

UNIT ONE

Introduction

Definition and scope of taxonomy

Def. Taxonomy is the theory and practice of classification of organisms.

- The term taxonomy was coined by a Swiss naturalist, **De Candolle**, in the French form as “taxonomie” in 1813.

⌘ **Taxonomy** is derived from two Greek words:

 | Taxis = to classify, to arrange;

 | nomos = law, science

→ Thus, **taxonomy** means the law governing the classification/arrangement of organisms

⌘ Although some naturalists use the term **systematics** as synonymous with taxonomy; many taxonomists consider **taxonomy** as a part of **systematics**.

⌘ Thus, **systematics** is defined as

- the study and description of the diversities of organisms,
- the investigation of the **causes and consequences** of the **variation**, and
- the manipulation of the data obtained to produce a **system of classification, or**
- the scientific study of the kinds and diversity of organisms and of any and all relationships between them.
- a science deals with the relationships between taxa, especially at the higher levels.

In short **systematics** is the science of the diversity of organisms.

Systematics stems from the Latinised Greek word “**systema**” as applied to **the systems of classification** developed by early naturalists, notably **Linnaeus** (1735).

Many taxonomists still equate taxonomy with systematics, but some see them as distinct branches of biology.

- **Taxonomy** is a branch of biology that deals with the **classification**, **nomenclature** and **identification** of organisms.
- Thus, taxonomy has three aspects.
- θ **Classification**-is defined in different ways by different authors as:
 - The ordering of organisms into groups based on similarities and/or differences;
 - The assignment of organisms to groups within a system or hierarchy of ranks or categories distinguished by certain characters;
 - refers to the act of systematically arranging organisms into categories according to specific criteria

Why classify??

A collage of various flowers and plants. At the top left, a cluster of small yellow daisies with a white butterfly perched on them. To the right, a large yellow cactus flower with a prominent stamen. Below the daisies, a single white flower with a yellow center. To the right of that, a cluster of pink columbines. Below the white flower, a cluster of pink and yellow columbines. To the right of the pink columbines, a purple iris. Below the pink and yellow columbines, a tall stem with many small white bell-shaped flowers. To the right of the purple iris, a yellow bellflower. At the bottom left, a cluster of small white flowers. At the bottom right, a yellow bellflower with a dark, patterned center.

Cont....

The need for classification is:

- to organize species into groups and to gather information about organisms in the world wide,
- to identify new organisms and
- to show relationships between organisms.

Goals of Classification

- Simplify
- Communicate
- Predict

- θ **Nomenclature**– The naming of groups of organisms and the rules governing the application of the names, or
- it is the application of distinctive names to each of the groups recognised in the organismic classification
 - after groups of organisms have been classified, names must be given to these groups so that communication about particular units will be facilitated and so that continued progress in classification can be made.
 - Nomenclature serves classification and the two are inseparable.

⊖ **Identification**—the naming of an organism or a specimen by reference to an already existent classification.

⊖ It is the process of associating an unknown taxon with a known one, or recognizing that the unknown is new to science and warrants formal description and naming.

–it involves referring an individual specimen to a previously classified and named group.

⊖ Thus, **identification** follows **classification** and **nomenclature**,

⌘ For example, if one walks out and picks a small branch of tree with leaves and flowers and takes the specimen back to the herbarium, and attempts to find a name for it, what is being sought is **identification** of a specimen.

→ In short, **identification** of an unknown organism or a specimen is the determination of it as being similar to or identical with an already known element.

Definitions of important terms

- 1) **Biosystematics**-the field of study dealing with variation and evolution, primarily experimental and analytical, and mostly treating the species and intraspecific taxa.
 - use of data to assess taxonomic relations especially within an evolutionary framework.
- 2) **Hierarchy**- is a series in which each element is categorised in to successive ranks or grades with each level subordinate to the above
- 3) **Taxon (plural taxa)** - a taxonomic group of any rank. Such as:
Form-- Variety--**Species**--Series--Section--**Genus**--Tribe--**Family**--**Order**--**Class**--**Division/Phylum**--**Kingdom**.
 - These are the 12 Main ranks in the taxonomic hierarchy.

