Module Title	Introduction to Metabolites of Plant Origin Traditional Systems of Medicine
Subject /Course	Introduction to Pharmacognosy
Subject/Course ID	BP105T
Semester	I
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Learning Outcome of Module 04

LO	Learning Outcome	Course Outcome
LO1	Describe the definition, characteristics, and classification of plant metabolites into primary and secondary metabolites.	BP105.4
LO2	Differentiate primary metabolites (carbohydrates, proteins, lipids) from secondary metabolites (alkaloids, glycosides, flavonoids, tannins, terpenoids, volatile oils, and resins) based on their occurrence and biological functions.	BP105.4
LO3	Explain the therapeutic relevance and pharmaceutical importance of major classes of plant metabolites in medicinal plants.	BP105.4
LO4	Describe the basic principles of disease treatment, dosage forms, and healthcare approaches in traditional systems of medicine including AYUSH and Traditional Chinese Medicine (TCM).	BP105.5
LO5	Explain the role of Pharmacognosy in drug discovery, allopathic medicine, and traditional systems of medicine such as AYUSH and TCM.	BP105.1, BP105.5

Content Table

Introduction to Metabolites of Plant Origin

Definition and general properties of plant metabolites. Primary and secondary metabolites such as carbohydrates, proteins, lipids, alkaloids, glycosides, flavonoids, tannins, terpenoids, volatile oils and resins.

Traditional Systems of Medicine Basic principles of treatment of diseases in different systems of medicine including AYUSH and TCM. Types of dosage forms in AYUSH medicines. Role of pharmacognosy in allopathy and traditional systems of medicine such as AYUSH and TCM.

PLANT METABOLITES

Plant metabolites are naturally occurring chemical compounds synthesized by plants through metabolic processes. They are essential for plant growth, development, reproduction, defense, adaptation to environmental conditions, and interactions with other organisms. These compounds are formed through complex biochemical pathways and are classified into primary metabolites and secondary metabolites based on their biological functions.

Properties of Plant Metabolites

- Naturally synthesized by plants through metabolic processes.
- Classified as primary and secondary metabolites.
- Chemically diverse (carbohydrates, proteins, alkaloids, flavonoids, terpenoids, etc.).
- Vary with plant species, age, and environmental conditions.
- Stored in specialized plant tissues and secretory structures.
- Differ in solubility, polarity, and chemical stability.
- Possess diverse biological and pharmacological activities.
- Aid in plant growth, defense, and ecological interactions.
- Impart characteristic colour, taste, aroma, and medicinal properties.
- Important for drug discovery, quality control, and standardization.

PRIMARY METABOLITES

Primary metabolites are chemical compounds that are essential for the normal growth, development, reproduction, and survival of plants. They are directly involved in fundamental metabolic processes such as photosynthesis, respiration, protein synthesis, and cell division. These metabolites are produced in relatively large amounts and are present in almost all living plant cells.

Characteristics of Primary Metabolites

- Essential for plant growth and survival.
- Universally distributed in almost all plant species.
- Produced during the active growth phase.
- Directly participate in basic metabolic processes.
- Generally present in large quantities.
- Less species-specific than secondary metabolites.
- Serve as precursors for the synthesis of secondary metabolites.

- Have high nutritional value and are important in human and animal nutrition.

Examples of Primary Metabolites

- Carbohydrates (glucose, starch, cellulose)
- Proteins
- Amino acids
- Lipids (fats and oils)
- Nucleic acids (DNA, RNA)
- Organic acids (citric acid, malic acid)
- Vitamins
- Enzymes

Functions of Primary Metabolites

- Provide energy for cellular activities.
- Form structural components of plant cells.
- Participate in growth and cell division.
- Store food and energy.
- Act as precursors for secondary metabolite biosynthesis.
- Support reproduction and seed development.

SECONDARY METABOLITES

Secondary metabolites are organic compounds synthesized from primary metabolites that are not directly required for the basic growth and survival of plants but provide ecological, defensive, and adaptive advantages. They are usually produced in smaller quantities and are often restricted to particular plant species or families.

Characteristics of Secondary Metabolites

- Not directly involved in primary metabolic processes.
- Synthesized from primary metabolites.
- Usually species-specific or family-specific.
- Produced in relatively small quantities.
- Accumulate in specialized tissues or secretory structures.
- Often synthesized in response to environmental or biological stress.
- Possess diverse chemical structures and biological activities.

- Widely used in medicine, agriculture, cosmetics, and food industries.

Examples of Secondary Metabolites

- Alkaloids (Morphine, Quinine, Atropine)
- Glycosides (Digoxin, Senna glycosides)
- Flavonoids (Quercetin, Rutin)
- Tannins
- Terpenoids
- Saponins
- Phenolic compounds
- Essential (volatile) oils
- Resins
- Lignans

Functions of Secondary Metabolites

- Protect plants against insects, herbivores, and pathogens.
- Attract pollinators through colour and fragrance.
- Provide protection against UV radiation and oxidative stress.
- Exhibit allelopathic effects by inhibiting competing plants.
- Aid in wound healing and defense after injury.
- Facilitate plant–microbe interactions.
- Serve as important sources of therapeutic agents and pharmaceutical drugs.

Table 1: Differences Between Primary and Secondary Metabolites

Feature	Primary Metabolites	Secondary Metabolites
Definition	Compounds essential for normal growth and survival	Compounds not directly essential for growth but important for defense and adaptation
Role	Basic metabolism	Ecological and protective functions
Distribution	Present in almost all plants	Restricted to certain species or families
Quantity	Produced in large amounts	Produced in smaller amounts
Stage of Production	Mainly during active growth	Often after active growth or under stress
Importance	Essential for life	Enhance survival and competitiveness
Biological Activity	Mainly nutritional and metabolic	Highly pharmacological and ecological
Examples	Carbohydrates, proteins, amino acids, lipids, nucleic acids	Alkaloids, glycosides, flavonoids, tannins, terpenoids, saponins, essential oils

PRIMARY METABOLITES

CARBOHYDRATES

Carbohydrates are organic compounds composed primarily of carbon (C), hydrogen (H), and oxygen (O), generally having the empirical formula $(CH_2O)_n$. They are synthesized in plants by photosynthesis and are the most abundant primary metabolites. Carbohydrates are also called saccharide which is a Greek word and it means sugar because almost all the carbohydrates have a sweet taste. Carbohydrates are probably the most abundant and widespread organic substances in nature, and they are essential constituents of all living things. Carbohydrates are formed by green plants from carbon dioxide and water during the process of photosynthesis. Carbohydrates serve as energy sources and as essential structural components in organisms; in addition, part of the structure of nucleic acids, which contain genetic information, consists of carbohydrate. Chemically, carbohydrates are defined as "optically active polyhydroxy aldehydes or ketones or the compounds which produce units of such type on hydrolysis".

General Characteristics

- They are primary metabolites essential for plant growth and development.
- Composed of carbon, hydrogen, and oxygen.
- Synthesized mainly during photosynthesis.
- Usually occur as sugars, starch, cellulose, and other polysaccharides.
- Most carbohydrates are water-soluble, whereas polysaccharides like starch and cellulose are insoluble.
- They are sweet in taste in their simple sugar form. Stored in plants mainly as starch.

Pharmaceutical Importance

- Used as diluents, binders, and disintegrants in tablet formulations.
- Starch is used as a pharmaceutical excipient and dusting powder.
- Cellulose derivatives are used as suspending agents, thickening agents, and controlled-release polymers.
- Pectin is used as a gelling agent and antidiarrheal agent.
- Inulin is used as a prebiotic and for the assessment of kidney function.
- Carbohydrates are widely used in food, pharmaceutical, cosmetic, and biotechnology industries.

