M.Sc. Botany (Semester II)
Course Title : Systematics and Evolution

Unit III: Chemotaxonomy

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Chemotaxonomy or Chemical taxonomy

- The chemical constituents of plants differ from species to species i.e. on the molecular characteristics
- The same type of metabolites can be product of two quite different pathways
- The classification of plants on the basis of chemical examination is called chemotaxonomy. They are the valuable characters for plant classification

In 1987, Some authors also divided into two groups on the basis of molecular weight:

- ***Low molecular weight compounds***: 1000 or below 1000 Da called as micromolecules. Ex. Amino acid, alkaloids, fatty acids, terpenoids, flavonoids

- ***High molecular weight compounds***: Molecular weight more than 1000 Da called as macromolecule. Ex. Protein, DNA, RNA, Polysaccharides

Classification of chemotaxonomy:

Based on the taxonomical and chemical nature

- **Descriptive taxonomy**: Based on secondary metabolites and other products, sugar and amino acids
- **Descriptive taxonomy**: Based on biosynthetic pathway
- **Serotaxonomy**: Based on pathway of specific proteins and amino acids sequences in protein

Depend upon the Chemical evidence, Plant are classified as :

- Non - protein amino acids
- Phenolics
- Betalins
- Alkaloids, Flavonoids, Carotenoids
- Terpenoids and steroids
- Crystals
- Immunological reactions

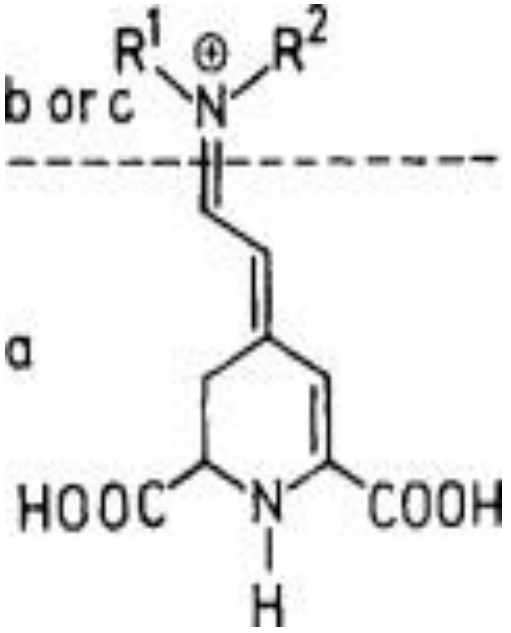
Non – protein amino acids

- There are more than **300 non- protein amino acids** found in food and fodder plants
- Roles: in protecting plants against predators, pathogens, and competing plant species
- They are **used to classify and distinguish** the taxa from others. **Example:**
  - Lathyrine – in Genus ***Lathyrus*** **(**in **Fabaceae)**
  - Azetidine-2- carboxylic acid- in Genus **Liliaceae, Amaryllidaceae and Agavaceae**

Phenolics

- Derivatives of phenolic compounds
- Plants are classified on the basis of specific phenolic compounds. Example:
  - Leucoanthocynin – abundant in woody plants
  - Flavonols and methoxycinnamic acid - in herbaceous plants
  - Ellagic acid – in tribe Kerrieae of Rosaceae
  - Isoflavone iridin in section Pogonivis of Iris
  - Absence of Iridin – Iris flauissima was removed from this section

Betalins



- Betalins possesses at least one heterocyclic nitrogen atom, acidic in nature due to the presence of several carboxyl groups

- They are present in 15 families including small families Caryophyllaceae and Molluginaceae

- Present in plants of the Centrospermae order, and mushrooms of the Amanita and Hygocybe genera

Alkaloids

- Alkaloids are nitrogen containing compounds with a heterocyclic ring (Mostly contain basic nitrogen atoms)
- There are about 5000 alkaloids in angiosperms.
- They are used as a source for plant classification

Examples-

Caffeine	*Coffea arabica*
Piperine	Black pepper (*Piper nigrum*)
Nicotine	*Nicotiana tobaccum*
Morphine	*Papaver somniferum*

Terpenoids and Steroids

- Terpenoids are unsaturated hydrocarbons derived from isoprenes. Eg. Carotenoids, iridoids
- Steroids are saturated hydrocarbons with four rings in their structure.

Example: • The tribes Genisteae of Fabaceae and of Asteraceae - **petal carotenoids**

- Arspernloside – Rubiaceae
- Acubin – Coenaceae, Scrophulariaceae and Orobanchaceae
- Buddleia contains **acubin** in the family Buddleiaceae
- Cucurbitins are present in Cucurbitaceae

Crystals

• Some plants have raphides crystals in different parts of their body (typically occur in aerial organs especially the leaves)

• **Raphides** are needle-shaped crystals of calcium oxalate

Raphides are found in specialized plant cells or crystal chambers called idioblasts.

• Plants like *Tradescantia pallida* also accumulate calcium oxalate crystals in response to heavy metals stress.

Examples: • Presence and absence of raphides are used in the grouping of plants in the family Rubiaceae

• Calcium oxalate crystals are present in the ovary walls of the members of Asteraceae

Cystolith (Gr. "cavity" and "stone") for outgrowths of the epidermal cell wall of plant, generally leaf.

- Calcium carbonate, formed in a cellulose matrix in special cells called lithocysts
- Cystoliths are present in many genera of Acanthaceae.
- Cannabis and other plants in the family Cannabaceae, which produce leaf and flower cystoliths
- *Ficus elastica*, the Indian rubber plant of the family Moraceae.

Immunological reactions

- The **storage protein** or **pollen protein** is **injected from the plant body** to a test animal usually mouse or rabbit

- The test animal produces **antiserum** against that protein

- The antiserum is **mixed** with the plant extract to **detect the precipitate** formed by **antigen – antibody reaction**
- The nature and amount of **precipitate indicate** the relationship of the protein to the plant.

- **High rate of precipitation** indicates **closeness of the plants** and **low precipitation** shows the **two plants are not related.**

- **This type of study is also known as serotaxonomy**

- **Karl Landsteiner's**: pioneering work on the Specificity of Serological Reactions"

Example-

- Serological studies confirmed by closeness of ***Delphinium*** to ***Aconitumis***

- Serological method is also useful in the classification of the members of ***Fabaceae, Bromus, Potato*** etc.

Recent technique used for chemotaxonomy

Rapid advancement during 1970-1980 in techniques of phytochemistry i.e.

- Paper Chromatography
- Capillary column (or high resolution)
- Gas- liquid chromatography (GLC),
- High-performance liquid chromatography (HPLC)
- Mass spectrometry (MS, as GLC–MS, LC–MS) and
- Nuclear magnetic resonance (^{1}H, ^{13}C–NMR)

Acknowledgements

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- I apologize to all authors whose findings could not be substantiated or cited in our presentation due to reasons of brevity

Thank you for your attention