- 1) **Description** -a characterisation or statement of attributes of a particular taxon, individual organism or its parts.
- 2) **Diagnosis** -a shortened description covering only those characters (diagnostic or key characters) which are necessary to distinguish a taxon from other related taxa.
- 3) **Character** -an attribute or a feature of an organism which can be assessed, measured or weighed. For example, hairy or glabrous, blue-eyed or brown-eyed.

Characters can be -qualitative- characters that are expressed in **qualitative** terms. For example, hair colour, corolla colour.

-**quantitative**- characters that are expressed in quantitative terms or which can be quantified, For example, seed weight, hair length, etc

1) **Character state** -an expression or condition of a character, or two or more forms of a character. For example, **petal colour** – red, blue, white, yellow.

2) **Leaf shape**-ovate, lanceolate, elliptic

Character is an **abstract** entity while a character state is **concrete**.

3) **Phenetic** -Over-all present day resemblance and differences.

4) **Flora** (with capital initial letter) -a book or other work describing the flora of a given area and usually providing a means of identifying the taxa contained in it.

5) **flora** (with lower case initial letter) -the plant life of a given area or region. For example, Arat Kilo campus. Shewa, Ethiopia, Tropical Africa, Africa, Europe, etc.

- }\ **Herbarium** -an institution or building in which a collection of dried and preserved plant specimens are housed. It also refers to the collection of dried and preserved plant specimens. For example, The National Herbarium (ETH), the Royal Botanic Gardens (K)
- }\ **Habit or growth form** -The overall appearance of a plant.
- }\ **Habitat** – The environment or plant community in which the plant occurs.

- 1) **Phylogenetics**- is the study about phylogeny
- 2) **Phylogeny** -is the evolutionary history of a group of related organisms.
- 3) **Monophyletic**- When a group of organisms arising from a single common ancestor.
- 4) **Polyphyletic**- if a taxa arising from two or more than two common ancestor.
- 5) **Clade**- a group of biological taxa or species that share features inherited from a common ancestors
- a group of organisms which includes the most recent common ancestors of all of

- 1) **Cladogram**- a tree diagram used to illustrate phylogenetic/evolutionary relations.
- 2) **Evolution** -the continuous genetic adaptation of organisms to their environment;
 - a directional change or gene frequency over time within a population or series of populations in response to selective factors of the environment.
 - In short, it is change over time within a population.

Objectives of Taxonomy

The objectives of Taxonomy are to provide:

1. A convenient **method of classifying, naming, identifying** and describing organisms;
2. A classification scheme which attempts to express natural relationships;
3. An inventory of organisms to be provided in the form of books; so as to gather information about organisms in the world wide.
4. An understanding of evolutionary

Types of Taxonomy

a) Alpha taxonomy - it is based solely on more or less obvious morphological-**exomorphic** characters.

It depends on **few** character

b) Omega taxonomy - is a modern taxonomy and it depends on blood r/n ship.

It is based on all available characters.

Each taxa are related by evolutionary history

UNIT TWO

THE DEVELOPMENT OF TAXONOMY

The history of taxonomy dates back to the origin of human language.

a) Non-human taxonomists.

Animals prove by their relations that they classify objects of their environment as:

- food or non-food
- competitors or potential mates; and
- enemies (predators) or prey.

Animals also recognise plants as:

- food or
- non-food.

b) Human taxonomists

The development of taxonomy was started at Greek by Greek philosophers.

The development of taxonomy is gradual.

- Modern taxonomy has arisen from a number of diverse origin which are not easily treated as a **linear** sequence.
- In any era dominated by one particular outlook there have always been other activities carried out in parallel or left over from a previous era.

- ⌘ The development of taxonomy has different **phases** with different people
- i. Ancient classification and
 - ii. The herbalists-based on their value to human
 - iii. The early taxonomists
 - iv. Linnaeus and his apostles- Artificial
 - v. Post Darwinian phylogenetic system
 - vi. Post Linnaeus natural system
 - vii. Phenetic methods (taxometrics)
 - viii. Modern phylogenetic methods (cladistics)

Ancient Classifications



Phase I. Ancient classification

Ancient man classify organisms that are significant to them. they have had systems of plant classification, for their needed to convey to others.