Classification of Carbohydrates

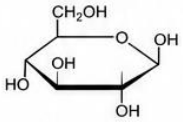
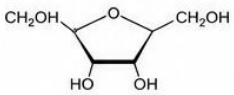
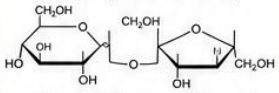
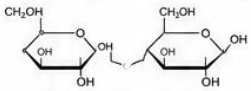
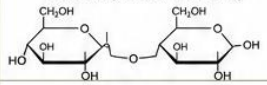
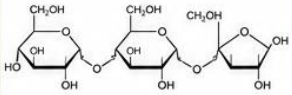
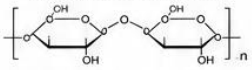
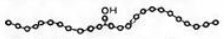
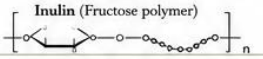
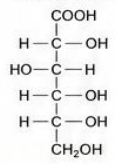
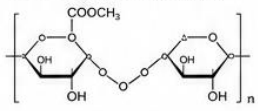
Group (Type)	Examples (Source)	Picture / Natural Source	Chemical Nature / Structure (Basic Moiety)	Pharmaceutical Use / Activity
1. Monosaccharides Simplest carbohydrates which cannot be hydrolyzed into smaller sugars.	• **Glucose** (Fruits, Honey) • **Fructose** (Fruits) • **Ribose** (RNA) • **Deoxyribose** (DNA)	 Grapes / Honey  Fruits  Ribose / Deoxyribose in Nucleic acids	**Aldoses** (e.g., Glucose)  **Ketoses** (e.g., Fructose) 	• Quick energy source (glucose) • Used in IV fluids (Dextrose) • Ribose in nucleotide synthesis • Deoxyribose in DNA synthesis & repair
2. Disaccharides Carbohydrates which on hydrolysis yield two monosaccharide units.	• **Sucrose** (Cane sugar) • **Lactose** (Milk sugar) • **Maltose** (Malt sugar)	 Cane Sugar  Milk  Malt	**Sucrose** (Glucose + Fructose)  **Lactose** (Glucose + Galactose)  **Maltose** (Glucose + Glucose) 	• Sucrose – energy source, used in syrups & medicinal preparations • Lactose – used as excipients in tablets & capsules • Maltose – used in fermentation & enzyme preparations
3. Oligosaccharides Carbohydrates which on hydrolysis yield 2–10 monosaccharide units.	• **Raffinose** (Pulses) • **Stachyose** (Soybean) • **FOS** (Fructo-oligosaccharides) (Chicory root)	 Pulses  Soybean  Chicory Root	**Raffinose** (Galactose + Glucose + Fructose) 	• Prebiotic – promotes beneficial gut microflora • Improves calcium absorption • Used in functional foods & nutraceuticals
4. Polysaccharides Carbohydrates which on hydrolysis yield more than 10 monosaccharide units.	• **Starch** (Cereals, Potatoes) • **Cellulose** (Plant cell wall) • **Glycogen** (Animal tissues) • **Inulin** (Chicory, Garlic)	 Cereals / Potatoes  Plants  Animal Liver  Chicory / Garlic	**Starch** (α-D-Glucose polymer)  **Cellulose** (β-D-Glucose polymer)  **Glycogen** (Highly branched)  **Inulin** (Fructose polymer) 	• Starch – disintegrant & binder in tablets • Cellulose – bulk forming agent, used in tablet excipients • Glycogen – used in biological research & vaccines stabilizer • Inulin – prebiotic, used in constipation & gut health
5. Sugar Acids Carbohydrates containing both carboxylic acid and hydroxyl groups.	• **Gluconic acid** (Fermented fruits) • **Galacturonic acid** (Pectin in fruits) • **Glucuronic acid** (Animal tissues)	 Fruits  Citrus / Pectin  Animal Tissues	**Gluconic acid** 	• Chelating agent in detoxification (e.g., heavy metals) • Used in drug conjugation (glucuronidation) • Used in pharmaceutical preparations, cosmetics & food industry
6. Sugar Esters Esters of sugar acids.	• **Sucrose acetate** • **Pectin esters**	 Sucrose acetate  Pectin (Apple)	**Pectin methyl ester** (example) 	• Used as emulsifiers, stabilizers & film formers • Used in controlled drug delivery systems

Figure 1: Classification of Carbohydrates

Table 2: Chemical Identification Tests for Carbohydrates

Test	Principle	Reagent Used	Positive Observation	Inference
Molisch's Test	Dehydration of carbohydrates forms furfural derivatives, which react with α-naphthol	Molisch reagent (α-naphthol) + Conc. H_2SO_4	Violet/Purple ring at the junction	Presence of carbohydrates
Benedict's Test	Reducing sugars reduce Cu^{2+} to Cu_2O in alkaline medium	Benedict's reagent	Green, yellow, orange, or brick-red precipitate	Presence of reducing sugars
Fehling's Test	Reducing sugars reduce cupric ions to cuprous oxide	Fehling's solution A & B	Brick-red precipitate	Presence of reducing sugars
Barfoed's Test	Monosaccharides reduce copper acetate in acidic medium more rapidly than disaccharides	Barfoed's reagent	Red precipitate within 2–3 minutes	Presence of monosaccharides
Seliwanoff's Test	Ketohexoses form hydroxymethylfurfural rapidly, reacting with resorcinol	Seliwanoff's reagent (Resorcinol + HCl)	Cherry-red colour	Presence of ketose sugars (e.g., fructose)
Iodine Test	Iodine forms a coloured complex with starch	Iodine solution	Blue-black colour	Presence of starch
Anthrone Test	Carbohydrates react with anthrone in concentrated sulfuric acid	Anthrone reagent	Blue-green colour	Presence of total carbohydrates

PROTEINS

Proteins are **high molecular weight nitrogen-containing organic compounds** composed of amino acids linked together by peptide bonds. They are one of the most important primary metabolites and are essential for the growth, development, repair, and maintenance of plant cells. Proteins also function as enzymes, structural components, transport molecules, and storage substances.

General Characteristics

- Proteins are primary metabolites essential for plant growth and survival.
- They are polymers of amino acids joined by peptide bonds.
- Composed mainly of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), and sometimes sulfur (S) and phosphorus (P).
- They possess high molecular weight and complex three-dimensional structures.
- Most proteins are colloidal in nature and may be soluble or insoluble depending on their type.
- They undergo denaturation when exposed to heat, extreme pH, organic solvents, or heavy metals.

- They are hydrolyzed by acids, alkalis, or proteolytic enzymes to yield amino acids.

Classification of Proteins

1. Based on Composition

- **Simple proteins:** Yield only amino acids on hydrolysis (e.g., Albumins, Globulins).
- **Conjugated proteins:** Contain a protein part and a non-protein prosthetic group (e.g., Glycoproteins, Lipoproteins, Metalloproteins).
- **Derived proteins:** Formed by partial hydrolysis or denaturation of proteins.

2. Based on Shape

- **Fibrous proteins:** Long, insoluble, structural proteins (e.g., Collagen, Keratin).
- **Globular proteins:** Compact, generally water-soluble proteins (e.g., Enzymes, Albumins).

Examples of Plant Proteins

- **Gluten** – Wheat (*Triticum aestivum*)
- **Zein** – Maize (*Zea mays*)
- **Legumin** – Pea (*Pisum sativum*)
- **Glycinin** – Soybean (*Glycine max*)
- **Ricin** – Castor (*Ricinus communis*)
- **Papain** – Papaya (*Carica papaya*) (proteolytic enzyme)
- **Bromelain** – Pineapple (*Ananas comosus*) (proteolytic enzyme)

Pharmaceutical Importance

- Proteolytic enzymes such as **papain** and **bromelain** are used as digestive aids, anti-inflammatory agents, and in wound debridement.
- Plant proteins are important ingredients in nutraceuticals and protein supplements.
- Proteins are used in biotechnology for the production of therapeutic enzymes, vaccines, and recombinant pharmaceuticals.
- Some plant proteins possess antimicrobial, antioxidant, and immunomodulatory activities.

Classification of Proteins

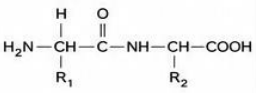
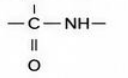
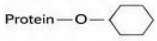
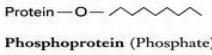
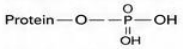
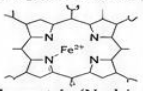
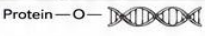
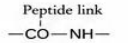
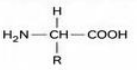
Group (Type)	Examples (Source)	Picture / Natural Source	Chemical Nature / Structure (Basic Moiety)	Pharmaceutical Use / Activity
1. Simple Proteins On hydrolysis yield only amino acids.	• **Albumins** (Egg white, Milk) • **Globulins** (Serum, Legumes) • **Protamines** (Fish sperm) • **Glutelins** (Wheat gluten) • **Scleroproteins** (Keratin, Collagen)	 Egg white (Albumin)  Soybean (Globulin)  Fish sperm (Protamine)  Wheat (Gluten)  Hair (Keratin)	Polypeptide chain (α–amino acids linked by peptide bond)  Peptide bond 	• **Albumin** – plasma expander, drug carrier • **Globulins** – immune function, used in vaccines (immunoglobulins) • **Protamines** – neutralize heparin anticoagulant effect • **Gelatin** (derived) – used in capsules, tablets, wound healing • **Collagen** – tissue regeneration, cosmetic preparations
2. Conjugated Proteins On hydrolysis yield amino acids and a non-protein prosthetic group.	• **Glycoproteins** (Mucus, Serum) • **Lipoproteins** (HDL, LDL) • **Phosphoproteins** (Casein) • **Chromoproteins** (Hemoglobin) • **Nucleoproteins** (Histones)	 Mucus (Glycoprotein)  LDL particle (Lipoprotein)  Milk (Casein)  Blood (Hemoglobin)  Nucleus (Histone)	**Glycoprotein** (Carbohydrate)  **Lipoprotein** (Lipid)  **Phosphoprotein** (Phosphate)  **Chromoprotein** (Heme group)  **Nucleoprotein** (Nucleic acid)  **Nucleoprotein** (Nucleic acid)	• **Glycoproteins** – used as antigens, drug delivery systems • **Lipoproteins** – drug transport, lipid metabolism modulators • **Casein** – used in controlled drug delivery • **Hemoglobin** – oxygen carrier, used in blood substitutes • **Nucleoproteins** – used in gene therapy, vaccines
3. Derived Proteins Products formed by denaturation or partial hydrolysis of proteins.	• **Primary Derived** (Proteans, Metaproteins, Coagulated proteins) • **Secondary Derived** (Proteoses, Peptones, Peptides) • **Tertiary Derived** (Amino acids)	 Coagulated protein  Peptones  Amino acids	Peptide link  Amino acid (General structure) 	• **Peptones** – used in culture media, nutrient supplements • **Peptides** – used in drug design, hormone analogues (e.g., Oxytocin, Desmopressin) • **Amino acids** – used in parenteral nutrition, hepatic encephalopathy therapy
4. Fibrous Proteins Insoluble in water, structural proteins.	• **Collagen** (Connective tissue) • **Elastin** (Ligaments) • **Keratin** (Hair, Nails, Wool) • **Fibroin** (Silk)	 Tendon (Collagen)  Ligament (Elastin)  Hair (Keratin)  Silk cocoon (Fibroin)	Polypeptide chains arranged in fibers/helix  –Repeating Gly–X–Y– (Proline, Hydroxyproline in collagen) β-pleated sheet structure (in keratin, fibroin) 	• **Collagen** – wound healing, tissue engineering, skin care • **Elastin** – vascular grafts, regenerative medicine • **Keratin** – used in drug adsorbents, nail & hair formulations • **Fibroin** – sutures, drug scaffolds, tissue engineering
5. Globular Proteins Soluble in water, functional proteins.	• **Enzymes** (Amylase, Pepsin) • **Insulin** (Pancreas) • **Immunoglobulins** (Plasma cells) • **Hemoglobin** (Blood) • **Serum Albumin** (Plasma)	 Pancreas (Insulin)  Antibody (IgG)  Red blood cells (Hb)  Plasma (Albumin)	Compact folded polypeptide chain (tertiary / quaternary structure)  Held by – H-bonds, disulfide bonds, ionic & hydrophobic interactions	• **Enzymes** – used in digestive aids, thrombolytics (e.g., Streptokinase) • **Insulin** – antidiabetic therapy • **Immunoglobulins** – immunotherapy, prophylaxis • **Hemoglobin** – oxygen therapy, anemia treatment • **Albumin** – plasma expander, drug carrier

