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PHARMACOGNOSY AND PHYTOCHEMISTRY – I

UNIT 4

TOPIC :

- **Introduction to secondary metabolites :**

  Definition, classification, properties and test for identification of Alkaloids, Glycosides, Flavonoids, Tannins, Volatile oil and Resins

Alkaloids

- Alkaloids are naturally occurring organic compounds, mostly nitrogen-containing, often in a heterocyclic ring.
- Mostly derived from plants, but can also be found in fungi and animals.
- They exert significant physiological and pharmacological effects in humans and animals.
- Term coined by W. Meissner, 1819.

General Characteristics

- Contain nitrogen, usually in a heterocyclic ring.
- Basic (alkaline) in nature.
- Derived mainly from amino acids.
- Found in seeds, barks, leaves, or roots of plants.
- Bitter in taste.
- Typically crystalline solids, though some may be liquids.
- Toxic in high doses, medicinal in small doses.

Classification of Alkaloids

A. Based on Chemical Structure

Type	Example
Pyridine & Piperidine alkaloids	Nicotine, Coniine
Tropane alkaloids	Atropine, Cocaine
Quinoline alkaloids	Quinine
Isoquinoline alkaloids	Morphine, Codeine
Indole alkaloids	Reserpine, Ergotamine
Imidazole alkaloids	Pilocarpine
Steroidal alkaloids	Solanine
Purine alkaloids	Caffeine, Theobromine

B. Based on Origin

Type	Characteristics	Example
True alkaloids	Derived from amines, N in heterocyclic ring	Morphine
Protoalkaloids	Derived from amino acids, N not in ring	Ephedrine
Pseudoalkaloids	Not from amino acids, but structurally resemble alkaloids	Caffeine

Sources

Source	Example
Plants	Opium Poppy (Morphine), Cinchona Bark (Quinine), Tobacco (Nicotine), Belladonna (Atropine)
Fungi	Claviceps purpurea (Ergot alkaloids)
Animals	Toads (Bufotenin)

Examples and Uses

Alkaloid	Source	Use
Morphine	Opium poppy	Pain relief
Quinine	Cinchona bark	Antimalarial
Caffeine	Coffee, Tea	CNS stimulant
Atropine	Belladonna	Anticholinergic
Nicotine	Tobacco	Stimulant, Insecticide
Reserpine	Rauwolfia	Antihypertensive
Ephedrine	Ephedra	Bronchodilator

Identification Tests

Test	Reagent	Positive Result
Dragendorff's Test	Dragendorff's reagent (Potassium Bismuth Iodide)	Orange-red precipitate
Mayer's Test	Mayer's reagent (Potassium Mercuric Iodide)	Creamy white precipitate
Hager's Test	Hager's reagent (Saturated Picric Acid)	Yellow crystalline precipitate
Wagner's Test	Wagner's reagent (Dilute Iodine Solution)	Reddish-brown precipitate

Glycosides

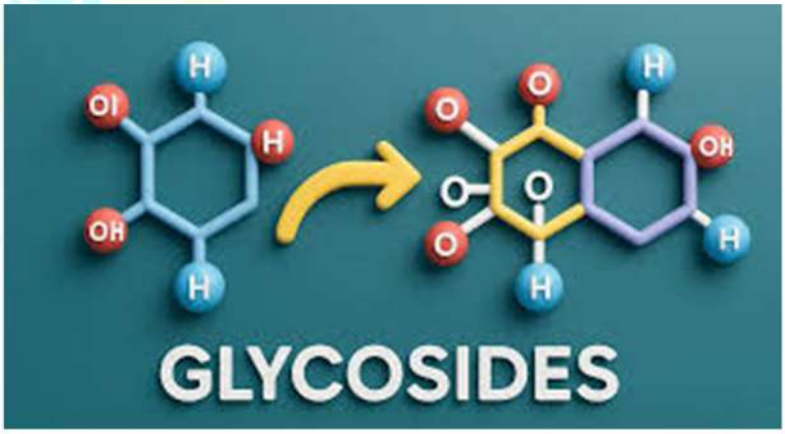
Glycosides are naturally occurring compounds consisting of two parts:

1. Sugar moiety (Glycone): Usually glucose or another monosaccharide.
2. Non-sugar moiety (Aglycone or Genin): Can be a phenol, steroid, aldehyde, or other compound.