- The names, and
- Properties of plants that were of significance to him.
- They give a vernacular name /common name/local name for their purpose and understanding
- They have developed a folk taxonomy
- **Folk- taxonomies**—Classifications which grow up in communities, both primitive and civilised through need and without the influence of science.

• **Classification by man** of organisms

The Taxonomic Practices by Early Greek (and Roman) Philosophers

- Several early Greek and Roman philosophers enumerated organisms. They are:

1. Aristotle (370-322BC)- He was the first to classify all living organisms in to plant and animal.

2. Theophrastus (370-285 BC)

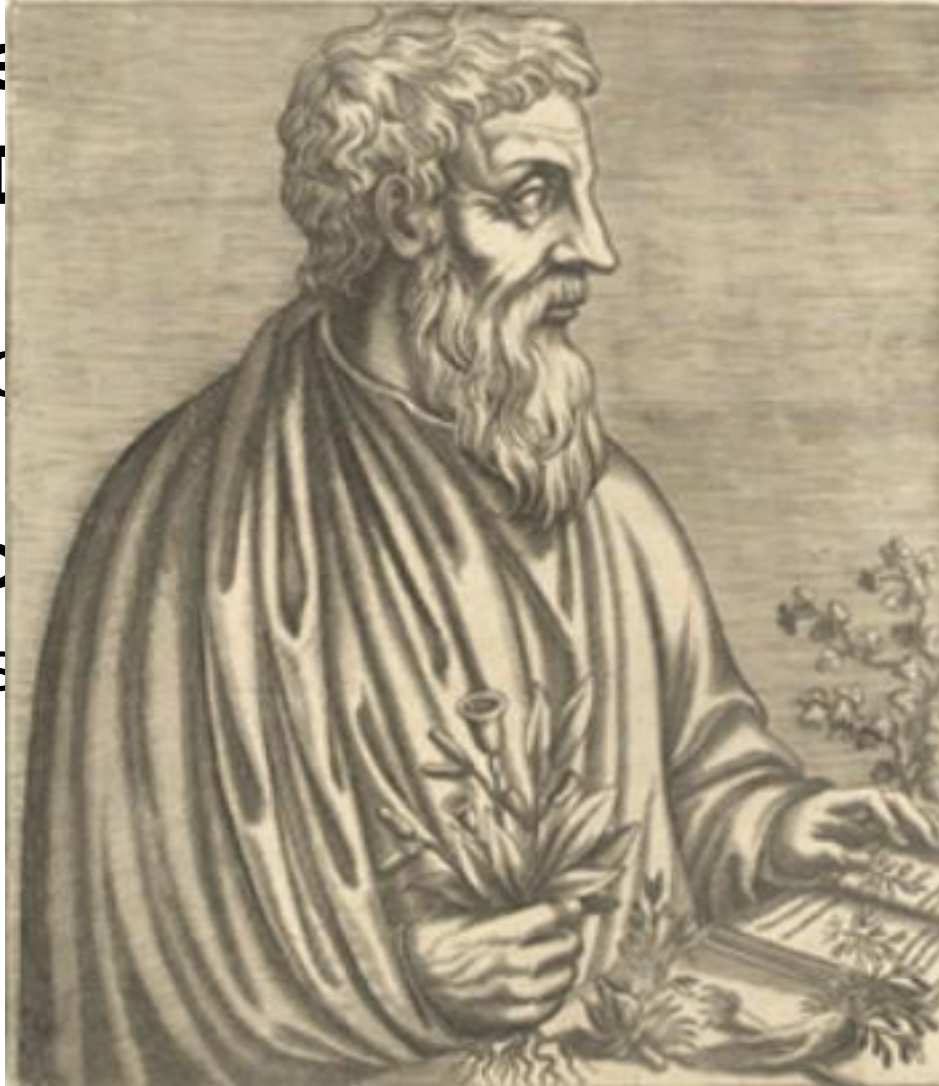
- He was a pupil of Aristotle.
Theophrastus was a keen observer of **plants**
- **Theophrastus** was the first to write