Figure 2: Classification of Proteins

Table 3: Chemical Identification Tests for Proteins

Test	Principle	Reagent Used	Positive Observation	Inference
Biuret Test	Peptide bonds react with copper ions in alkaline medium	Biuret reagent ($CuSO_4$ + NaOH)	Violet/Purple colour	Presence of proteins (peptide bonds)
Ninhydrin Test	Free amino groups react with ninhydrin	Ninhydrin reagent	Blue or purple colour	Presence of amino acids/proteins
Xanthoproteic Test	Aromatic amino acids undergo nitration with nitric acid	Concentrated HNO_3 (followed by $NaOH/NH_4OH$)	Yellow colour turning orange	Presence of aromatic amino acids
Millon's Test	Phenolic group of tyrosine reacts with mercuric nitrate	Millon's reagent	White precipitate turning brick-red on heating	Presence of tyrosine-containing proteins

LIPID DRUGS

Lipids are the substances of animal or plant origin and comprise of fixed oils, fats and waxes. The basic function of fat and oil is energy storage. These are obtained by expression or extraction methods.

Lipids are a diverse group of **water-insoluble, organic compounds** composed mainly of **carbon (C), hydrogen (H), and oxygen (O)**, and sometimes phosphorus (P), nitrogen (N), and sulfur (S). They are important **primary metabolites** that serve as energy reserves, structural components of cell membranes, and signaling molecules. In plants, lipids are stored mainly in **seeds and fruits** as fixed oils.

General Characteristics

- Lipids are primary metabolites essential for plant growth and metabolism.
- They are composed mainly of carbon, hydrogen, and oxygen.
- Insoluble in water but soluble in organic solvents such as ether, chloroform, benzene, hexane, and acetone.
- They possess a greasy or oily nature and leave a permanent translucent stain on paper.
- Most lipids are esters of glycerol and fatty acids.
- They serve as concentrated energy reserves, yielding more energy than carbohydrates.
- Lipids may be solid (fats) or liquid (oils) at room temperature depending on the degree of saturation.
- They are susceptible to oxidation, resulting in rancidity during prolonged storage.
- They are stored predominantly in seeds, fruits, and embryos of plants.

- They are essential components of biological membranes.

Examples of Plant Lipids

- **Castor oil** – Castor (*Ricinus communis*)
- **Groundnut oil** – Groundnut (*Arachis hypogaea*)
- **Sesame oil** – Sesame (*Sesamum indicum*)
- **Sunflower oil** – Sunflower (*Helianthus annuus*)
- **Coconut oil** – Coconut (*Cocos nucifera*)
- **Olive oil** – Olive (*Olea europaea*)
- **Linseed oil** – Flax (*Linum usitatissimum*)

Pharmaceutical Importance

- Fixed oils are used as emollients, laxatives, ointment bases, and massage oils.
- Lipids serve as vehicles and solvents for lipid-soluble drugs.
- Phospholipids are used in the preparation of liposomes for targeted drug delivery.
- Plant oils are widely used in cosmetics, creams, lotions, soaps, and pharmaceutical formulations.
- Essential fatty acids contribute to cardiovascular health and possess anti-inflammatory properties.
- Lipids are important ingredients in nutraceuticals and functional foods.

Table 4: Chemical Identification Tests for Lipids

Test	Principle	Reagent Used	Positive Observation	Inference
Sudan III Test	Lipids are stained by fat-soluble dyes	Sudan III reagent	Orange-red or red-stained oil layer	Presence of lipids
Sudan IV Test	Lipids absorb Sudan IV dye	Sudan IV reagent	Bright red coloration	Presence of lipids
Emulsion Test	Lipids form an emulsion in water after dissolution in ethanol	Ethanol + Water	Milky white emulsion	Presence of lipids
Grease Spot Test	Lipids leave a permanent translucent spot on paper	Filter paper	Permanent greasy translucent spot	Presence of lipids
Saponification Test	Lipids are hydrolyzed by alkali to form soap and glycerol	Alcoholic KOH/NaOH	Formation of soap (lather)	Presence of triglycerides (fixed oils/fats)

Classification of Lipids

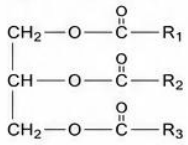
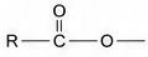
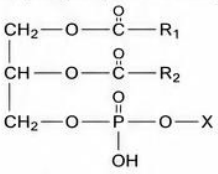
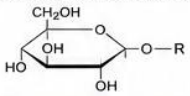
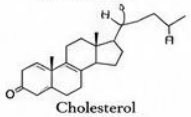
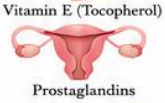
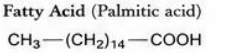
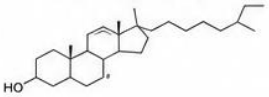
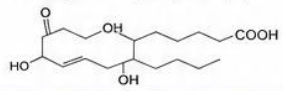
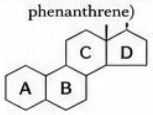
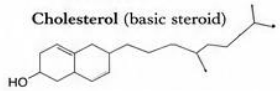
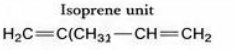
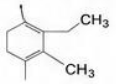
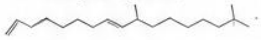
Group (Type)	Examples (Source)	Picture / Natural Source	Chemical Nature / Structure (Basic Moiety)	Pharmaceutical Use / Activity
1. Simple Lipids Esters of fatty acids with alcohols.	• **Fats & Oils** (Butter, Ghee, Coconut oil) • **Waxes** (Beeswax, Carnauba wax) • **Fats (Animal)** (Adipose tissue)	 Butter, Coconut oil  Beeswax  Animal fat	**Triglycerides** (Fats & Oils)  **Waxes** (Ester of long chain acid and long chain alcohol) 	• Energy source & nutrient • Vehicle for fat soluble drugs • Emollient & protective (waxes in ointments & creams) • Used in suppositories & liposomal drug delivery
2. Compound Lipids Contain fatty acids along with other groups (phosphate or carbohydrates).	• **Phospholipids** (Lecithin) • **Glycolipids** (Cerebrosides) • **Lipoproteins** (HDL, LDL)	 Soy lecithin  Brain (cerebrosides)  Blood lipoproteins	**Phospholipids** (Lecithin example)  **Glycolipids** (Cerebroside example) 	• Phospholipids – used in liposomes, drug carriers and cell membrane modeling • **Glycolipids** – used in vaccines & adjuvants • **Lipoproteins** – drug transport & targeting systems
3. Derived Lipids Hydrolysis products of simple or compound lipids.	• **Fatty Acids** (Palmitic acid) • **Sterols** (Cholesterol) • **Fat soluble Vitamins** (Vit A, D, E, K) • **Eicosanoids** (Prostaglandins)	 Palmitic acid  Cholesterol  Vitamin E (Tocopherol)  Prostaglandins	**Fatty Acid** (Palmitic acid)  **Sterol** (Cholesterol)  **Prostaglandin** (PGE_2 example) 	• **Fatty acids** – used in topical preparations & IV lipid emulsions • **Sterols** – used as precursors for steroid hormones & vitamins • **Fat soluble vitamins** – essential in nutrition & therapy • **Prostaglandins** – used in labor induction, gastric protection, glaucoma therapy
4. Steroids Lipids with steroid nucleus (cyclopentano-perhydrophen-anthrene).	• **Corticosteroids** (Hydrocortisone) • **Sex Hormones** (Testosterone, Estrogen) • **Bile Acids** (Cholic acid)	 Hydrocortisone  Sex hormones  Bile acids	**Steroid nucleus** (Cyclopentanoperhydro-phenanthrene)  **Cholesterol** (basic steroid) 	• **Corticosteroids** – anti-inflammatory, anti-allergic • **Sex hormones** – used in contraception, hormone therapy • **Bile acids** – used in digestion & as excipients
5. Terpenoids (Isoprenoids) Built from isoprene units $(C_5H_8)_n$.	• **Essential Oils** (Limonene, Menthol) • **Carotenoids** (β-Carotene) • **Squalene**	 Menthol (Essential oil)  β-Carotene  Squalene (Olive oil)	Isoprene unit  **Monoterpene** (Limonene)  **Triterpene** (Squalene) 	• **Essential oils** – used as flavors, fragrances & antimicrobial agents • **Carotenoids** – antioxidant, used in nutraceuticals • **Squalene** – used in cosmetics, vaccine adjuvants

