xavier's College, Mumbai	**BLAT**	Mumbai	2,00,000
CSIR-national Botanical Research Institute	**LWG**	Lucknow	3,00,000
Botanical Survey of India, Southern Circle	**MH**	Coimbatore	2,64,000

VIRTUAL HERBARIUM

Modernization of herbaria according to the changing needs, enhances their potential usefulness as a baseline for scientific utility. Through digitization, database development and the internet the herbaria has become more accessible all over the world.

The term '**Virtual Herbarium'**includes **all the activities that result in a web-searchable database of herbarium specimen data and images.** In other words we can say that, a virtual herbarium is a referral system for plants that maximize the usefulness of the collections. The information content of such a database is essentially built on the voucher specimens that the herbarium has in its care.

Objectives of Virtual Herbarium

a. To make specimen data available electronically for use to the botanists all over the world.
b. To make a major resource for protecting biological diversity and for managing natural resources of a country/area.
c. To develop a universally accessible, integrated flora information system.
d. To reduce handling of specimens by supplying data transcription and images that do not require direct examination of specimens.
e. To reunite data elements (e.g. photographs and drawings, manuscripts, published works, microscopic preparations, and gene sequences) derived from a specimen with the catalogue record for that specimen.

Date Contents of Virtual Herbarium

Plant taxonomic data to be presented on the website is first entered into Microsoft Excel spreadsheet by herbarium staff and volunteers. Each entry has all the information presented on the herbarium specimen level, including species name, author citation, sub-species and variety [if any], family, subfamily, collection number, locations, date of collection, habitat and the collector's name. Additional information includes the nomenclature update and a detailed description of phenology, distribution, threat status and comments on any special features of the taxon.

The digitized herbarium specimens at a minimum resolution of 300 dpi and images of life specimens provided in the database form an information synergy of the species.

Once entered, the data is scrutinized for accuracy and formatting using standard open-source software.

Herbarium-based databases

Some important herbarium-based databases are as follows :

- http://apps.kew.org/herbcat/navigator.do [Herbarium catalogue of the Royal Botanic Garden at Kew].
- http://www.tropiocos.org/ [Tropicos, the interactive database of Missourie
- http://sc.web.nybg.org/science2/Virtual/Herbarium.asp [C. V. Star Virtual Herbarium from New YorkBotanic Garden's International Plant Science Centre
- http://www..bgci.org/ [BGCI-Botanic Garden Conservation International.
- http://www.nbri.res.in/herbarium [LWG-virtual herbarium of the National Botanical Research Institute, Lucknow.
- http://www.rprcbbsr.com/herbarium/ [Regional Plant Resource Centre (RPRC digital herbarium), Odisha.]
- http://www.iim.res.in/herbarium.htm. [Janaki Ammal Herbarium]
- www.nio.org [National Institute of Oceanography (NIO) Digital Herbarium]

Importance of Virtual Herbarium

A herbarium-based database is an information system that provides access to data on plant diversity of one or more regions, or on the collection that the herbarium has in its care. The information content of the database is essentially built on the voucher specimens

Declaration

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THANX