- **Theophrastus** classified **480 kinds of plants** based **primarily on habit**
- In his book, **De Historia Plantarum**, he divided plants into:
 - trees;
 - shrubs;
 - under shrubs; and
 - herbs
- These are subdivided into:
 - cultivated; and
 - wild

- **Theophrastus** was a good morphologist and recognised the differences between:
 - polypetalous and sympetalous corollas;
 - superior and inferior ovaries;
 - determinate and indeterminate inflorescences
 - Fruit types
- Several of the names used by **Theophrastus** were later taken up by **Linnaeus** in *Genera Plantarum* and thus still used in the same sense today.

3. Dioscorides (1st Century AD)

- He was a Greek **physician** in the Roman army. He was interested in the **medicinal properties**
 - His book **De Materia Medica** described **600 taxa** of plants, their medicinal uses, and their application in medicine. It was one of the most influential works on the subject of medicine for centuries.
 - Perfumes
 - Oils;
 - Spices;
 - Cereals;
 - Condiments
- for giving a special taste to food, as a preservative



PHASE II-THE HERBALS (15-16TH CENTURIES)

- During the 15th and 16th Centuries, a period known as the **Age of the Herbals**,
 - many new plants were described and illustrated.
- There were the invention of printing machine & this enable new books to be produced in large numbers
 - └ This was the time of the different herbals written by herbalists like:
 - └ O. Brunfels (1530),
 - └ J. Bock (1539),
 - └ L. Fuch (1542),
 - └ P. Mettoli (1544),
 - └ W. Turner (1551), etc

- **Herbalism** dominated the 16th century botanical world.
- During this period the first field of science were herbals
- **Herbalism** is the study of plants in relation to their value to man, particularly as:
 - Food and
 - Medicines
- **Herbalists** are people who studied plants in relation to their use to man, particularly as food and medicines.

- However, herbals remained popular well after the 16th century, for they marked an important stage of development in:
 - Botany
 - Taxonomy
 - Medicine, and
 - Pharmacognosy

Phase III-Early Taxonomists

- Towards the end of the 16th century plants began to be the focus of attention of a number of naturalists for **their intrinsic interest** rather than for **their nutritive value or medicinal value**.
- The **books** that these botanists produced marked an important step forward in plant