Figure 3: Classification of Lipids

SECONDARY METABOLITES

Alkaloids are a diverse group of naturally occurring nitrogen-containing basic organic compounds, predominantly found in plants. They are produced as secondary metabolites and possess significant physiological and pharmacological activities even in minute quantities. Most alkaloids are biosynthesized from amino acids and contain one or more nitrogen atoms, usually within a heterocyclic ring.

The term "alkaloid" was introduced by Carl Friedrich Wilhelm Meissner in 1819.

Alkaloids are naturally occurring, basic, nitrogen-containing secondary metabolites, usually of plant origin, that exhibit marked physiological activity on humans and animals.

Alkaloids occur mainly in about 20% of flowering plants and are distributed in different plant parts.

Table 5: Examples of Alkloids

Plant Part	**Examples**
Roots	*Rauwolfia serpentina*
Rhizomes	*Hydrastis canadensis*
Bark	*Cinchona officinalis*
Leaves	*Nicotiana tabacum*, *Camellia sinensis*
Seeds	*Strychnos nux-vomica*
Fruits	*Piper nigrum*
Latex	*Papaver somniferum*

General Properties

- Physical Properties
- Mostly colorless, crystalline solids.
- Generally bitter in taste.
- Usually odourless.
- Mostly non-volatile (except liquid alkaloids).
- Usually optically active.
- Possess high melting points.
- Occur as free bases or as salts of organic acids.

Table 6: Exceptions in properties of Alkaloids

Property	General Character	Exceptions
Colour	Colorless	Berberine (yellow), Sanguinarine (orange-red), Chelerythrine (yellow-orange)
Odour	Odourless	Nicotine (tobacco-like odour), Coniine (mouse-like odour), Sparteine (pyridine-like odour)
Taste	Bitter	Piperine (pungent), Nicotine (acrid, burning taste)
Physical State	Crystalline solids	Nicotine, Coniine, Sparteine are liquids

Chemical Properties

- Basic due to the presence of nitrogen.
- Form salts with mineral and organic acids.
- Free alkaloids are generally soluble in organic solvents such as chloroform, ether, benzene, and alcohol.
- Alkaloidal salts are generally soluble in water.

Classification

Chemical Classification of alkaloids- Alkaloids can be classified by following methods-

A. Based on Biosynthetic Origin

- True Alkaloids
- Protoalkaloids
- Pseudoalkaloids

B. Based on Basic Heterocyclic Moiety

- Pyridine alkaloids
- Piperidine alkaloids
- Pyrrolidine alkaloids
- Tropane alkaloids
- Quinoline alkaloids
- Isoquinoline alkaloids
- Indole alkaloids
- Imidazole alkaloids
- Purine alkaloids
- Quinolizidine alkaloids
- Steroidal alkaloids

•**True alkaloid**- The alkaloids which have all basic properties of alkaloids, derived from amino acid and contain Nitrogen in heterocyclic ring. Ex. Atropine, Morphine.

•**Proto alkaloid**- The alkaloid in which nitrogen atom is not present in the ring, but it is present outside the ring I form of amino group, so also called amino alkaloids or biological amines. Ex. Ephedrine.

•**Pseudo alkaloids**- Actually these are not alkaloids. These are not derived from amino acid and not give basic identification tests of alkaloids. These are Steroidal (Solanine), Terpenoidal (Diterpene alkaloid) and Purine alkaloid (Caffeine).

2. **Taxonomic classification**- On the basis of taxonomic profile of the drug. For ex. Solanaceous, Theaceae alkaloids
3. **Biogenetic classification**- On the basis of amino acid precursor. For ex. Phenylalanine, Tyrosine alkaloids
4. **Pharmacological classification**- On the basis of therapeutic activity of the alkaloid. For ex. Morphine as analgesic, Quinine as antimalarial, Quinidine as cardiac antidepressant.

Classification of Alkaloids

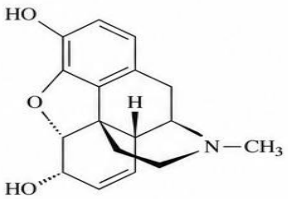
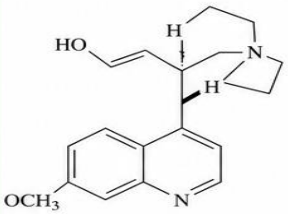
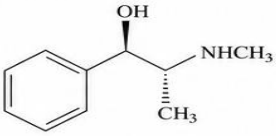
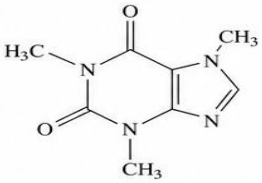
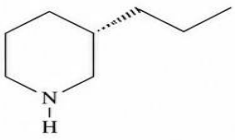
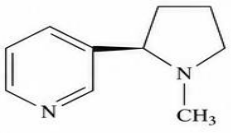
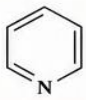
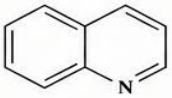
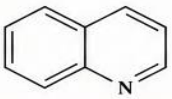
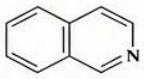
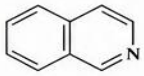
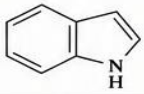
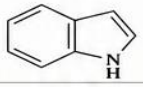
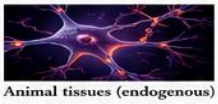
Class	Key Structural Feature	Plant (Picture)	Examples (Plant Source) with Structure	
			Example 1	Example 2
1. True Alkaloids (Contain N in heterocyclic ring)	Nitrogen is part of a heterocyclic ring system.	Opium Poppy (*Papaver somniferum*)  Cinchona (*Cinchona officinalis*) 	Morphine (*Papaver somniferum*) 	Quinine (*Cinchona officinalis*) 
2. Protoalkaloids (N not in heterocyclic ring)	Nitrogen is outside the heterocyclic ring (usually in side chain).	Ephedra (*Ephedra sinica*)  Tea Plant (*Camellia sinensis*) 	Ephedrine (*Ephedra sinica*) 	Caffeine (*Camellia sinensis*) 
3. Pseudoalkaloids (N not in heterocyclic ring; derived from amino acids)	Do not originate from amino acids; N is outside heterocyclic ring.	Poison Hemlock (*Conium maculatum*)  Tobacco Plant (*Nicotiana tabacum*) 	Coniine (*Conium maculatum*) 	Nicotine (*Nicotiana tabacum*) 

Figure 4: Classification of Alkaloids on the basis of Biosynthesis

Classification of Alkaloids

(On the Basis of Basic Moiety)