These two parts are linked by a glycosidic bond.

General Structure:
Glycoside = Glycone (sugar) + Aglycone (non-sugar)

- Glycone: Determines solubility and transport in the body.
- Aglycone: Determines biological or pharmacological activity.



Classification of Glycosides

A. Based on Type of Linkage Between Sugar and Aglycone

Type	Bond	Example
O-Glycosides	Oxygen	Salicin
N-Glycosides	Nitrogen	Nucleosides
S-Glycosides	Sulfur	Singaia
C-Glycosides	Carbon	Alain (from Aloe)

B. Based on Pharmacological Activity

Activity	Example / Source
Laxative / Purgative	Aloe, Senna, Cascara
Cardiac Glycosides	Digitalis, Streptanthus, Thevetia,

	Squill
Immunomodulator	Ginseng, Picrorhiza
Expectorant	Liquorice, Wild cherry bark
Bitter Glycosides / Hepatoprotective	Gentiana, Picrorrhiza, Chirata, Guasa
Emetic	Black mustard
Antidiabetic	Gymnema
Leukoderma treatment	Psoralea, Ammi

Properties of Glycosides

Property	Description
Appearance / Color	Usually **crystalline solids**, mostly **colorless**, some (anthraquinone glycosides) are colored.
Taste	Often **bitter** or slightly sweet.
Solubility	Soluble in **water and alcohol** (due to glycone); aglycone may dissolve in **organic solvents**.
Melting Point	Usually **definite melting points**, helpful for identification.

Identification Tests of Glycosides

A. Keller-Killiani Test

- Purpose: Detects deoxy sugars in cardiac glycosides.
- Procedure: Add glacial acetic acid + a few drops of ferric chloride, then conc. H_2SO_4 to the extract.
- Positive Result: Reddish-brown color appears.

B. Antimony Trichloride Test

- Purpose: Detects steroidal nucleus in aglycone.
- Procedure: Add antimony trichloride reagent to extract; warm gently if needed.
- Positive Result: Blue or violet color develops.

C. Raymond's Test

- **Purpose:** Detects **condensed type aglycones**.
- Procedure: Add Raymond's reagent (dinitrobenzene in alcohol) to extract.
- Positive Result: Red to violet color develops.

D. Legal's Test

- Purpose: Detects keto group in cardiac glycosides.
- Procedure: Add sodium nitroprusside + alkali to extract.
- Positive Result: Pink to red color appears.

Tannins

Tannins are high molecular weight polyphenolic compounds found in plants.

- They are capable of precipitating proteins, giving them their characteristic astringent taste.
- Widely used in medicine, leather tanning, and dyeing industries.

Classification of Tannins

Type	Description	Example
Hydrolysable Tannins	Can be hydrolyzed to yield **gallic acid** or **ellagic acid**.	Gallotannins, Ellagitannins
Condensed Tannins (Proanthocyanidins)	Do not hydrolyze easily; form **insoluble polymers**.	Catechins
Complex Tannins	Combination of **hydrolysable and condensed tannins**.	—
Pseudo Tannins	Low molecular weight, **do not precipitate proteins**.	Chlorogenic acid, Coffee tannins

Properties of Tannins

Property	Description
Solubility	Soluble in water; also soluble in alcohol.
Taste	Astringent.
Protein Interaction	Forms **insoluble complexes** with alkaloids, gelatin, and other proteins.
Color Reactions	Gives **blue-black** or **green-black** color with ferric salts.
Physical Form	Non-crystalline, amorphous powders.

Identification Tests for Tannins

A. Ferric Chloride Test

- Procedure: Add ferric chloride solution to the extract.
- Results:
  - Hydrolysable tannins → Blue-black color
  - Condensed tannins → Green-black color

B. Goldbeater's Skin Test

- Procedure: Soak goldbeater's skin in the tannin solution.
- Result: Brown/black coloration confirms the presence of tannins.

C. Gelatin Test

- Procedure: Add 1% gelatin solution containing NaCl to the extract.
- Result: White precipitate indicates presence of tannins.

D. Matchstick Test (for Catechin-type)

- Procedure: Moisten matchstick with the sample + HCl.
- Result: Pink/red color confirms catechin-type tannins.