1. A. Caesalpinus (1519-

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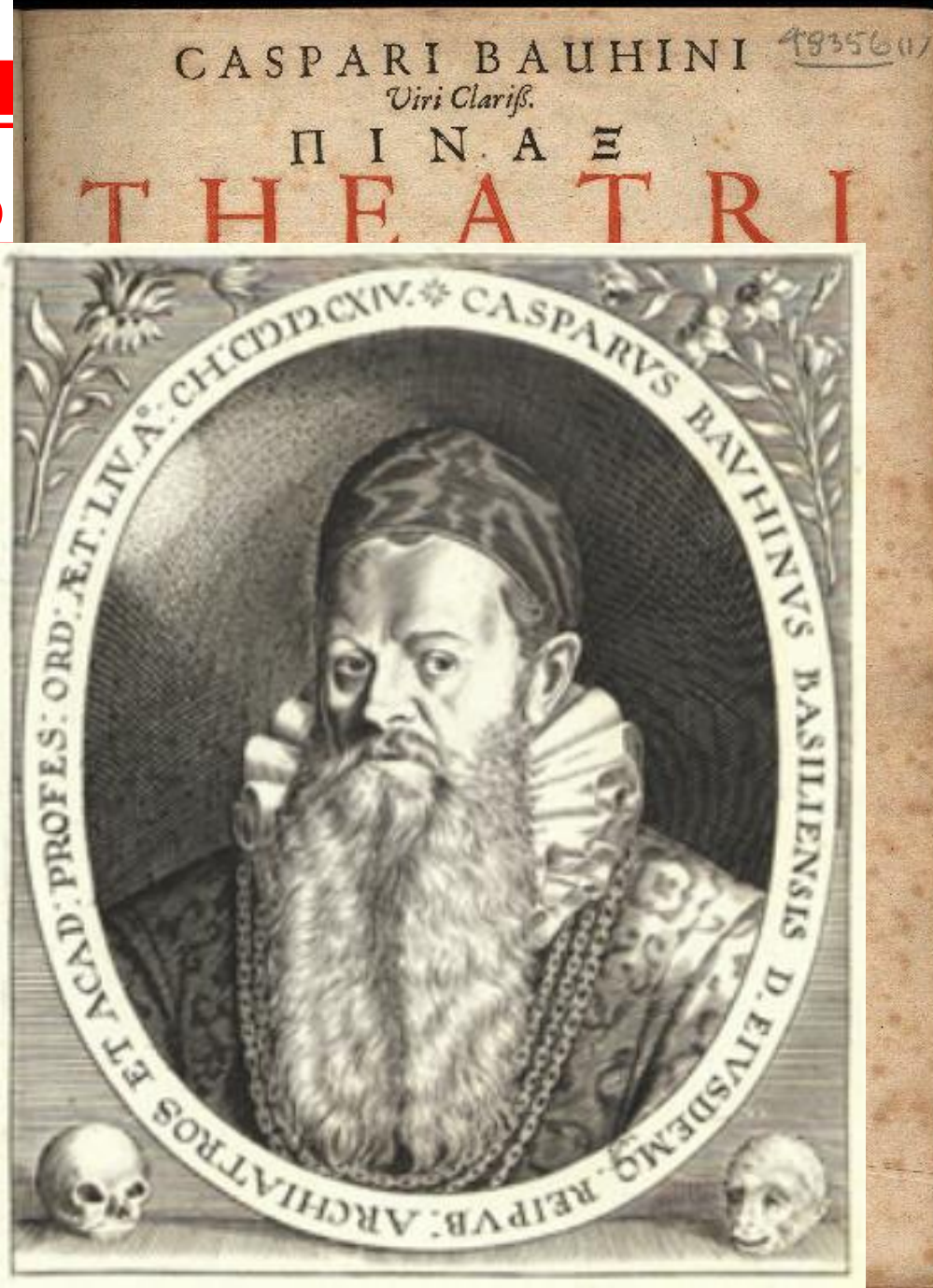
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J. P. de Tournfort (1656-1708)

- He was a Frenchman who carried out further **Bauhin's** promotion of the rank of genus.
- He had a clear idea of the genus.
- **De Tournfort** wrote a book called "Institutiones Rei Herbariae" (1700) and many of his genera were later adopted by Linnaeus and are still in use today.
- **His system classified about 9000 species into 698 genera and 22 Classes (Orders).**

J. Ray (1627-1705)

- An English naturalist who produced several important works in plant classification.
- The most influential of Ray's works were
- **Methodus** (1682, 2nd ed. 1705)
- **Historia** (1686, 1688)