Group	Example (Plant Source)	Picture of Plant / Drug	Chemical Structure (Basic Moiety)	Use / Activity
1. Pyridine Alkaloids (Basic moiety contains pyridine ring)	• **Nicotine** **Plant Source (Drug):** Tobacco leaves (*Nicotiana tabacum*) **Phytoconstituent:** Nicotine	 Tobacco leaves	**Pyridine** 	• Stimulant • Used in smoking cessation (in controlled forms) • Insecticidal
	• **Arecoline** **Plant Source (Drug):** Areca nut (*Areca catechu*) **Phytoconstituent:** Arecoline	 Areca nut	**Pyridine** 	• Stimulant • Digestive • Anthelmintic
2. Tropane Alkaloids (Basic moiety contains tropane ring system)	• **Atropine** **Plant Source (Drug):** Belladonna leaves (*Atropa belladonna*) **Phytoconstituent:** Atrepine	 Belladonna plant	**Tropane** 	• Anticholinergic • Mydriatic • Used in ophthalmic preparations
	• **Cocaine** **Plant Source (Drug):** Coca leaves (*Erythroxylum coca*) **Phytoconstituent:** Cocaine	 Coca leaves	**Tropane** 	• Local anaesthetic • Vasoconstrictor • Used in ENT surgeries (topically)
3. Quinoline Alkaloids (Basic moiety contains quinoline nucleus)	• **Quinine** **Plant Source (Drug):** Cinchona bark (*Cinchona officinalis*) **Phytoconstituent:** Quinine	 Cinchona bark	**Quinoline** 	• Antimalarial • Antipyretic • Used in nocturnal leg cramps
	• **Cinchonine** **Plant Source (Drug):** Cinchona bark (*Cinchona officinalis*) **Phytoconstituent:** Cinchonine	 Cinchona bark	**Quinoline** 	• Antimalarial • Febrifuge • Used in treatment of malaria
4. Isoquinoline Alkaloids (Basic moiety contains isoquinoline nucleus)	• **Morphine** **Plant Source (Drug):** Opium (*Papaver somniferum*) **Phytoconstituent:** Morphine	 Opium poppy	**Isoquinoline** 	• Analgesic • Antitussive • Narcotic (pain reliever)
	• **Berberine** **Plant Source (Drug):** Indian barberry root (*Berberis aristata*) **Phytoconstituent:** Berberine	 Indian barberry	**Isoquinoline** 	• Antimicrobial • Antidiarrheal • Hypoglycemic
5. Indole Alkaloids (Basic moiety contains indole nucleus)	• **Reserpine** **Plant Source (Drug):** Rauwolfia root (*Rauwolfia serpentina*) **Phytoconstituent:** Reserpine	 Rauwolfia plant	**Indole** 	• Antihypertensive • Sedative • Tranquilizer
	• **Ergotamine** **Plant Source (Drug):** Ergot (*Claviceps purpurea*) **Phytoconstituent:** Ergotamine	 Ergot (sclerotia)	**Indole** 	• Antimigraine • Uterotonic • Used in postpartum hemorrhage
6. Imidazole Alkaloids (Basic moiety contains imidazole ring)	• **Pilocarpine** **Plant Source (Drug):** Jaborandi leaves (*Pilocarpus microphyllus*) **Phytoconstituent:** Pilocarpine	 Jaborandi leaves	**Imidazole** 	• Sialogogue (increases salivation) • Used in glaucoma
	• **Histamine** **Plant Source (Drug):** Ergot, animal tissues (*Endo*genous alkaloid) **Phytoconstituent:** Histamine	 Animal tissues (endogenous)	**Imidazole** 	• Vasodilator • Involved in allergic reactions • Increases gastric acid secretion

Note: The classification is based on the basic (heterocyclic) ring present in the alkaloid molecule.

Figure 5: Classification of Alkaloids on the Basis of basic moiety

Table 7: Chemical Identification Tests for Alkaloids

Test	Principle	Reagent Used	Positive Observation	Inference
Dragendorff's Test	Alkaloids form insoluble complexes with potassium bismuth iodide	Dragendorff's reagent	Orange or reddish-brown precipitate	Presence of alkaloids
Mayer's Test	Alkaloids react with potassium mercuric iodide	Mayer's reagent	Cream or pale yellow precipitate	Presence of alkaloids
Wagner's Test	Alkaloids form complexes with iodine-potassium iodide	Wagner's reagent	Reddish-brown or brown precipitate	Presence of alkaloids
Hager's Test	Alkaloids react with picric acid	Hager's reagent (Saturated picric acid)	Yellow crystalline precipitate	Presence of alkaloids

GLYCOSIDES

A no of medicinal plants containing organic constituents in conjugation with a sugar moiety. .It can be 1 or 2 .such compounds are called as glycosides. They exert therapeutically significant effect on human and animals. .Traditionally used in modern medicine because of their cardio tonic, purgative, analgesic, anti-arrhythmic, demulcent action.

Glycosides are defined as organic compound from plants and animal source, which on enzymatic hydrolysis gives one or more sugar moieties along with anon sugar moiety. Sugar moiety is called glycon and non-sugar moiety is called aglycon or genin.

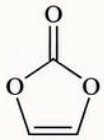
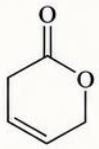
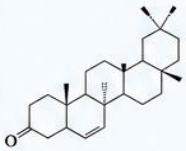
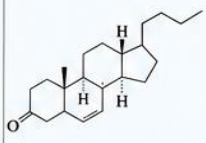
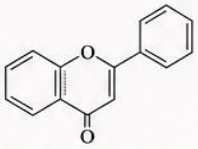
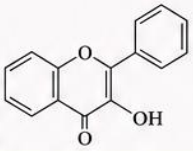
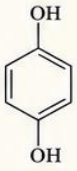
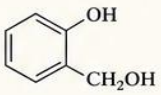
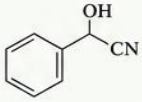
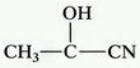
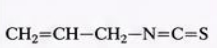
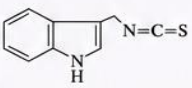
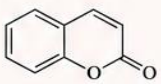
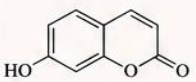
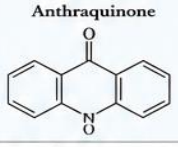
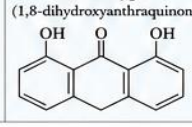
Classification:-

1. Based on the chemical nature of non sugar moiety

a. Anthraquinone glycoside : - anthraquinone moiety as aglycon . Ex: senna
b. Sterol or cardiac glycoside: - aglycon portion is steroid molecule. Ex: digitalis
c. Saponine glycoside
d. Cyanogentic glycoside Ex : white cherry bark
e. Isothiocynate glycoside Ex: black mustard.
f. Flavonoid glycoside Ex : rutra graveolens, citrus bio flavonoid
g. Coumarin glycoside or furano coumarine glycoside:- Ex : celery fruit
h. Aldehyde glycoside Ex: vanilla pods
i. Phenol glycoside Ex salcive
j. Steroidal glycoside
k. Glucosidal bitter or miscellaneous glycoside Ex salix species

Classification of Glycosides

(Based on the Chemical Nature of the Non-Sugar Moiety)

Group	Example (Plant Source)	Chemical Structure (Basic Moiety)		Use / Activity
1. Cardiac Glycosides (Steroidal nucleus) Non-sugar part is a steroidal nucleus (lactone ring at C-17)	• Digitalis leaf *(Digitalis purpurea)* • Strophanthus seed *(Strophanthus kombe)* 	**Cardenolide** 	**Bufadienolide** 	• Potent cardiotonic (increase force of heart contraction) • Used in treatment of congestive heart failure and arrhythmia
2. Saponin Glycosides (Triterpenoid or Steroidal) Non-sugar part is triterpenoid or steroidal (sapogenin)	• Liquorice root *(Glycyrrhiza glabra)* • Horse chestnut seed *(Aesculus hippocastanum)* 	**Oleanane** *(triterpenoid)* 	**Diosgenin–type** *(steroidal)* 	• Expectorant, anti-inflammatory • Immune-modulating • Hemolytic, adjuvant and cholesterol-lowering activity
3. Flavonoid Glycosides (Flavonoid nucleus) Non-sugar part is a flavonoid nucleus	• Sophora flower bud *(Sophora japonica)* • Ginkgo leaf *(Ginkgo biloba)* 	**Flavone nucleus** *(2-phenylchromen-4-one)* 	**Flavonol nucleus** *(3-hydroxyflavone)* 	• Antioxidant, anti-inflammatory • Capillary protective, hepatoprotective • Used in circulatory and venous disorders
4. Phenolic (Simple Phenol) Glycosides Non-sugar part is a simple phenolic compound other than flavonoids	• Arbutus leaf *(Arctostaphylos uva-ursi)* • Willow bark *(Salix alba)* 	**Hydroquinone** 	**Salicylic alcohol** *(o-hydroxybenzyl alcohol)* 	• Antimicrobial, antiseptic • Analgesic, antipyretic • Used in urinary antiseptics and anti-inflammatory preparations
5. Cyanogenic Glycosides (Cyanohydrins) Non-sugar part is a cyanohydrin (contains –C≡N group)	• Bitter almond *(Prunus amygdalus)* • Cassava root *(Manihot esculenta)* 	**Mandelonitrile** *(benzaldehyde cyanohydrin)* 	**Linamarin type** *(acetone cyanohydrin)* 	• Release HCN on hydrolysis • Act as plant defense compounds • Used in flavoring (bitter almond) in controlled amounts
6. Thioglucosides (Sulfur-containing) Non-sugar part contains sulfur (S) atom	• Black mustard seed *(Brassica nigra)* • Horseradish root *(Armoracia rusticana)* 	**Allyl isothiocyanate** (–N=C=S) 	**Indole isothiocyanate** (–N=C=S) 	• Antimicrobial, antifungal • Carminative, flavor and aroma • Used in condiments and medicinal preparations
7. Coumarin Glycosides (Coumarin nucleus) Non-sugar part is a coumarin nucleus	• Indian gooseberry *(Emblica officinalis)* • Sweet clover *(Melilotus officinalis)* 	**Coumarin** *(2H-1-benzopyran-2-one)* 	**Umbelliferone** *(7-hydroxycoumarin)* 	• Anticoagulant, antispasmodic • Vasodilator, anti-inflammatory • Used in circulatory disorders and as anticoagulant
8. Anthraquinone Glycosides (Anthraquinone nucleus) Non-sugar part is an anthraquinone nucleus	• Senna leaf *(Senna alexandrina)* • Aloe latex *(Aloe vera)* 	**Anthraquinone** 	**Aloin-type** (1,8-dihydroxyanthraquinone) 	• Laxative, purgative • Used in constipation and bowel cleansing preparations

Note: Glycosides are classified according to the chemical nature of the non-sugar part (aglycone or genin).