Resins

Resins are solid or semi-solid, amorphous substances of plant origin, usually obtained as exudates or secretions.

- Insoluble in water but soluble in alcohol and organic solvents.
- Widely used in medicine, varnishes, adhesives, and perfumery.

Classification of Resins

A. Based on Constituents

Type	Composition	Example
Oleoresins	Resin + Volatile oil	Ginger, Turpentine
Gum Resins	Resin + Gum	Myrrh
Oleo-Gum Resins	Resin + Gum + Volatile oil	Asafoetida
Glycoresins	Resin + Sugar	Jalap
Balsams	Resin + Benzoic or Cinnamic acid	Balsam of Tolu

B. Based on Source

Type	Description
Natural Resins	Obtained from plant exudates naturally.
Synthetic Resins	Chemically prepared resins with similar properties.

Properties of Resins

Property	Description
Physical State	Solid, brittle, and sticky.
Solubility	Insoluble in water; soluble in alcohol, ether, chloroform.
Burning	Burns with smoky flames.
Odor	Characteristic odor if volatile oils are present.

Identification Tests for Resins

Test	Procedure	Result
Solubility Test	Dissolve in alcohol or organic solvent	Soluble in alcohol, insoluble in water
Ferric Chloride Test	Add ferric chloride to phenolic resins	Colored complex forms
HCl Test	Add HCl to resin acids	Precipitation occurs
NaOH Test	Add NaOH to phenolic resins	Colored solution forms
Turbidity Test	Triturate resin with water	Forms emulsion or turbidity

Flavonoids

Flavonoids are a large group of naturally occurring polyphenolic compounds found in fruits, vegetables, tea, wine, and medicinal plants.

- They are secondary metabolites in plants.
- Known for antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, and cardioprotective activities.

Classification of Flavonoids

Type	Example
Flavones	Apigenin, Luteolin
Flavonols	Quercetin, Kaempferol
Flavanones	Naringenin, Hesperetin
Flavanols (Catechins)	Epicatechin, Catechin
Anthocyanidins	Cyanidin, Delphinidin
Isoflavones	Genistein, Daidzein

Properties of Flavonoids

A. Physical Properties

Property	Description
Color	Yellow to orange (especially flavones and flavonols)
State	Crystalline solids
Solubility	Soluble in alcohol; slightly soluble in water

B. Chemical Properties

- Contain a **polyphenolic structure**.
- Can **undergo oxidation**.
- **pH-sensitive**: Color changes with acidic or basic conditions.

Identification Tests

Test	Procedure	Positive Result
Shinoda Test	Add magnesium turnings + concentrated HCl to extract	Pink or red color
Lead Acetate Test	Add lead acetate solution to extract	Yellow precipitate
Alkaline Reagent Test	Add NaOH solution	Intense yellow color, which turns colorless on acidification

Volatile Oils (Essential Oils)

Volatile oils, also known as essential oils, are aromatic, odorous substances obtained from plants.

- Called volatile because they evaporate easily at room temperature.
- They are insoluble in water but soluble in alcohol.
- Widely used in flavoring, perfumery, and medicinal preparations.

Classification

A. Based on Chemical Constituents

Type	Example
Hydrocarbons	Turpentine oil
Alcohols	Peppermint oil
Aldehydes	Cinnamon oil
Ketones	Spearmint oil
Phenols	Eucalyptus oil
Esters	Lavender oil

B. Based on Volatility or Use

Type	Use
Therapeutic oils	Medicinal purposes
Flavoring oils	Food and beverages
Perfume oils	Fragrance and cosmetics

Properties

Property	Description
Odor	Strong aromatic smell
Volatility	Evaporates easily at room temperature
Solubility	Insoluble in water; soluble in alcohol
Color	Colorless or pale yellow when fresh
Density	Lighter than water (except some oils like clove, elemi)
Physical form	Usually oily liquid; non-greasy on paper

Identification Tests

Test	Procedure	Positive Result
Solubility Test	Dissolve in alcohol and water	Soluble in alcohol; insoluble in water
Stain Test	Place a drop on paper	Does not leave a permanent greasy stain
Turbidity Test	Add water to alcoholic solution	Solution becomes turbid
Chemical Tests	Based on functional groups (e.g., phenols with ferric chloride)	Color change indicates presence of functional group