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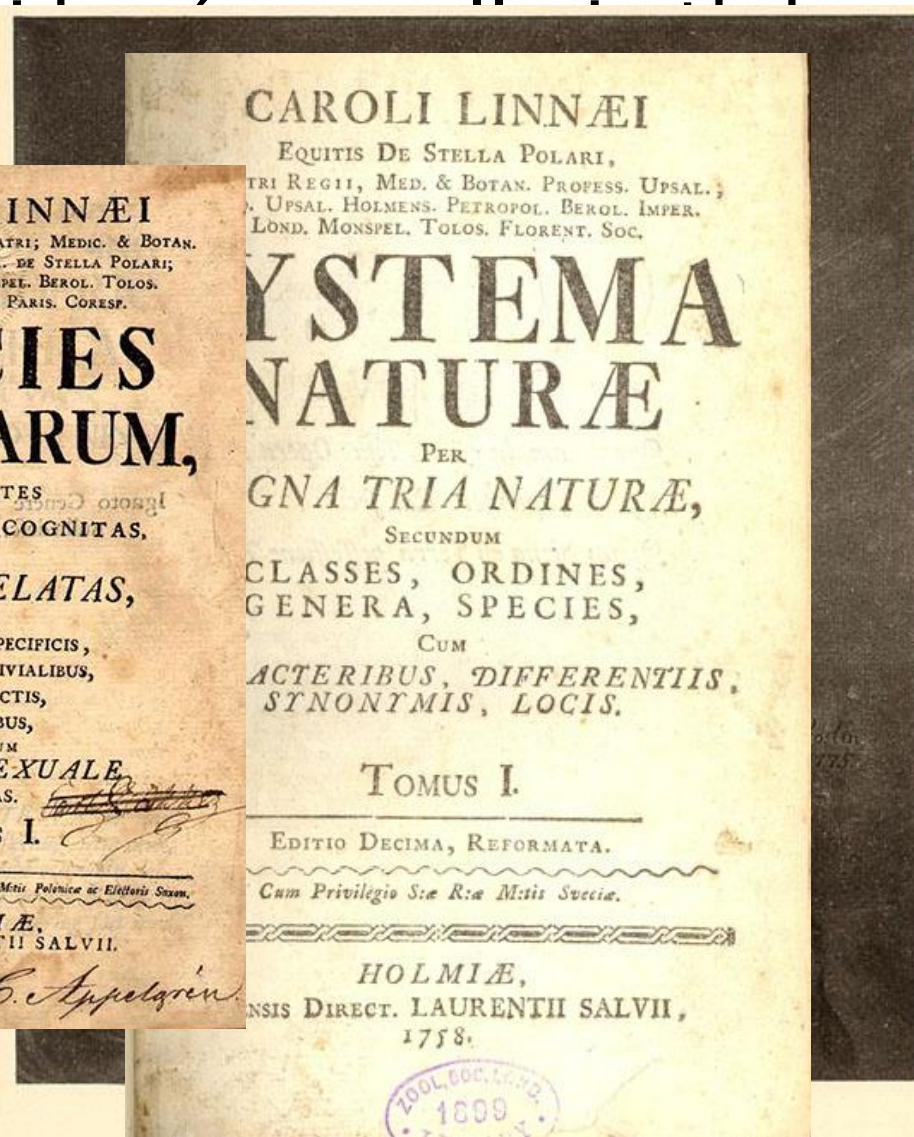
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- The 2nd edition of Ray's Methodus dealt with nearly **18,000 species** in a complicated system of classification, using a very large number of characters of:
 - Flower and
 - Vegetative parts, he believed that all parts of a plant should be used in taxonomy.
- **Ray did not develop the idea of binary nomenclature** commenced by G. Bauhin.
- His **species** were characterised by **phrase-names.**

Phase IV-Linnaeus (& his students/Apostles)

- Carl von Linné as Carolus Linnaeus



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Painting by A. Roslin, 1775

- Linnaeus produced many books and other literatures.
- His system was first published in **1735** in **Systema Naturae**, a work that classified all known:
 - animals
 - plants and
 - minerals
- For plant taxonomists the two most important works are
 - Genera Plantarum (1737, with later editions) and
 - Species Plantarum (1753, with later editions)

- The Genera Plantarum listed and briefly described the plant genera recognised by Linnaeus, and hence carried forward the work of G. Bauhin and Tournfort in giving prominence to the rank of genus.
- Genera Plantarum and Species Plantarum, which were published in Stockholm together, cover **7700 species in 1105 genera.**
- Linnaeus classification continued to dominate taxonomic works until well into the 19th c.

Phase V. Post - Linnaean

Natural System

- **Linnaeus'** system was called the **Sexual System**, because it was based on the use of characters of:
 - The stamens (Number, Fusion and, Relative length) and
 - The pistil/carpel
- Linnaeus' sexual system was popular largely because of its simplicity.
 - **His sexual system was very artificial.**

- **The foundation of modern families** comes mainly from the works of **French taxonomists** in the latter part of the 19th century, notably
 - **M. Adanson (1727-1806),**
 - **A.A. de Jussieu (1748-1836),** and
 - **J. de Lamarck (1744-1829),**
- who never followed the sexual system of Linnaeus.