Figure 6: Classification of Glycosides on the basis of basic moiety

2. Based on the nature of sugar moity

a. Glucoside: sugar portion is glucose
b. Rhamnoside: sugar portion is rhamnose
c. Pentoside: sugar portion is pentose
d. Fructoside: sugar portion is fructose
e. Arabinoside: sugar portion is arabinose

3. Based on linkage between glycon and aglycon portion

OH groups reacting with any of the following medicates like, OH, CN, SH, NH product in aglycon part

a. C-glycoside:-

   Glycon-OH + HC –aglycon --> glycone-c-aglycon +H2O

   Some of the anthraquinone glycoside like cascaroside in cascara, aloin in aloes shows the particular linkage. C-glycosides are called aloin type glycoside present in aloes. They do not hydrolyzed by heating with dil acid or alkalis but by oxidative hydrolysis with Fecl3. cochical contains c-glycoside in the form of coloring matter called carminoic acid.

b. O-glycoside

   They are common in higher in plants Ex senna, rhubarb

   They are hydrolyzed by treatment wit acid or alkali into glycon and aglycon portion.

c. S-glycoside

   They occurrence of this glycoside is restricted to isothiacyanate glycoside like sinigirin in black mustard formed by the condensation of sulphohydryl group aglycon to OH group of glycon.

d. N-glycoside

   They most typical representation of this is nucleoside where the amino group reacts with OH group of ribose or deoxyribose resulting into N-glycoside

4. Based on therapeutic nature of glycoside:-

a. Cardiac glycoside Ex : Digitalis
b. laxative glycoside Ex : Senna

c. Anti-ulcer glycoside Ex : Liquorice
d. Bitter glycoside Ex : quassia wood

General Characteristics

- Glycoside contains sugar but still the physical, chemical and therapeutic activity is based on aglycon portion. Sugar facilitates the absorption of the glycoside .helping it to reach the site of action
- Glycoside are crystalline, amorphous substance which are soluble in water, and dilute alcohol but in soluble in the CHCl3 and ether. The aglycon moiety is insoluble in non polar solvent like C6H6
- Glycosides are easily hydrolyzed by mineral acids, water and enzyme. They show optical activity normally they are levorotatory
- Glycoside can not reduce fehling‘s solution until they are hydrolyzed
- They are believed to facilitates growth and protection of plant

Isolation of Glycoside

The method by which glycoside are isolated is called stas-otto method. The drug containing glycoside is finely powdered and subjected to successive extraction in a soxhlet apparatus with alcohol or suitable solvent.

During this method at first take drug containing glycoside, finely powdered that, and it is extracted with alcohol or water by using soxhlet apparatus. After extraction, collect the extract and treat with lead acetate to precipitate tannins after that filter it and to the filtrate pass H2S gas, no lead acetate the precipitate as lead sulphide as this is toxic. Now after the extract again filter. The filtrate is subjected to fractional crystallization, distillation or chromatography gives pure component and the extract molecular structure is determined by the spectrophotometer, Ultra Red assays, Infra-red , NMR and mass spectroscopy etc.

CARDIAC GLYCOSIDES

Cardiac glycosides are a group of naturally occurring **secondary metabolites** belonging to the class of **glycosides**. They consist of a **steroid (aglycone/genin) nucleus** attached to one or more sugar molecules (**glycone**) through a glycosidic bond. Cardiac glycosides are primarily obtained from plants and possess a **specific and powerful action on the heart**, making them valuable in the treatment of certain cardiovascular disorders.

These compounds increase the force of cardiac muscle contraction (**positive inotropic effect**) while reducing heart rate (**negative chronotropic effect**) and slowing atrioventricular (AV) conduction (**negative dromotropic effect**). Their pharmacological activity is mainly due to inhibition of the **Na^+/K^+-ATPase enzyme**, resulting in increased intracellular calcium levels and enhanced cardiac contractility.

A cardiac glycoside consists of two parts:

- **Aglycone (Genin):** Steroidal nucleus with an unsaturated lactone ring responsible for pharmacological activity.
- **Glycone (Sugar):** One or more sugar molecules attached to the aglycone that influence solubility, absorption, and pharmacokinetic properties.

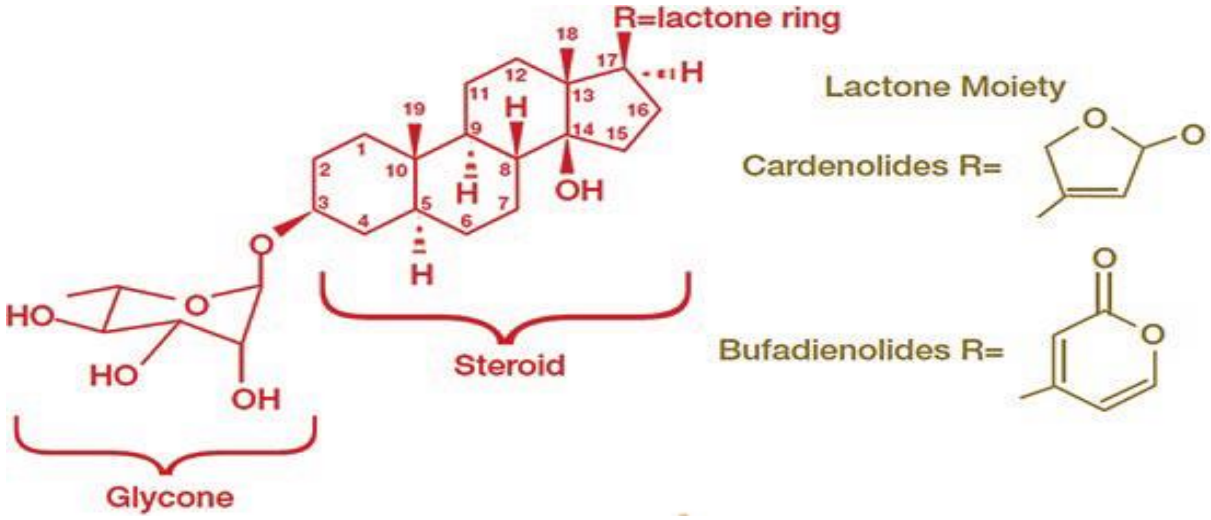


Figure 7: Basic moiety of Cardiac Glycosides

Classification of Cardiac Glycosides

Based on the structure of the lactone ring, cardiac glycosides are classified into two groups:

1. Cardenolides

- Possess a five-membered unsaturated lactone ring.
- Usually contain 23 carbon atoms (C_{23}).
- Mainly obtained from higher plants.

Examples: Digoxin, Digitoxin, Ouabain, Gitoxin

2. Bufadienolides

- Possess a six-membered doubly unsaturated lactone ring.
- Usually contain 24 carbon atoms (C_{24}).
- Found mainly in certain plants and toad venom.

Examples: Proscillaridin A, Bufalin, Scillaren A

Pharmacological Activities

- Positive inotropic effect (increases force of cardiac contraction)
- Negative chronotropic effect (reduces heart rate)
- Negative dromotropic effect (slows AV conduction)
- Improves cardiac output
- Reduces venous congestion
- Increases renal blood flow and urine output
- Helps control certain cardiac arrhythmias

Therapeutic Uses

- Congestive heart failure (CHF)
- Atrial fibrillation
- Atrial flutter
- Supraventricular tachycardia
- Improvement of cardiac efficiency in weakened heart muscles

Table 8: Cardiac glycosides and there uses

Cardiac Glycoside	Source Plant	Clinical Use
Digoxin	*Digitalis lanata*	Congestive heart failure, atrial fibrillation
Digitoxin	*Digitalis purpurea*	Congestive heart failure
Ouabain	*Strophanthus gratus*	Cardiotonic (limited clinical use)
Oleandrin	*Nerium oleander*	Mainly toxic; limited research use
Proscillaridin A	*Drimia maritima*	Cardiotonic

ANTHRAQUINONE GLYCOSIDES

Anthraquinone glycosides are a class of glycosides in which the aglycone (non-sugar part) is an anthraquinone or its reduced derivatives (anthranol or anthrone). They are widely distributed in medicinal plants and are mainly used as stimulant laxatives (purgatives).

Sugar (glycone) — O/C — Anthraquinone nucleus (aglycone)

The basic anthraquinone nucleus is **9,10-anthraquinone**.

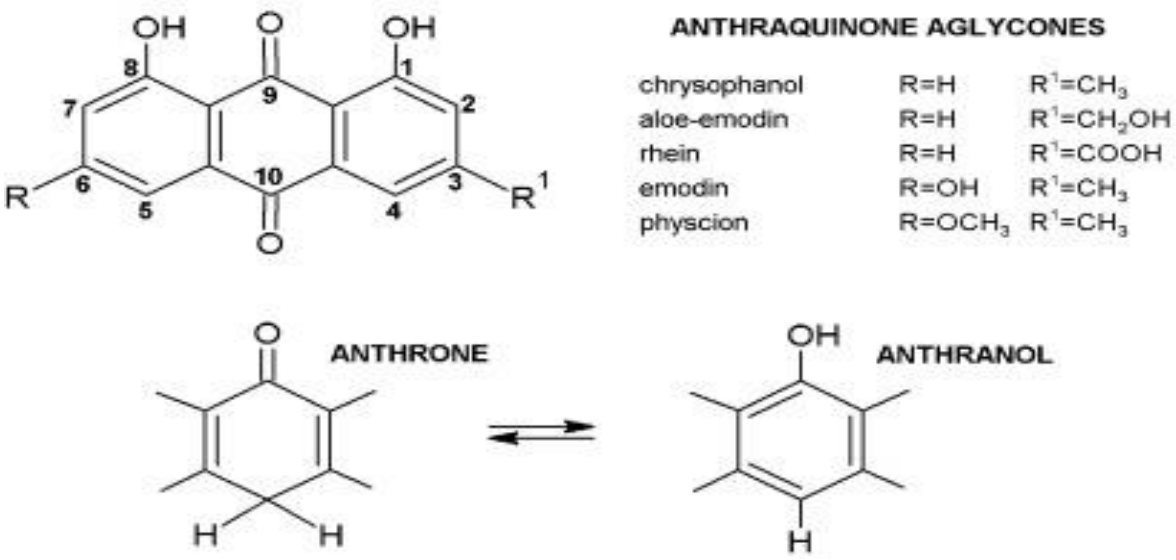


Figure 8: Basic moiety of Anthraquinone glycosides

Table 9: Classification of Anthraquinones

Type	Description	Examples
O-Glycosides	Sugar attached through an oxygen atom	Aloe-emodin glycoside, Frangulin
C-Glycosides	Sugar attached directly through a carbon-carbon bond; more resistant to hydrolysis	Aloin (Barbaloin), Cascarosides

Table 10: Important Plant Sources of Anthraquinones

Crude Drug	Botanical Source	Major Anthraquinone Glycosides
Senna	*Senna alexandrina (formerly Cassia angustifolia)*	Sennosides A & B
Aloe	*Aloe barbadensis*	Aloin (Barbaloin)
Cascara	*Rhamnus purshiana*	Cascarosides
Rhubarb	*Rheum palmatum*	Rhein, Emodin glycosides
Buckthorn	*Rhamnus frangula*	Frangulins

Pharmaceutical Uses

- Stimulant laxative
- Purgative
- Treatment of constipation
- Used for bowel evacuation before surgery or diagnostic procedures (under medical supervision)

Mechanism of Action

- Stimulate peristaltic movement of the colon.
- Increase water and electrolyte secretion into the intestinal lumen.
- Reduce water absorption from the colon.
- Produce a laxative effect within 6–12 hours.

SAPONIN GLYCOSIDES

Saponin glycosides are glycosides in which the aglycone (sapogenin) is either a triterpenoid or steroidal nucleus. They produce a stable, persistent foam when shaken with water due to their surfactant properties.

Table 11: Classification of saponin glycosides

Type	Aglycone (Basic Moiety)	Examples
Steroidal saponins	Steroid nucleus (C27)	Dioscin, Digitonin
Triterpenoid saponins	Pentacyclic triterpene (C30)	Glycyrrhizin, Asiaticoside, Escin

Pharmaceutical Uses / Activities

- Steroidal saponins are precursors for the synthesis of corticosteroids and sex hormones
- Expectorant
- Anti-inflammatory
- Adaptogenic (Ginseng)
- Immunomodulatory
- Hepatoprotective
- Natural emulsifying and foaming agent

Mechanism of Action

- Lower surface tension and produce foam.
- Increase bronchial secretion (expectorant action).
- Enhance membrane permeability.
- Exhibit immunostimulatory and anti-inflammatory activities.

Table 12: Important Examples

Saponin	Plant Source	Activity
Glycyrrhizin	*Glycyrrhiza glabra*	Expectorant, anti-inflammatory
Dioscin	*Dioscorea deltoidea*	Steroid precursor
Ginsenosides	*Panax ginseng*	Adaptogen, immunomodulator
Asiaticoside	*Centella asiatica*	Wound healing
Escin	*Aesculus hippocastanum*	Anti-inflammatory, venotonic
Shatavarins	*Asparagus racemosus*	Galactagogue, adaptogenic

Table 13: Chemical Identification Tests for Glycosides

Test	Principle	Reagent Used	Positive Observation	Inference
Borntrager's Test	Anthraquinone glycosides release anthraquinones, which react with alkali	Benzene/Chloroform + Ammonia solution	Pink to cherry-red colour in ammoniacal layer	Presence of anthraquinone glycosides
Modified Borntrager's Test	Detects C-glycosides after hydrolysis with ferric chloride and HCl	$FeCl_3$ + HCl + Benzene + Ammonia	Pink or red colour	Presence of C-anthraquinone glycosides
Keller–Killiani Test	Deoxysugars of cardiac glycosides react with ferric ions and sulfuric acid	Glacial acetic acid + $FeCl_3$ + Conc. H_2SO_4	Brown ring at the junction with bluish-green upper layer	Presence of cardiac glycosides
Legal's Test	Unsaturated lactone ring of cardiac glycosides reacts with sodium nitroprusside	Sodium nitroprusside + Pyridine + NaOH	Pink to blood-red colour	Presence of cardiac glycosides
Baljet Test	Cardiac glycosides react with alkaline picrate	Sodium picrate (Baljet reagent)	Orange to orange-red colour	Presence of cardiac glycosides
Kedde Test	Unsaturated lactone ring reacts with 3,5-dinitrobenzoic acid in alkaline medium	Kedde reagent	Purple or violet colour	Presence of cardiac glycosides
Foam Test	Saponin glycosides reduce surface tension, producing stable foam	Distilled water	Persistent honeycomb-like froth for 10–15 minutes	Presence of saponin glycosides
Sodium Picrate Test	Cyanogenic glycosides liberate hydrogen cyanide on hydrolysis	Sodium picrate paper	Brick-red colour on picrate paper	Presence of cyanogenic glycosides

FLAVONOIDS

Flavonoids are the most abundant polyphenols in human diet, representing about 2/3 of all those ones ingested. Like other phytochemicals, they are the products of secondary metabolism

of plants and, currently, it is not possible to determine precisely their number, even if over 4000 have been identified. In fruits and vegetables, they are usually found in the form of glycosides and sometimes as acylglycosides, while acylated, methylated and sulfate molecules are less frequent and in lower concentrations. They are water-soluble and accumulate in cell vacuoles.

Chemical structure of flavonoids

Their basic structure is a skeleton of ***diphenylpropane***, namely, two benzene rings (ring A and B, see figure) linked by a three carbon chain that forms a closed pyran ring (heterocyclic ring containing oxygen, the C ring) with benzenic A ring. Therefore, their structure is also referred to as C6-C3-C6.

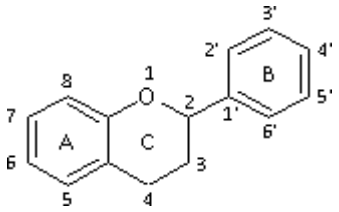


Figure 9: Skeleton of Diphenylpropane

In most cases, B ring is attached to position 2 of C ring, but it can also bind in position 3 or 4; this, together with the structural features of the ring B and the patterns of glycosylation and hydroxylation

of the three rings, makes the flavonoids one of the larger and more diversified groups of phytochemicals, so not only of polyphenols, in nature. Their biological activities, for example they are potent antioxidants, depend both on the structural characteristics and the pattern of glycosylation.

Classification

They can be subdivided into different subgroups depending on the carbon of the C ring on which B ring is attached, and the degree of unsaturation and oxidation of the C ring. Flavonoids in which B ring is linked in position 3 of the ring C are called isoflavones; those in which B ring is linked in position 4, neoflavonoids, while those in which the B ring is linked in position 2 can be further subdivided into several subgroups on the basis of the structural features of the C ring. These subgroups are: flavones, flavonols, flavanones, flavanonols, flavanols or catechins and anthocyanins. Finally, flavonoids with open C ring are called chalcones.