1. M. Adanson (1727-1806)

- He produced his book "Familles Des Plantes in 1763.
- Today, Adanson is most remembered for championing the idea that
- In classification:
 - One should use a great range of characters covering all aspects of the plant and without placing greater emphasis on some than on others.
- This is called an **empirical approach**.
- **Adanson was a severe critic of Linnaeus' works.**
- Adanson recognised **58 families of**

2. A.L. de Jussieu (1748-1836)

- His most significant work was *genera Plantarum* (1789), in which he divided plants into three groups:
 - **Acotyledones** – Cryptogams + a few misunderstood monocotyledons
 - **Monocotyledones** – Monocotyledons
 - **Dicotyledones** – Dicotyledons plus gymnosperms
- Within group three, he used **many of the familiar modern characters** like:
 - Superior versus inferior ovaries;
 - Stamens fused versus stamens attached to the corolla;
 - Petals free versus petals fused, etc.
- He classified plants as whole into **15 classes** and **100 natural orders (families)**.
- **A good number of his families** are still found similarly delimited in modern

3. J. de Lamarck (1744-1829)

- Lamarck is best known for his theory of evolution, Lamarckism whereby characters acquired during life become inherited.
- Lamarck wrote **Flore Francoise** (1778).
- He also wrote **Encyclopedie Methodique** (1783-1798)
- Lamarck's fame rests on his realisation that a natural system of classification was not the best for **rapid identification. (Used artificial keys)**
- In general the way was paved for the

A. P. de Candolle (1778-1841).

- A Swiss botanist who contributed much to the development of plant classification science.
- His book **Botanique** introduced the word taxonomy.
- De Candolle's major contributions to two fields of plant science:
 - Cellular
 - Vascular



G. Bentham (1800-1884) and J.D. Hooker (1817-1911)

- They produced the last major classification in their book **Genera Plantarum** (1862-1883), which dealt with only seed plants, described **200 families** and **7569 genera**.
- It became a standard reference.
- **Dicotyledons** were divided into **three groups**:
 - **Polypetales** (with free petals)
 - **Gamopetales** (with fused petals)
 - **Monochlamydeae** (without petals)
- **Bentham** was an extremely accomplished self-trained classical taxonomist who wrote many important **monographs**.

Phyletic/Evolutionary System of Classification (post Darwinian system)

- Darwin's the Theory of Evolution by Means of Natural Selection (1859), had little immediate impact on plant classification.
- The aim of phyletic classification is:
- To construct a sequence starting with the most primitive or least specialised and ending with the most advanced or derived, and
- To ensure that each taxon recognised is **monophyletic** i.e. has arisen by the diversification of the single ancestor as

A.W. Eichler (1839-1887)

- The earliest **phyletic system** is generally reckoned to be that of **Eichler**.
- He obtained the division of plants into two:
 - Cryptogamae
 - Thallophyta
 - Bryophyta
 - Pteridophyta
 - Phanerogamae
 - Gymnospermae
 - Angiospermae
 - Dicotyledons
 - » Choripetalae (with free petals)
 - » Sympetalae (with fused petals)
 - Monocotyledons

B. G. A. Engler (1844-1930)

- Engler's classification scheme first appeared in his major books (Main works):
 - Die Naturgeschichte der Pflanzenwelt (1915), with Pringsheim
 - Syllabus der Pflanzenfamilien (1892, 1st ed.)
 - Das Pflanzenreich (1906-1916)
- Engler's system was widely adopted and today still frequently followed.



C.E. Bessey (1845-1915)

- The first American to make a major contribution to the study of

- Bessey's work in Phylogeny and biogeography

H. H. Silliman

- Independent research but

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Darwin and the Impact of his book, The Origin of Species (1859) on Taxonomy

- The evolutionary theory of Darwin, **The Origin of Species by Means of Natural Selection (1859)** had little immediate impact on classifications of organisms.
- Even if the impact came later, the process of classification remained the same, but **evolutionary thinking** was incorporated into classification.