Classification of Flavonoids

Group (Type)	Example (Plant Source)	Chemical Structure (Basic Moiety)	Use / Activity
1. Flavonols (Contain 3-hydroxy flavone nucleus)	• **Ginkgo leaf** (*Ginkgo biloba*) – Phytoconstituents: Quercetin, Kaempferol • **Onion skin** (*Allium cepa*) – Phytoconstituents: Quercetin, Kaempferol	**Quercetin** (*Flavonol nucleus*) **Kaempferol** (*Flavonol nucleus*)	• Potent antioxidant and free radical scavenger • Anti-inflammatory • Cardioprotective • Used in management of chronic diseases (diabetes, CVD)
2. Flavones (Contain 2-phenyl-chromen-4-one nucleus)	• **Chamomile flower** (*Matricaria chamomilla*) – Phytoconstituents: Apigenin, Luteolin • **Parsley leaf** (*Petroselinum crispum*) – Phytoconstituents: Apigenin, Luteolin	**Apigenin** (*Flavone nucleus*) **Luteolin** (*Flavone nucleus*)	• Anti-inflammatory, anticancer • Hepatoprotective • Anxiolytic and neuroprotective • Used in skin health and wound healing
3. Flavanones (Contain dihydroflavone nucleus)	• **Citrus peel** (*Citrus limon*) – Phytoconstituents: Hesperetin, Naringenin • **Bitter orange** (*Citrus aurantium*) – Phytoconstituents: Naringenin, Hesperetin	**Naringenin** (*Flavanone nucleus*) **Hesperetin** (*Flavanone nucleus*)	• Antioxidant • Antidiabetic • Cardioprotective • Used in nutraceuticals and functional foods
4. Flavanonols (Dihydroflavonols) (Contain 3-hydroxy dihydroflavone nucleus)	• **Milk thistle** (*Silybum marianum*) – Phytoconstituents: Taxifolin, Silybin • **Green tea** (*Camellia sinensis*) – Phytoconstituents: Catechin, Epicatechin	**Taxifolin** (*Dihydroflavonol nucleus*) **Catechin** (*Dihydroflavonol nucleus*)	• Strong antioxidant • Protects liver • Anti-inflammatory • Used in prevention of oxidative stress related disorders
5. Anthocyanidins (Contain flavylium cation nucleus)	• **Black grape** (*Vitis vinifera*) – Phytoconstituents: Cyanidin, Delphinidin • **Hibiscus flower** (*Hibiscus sabdariffa*) – Phytoconstituents: Cyanidin, Pelargonidin	**Cyanidin** (*Anthocyanidin nucleus*) **Delphinidin** (*Anthocyanidin nucleus*)	• Antioxidant • Anticancer • Improves vascular health • Used as natural colorants in foods and beverages
6. Isoflavones (Contain 3-phenyl-chromen-4-one nucleus)	• **Soybean** (*Glycine max*) – Phytoconstituents: Genistein, Daidzein • **Red clover** (*Trifolium pratense*) – Phytoconstituents: Genistein, Biochanin A	**Genistein** (*Isoflavone nucleus*) **Daidzein** (*Isoflavone nucleus*)	• Phytoestrogenic activity • Menopausal symptom relief • Bone protective • Anti-cancer
7. Chalcones (Contain open chain flavonoid structure)	• **Licorice root** (*Glycyrrhiza glabra*) – Phytoconstituents: Isoliquiritigenin, Licochalcone A • **Angelica root** (*Angelica dahurica*) – Phytoconstituents: Xanthohumol, Chalconaringenin	**Isoliquiritigenin** (*Chalcone nucleus*) **Licochalcone A** (*Chalcone nucleus*)	• Anti-inflammatory • Antimicrobial • Anticancer • Used in cosmetics and pharmaceuticals

Note: Classification is based on the chemical nature of the basic flavonoid skeleton (non-sugar moiety).

Figure 10: Classification of Flavonoids

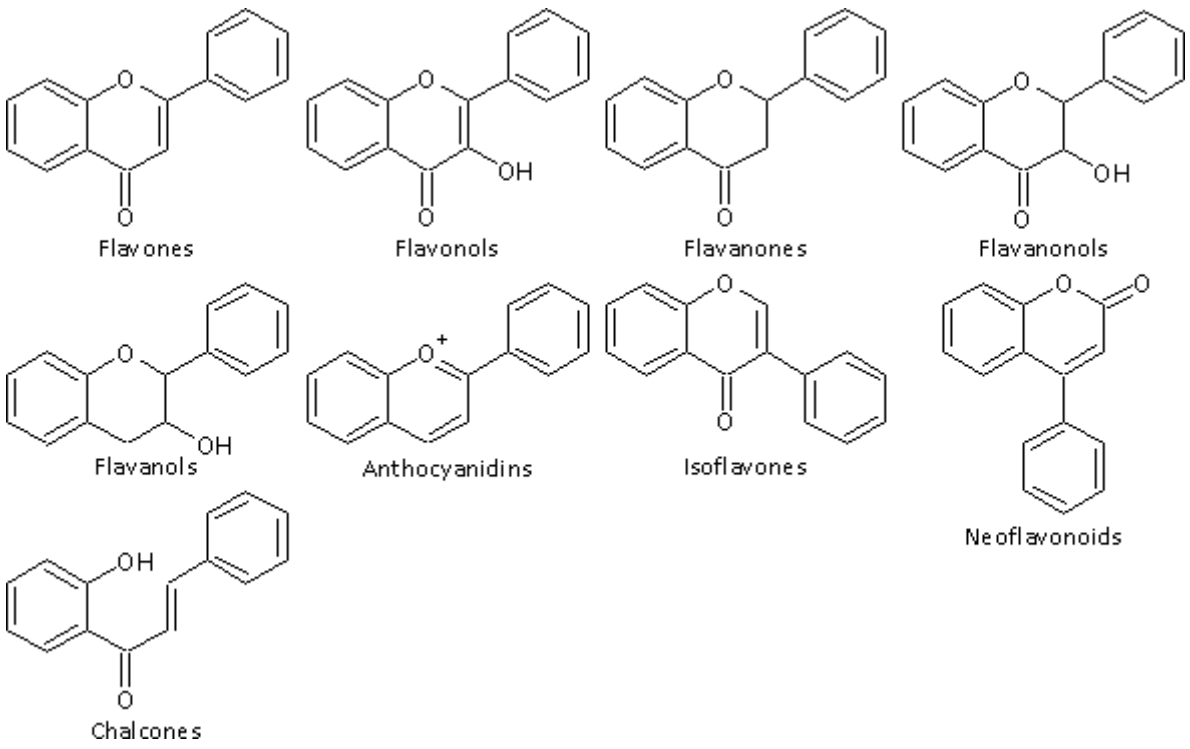


Figure 11 – Flavonoid Subgroups

Flavones

They have a double bond between positions 2 and 3 and a ketone in position 4 of the C ring. Most flavones of vegetables and fruits has a hydroxyl group in position 5 of the A ring, while the hydroxylation in other positions, for the most part in position 7 of the A ring or 3′ and 4′ of the B ring may vary according to the taxonomic classification of the particular vegetable or fruit.

Glycosylation occurs primarily on position 5 and 7, methylation and acylation on the hydroxyl groups of the B ring. Some flavones, such as nobiletin and tangeretin, are polymethoxylated.

Flavonols

Compared to flavones, they have a hydroxyl group in position 3 of the C ring, which may also be glycosylated. Again, like flavones, flavonols are very diverse in methylation and hydroxylation patterns as well, and, considering the different glycosylation patterns, they are perhaps the most common and largest subgroup of flavonoids in fruits and vegetables. For example, quercetin is present in many plant foods.

Flavanones

Flavanones, also called dihydroflavones, have the C ring saturated; therefore, unlike flavones, the double bond between positions 2 and 3 is saturated and this is the only structural difference between the two subgroups of flavonoids.

The flavanones can be multi-hydroxylated, and several hydroxyl groups can be glycosylated and/or methylated. Some have unique patterns of substitution, for example, furanoflavanones, prenylated flavanones, pyranoflavanones or benzylated flavanones, giving a great number of substituted derivatives. Over the past 15 years, the number of flavanones discovered is significantly increased.

Flavanonols

Flavanonols, also called dihydroflavonols, are the 3-hydroxy derivatives of flavanones; they are an highly diversified and multisubstituted subgroup.

Isoflavones

As anticipated, isoflavones are a subgroup of flavonoids in which the B ring is attached to position 3 of the C ring. They have structural similarities to estrogens, such as estradiol, and for this reason they are also called phytoestrogens.

Neoflavonoids

They have the B ring attached to position 4 of the C ring.

Flavanols or flavan-3-ols or catechins

Flavanols are also referred to flavan-3-ols as the hydroxyl group is almost always bound to position 3 of C ring; they are called **catechins** as well. Flavanols to have two chiral centers in the molecule, on positions 2 and 3, then four possible diastereoisomers. Epicatechin is the isomer with the *cis* configuration and catechin is the one with the *trans* configuration. Each of these configurations has two stereoisomers, namely, (+)-epicatechin and (-)-epicatechin, (+)-catechin and (-)-catechin. (+)-Catechin and (-)-epicatechin.

Anthocyanidins

Chemically, anthocyanidins are flavylium cations and are generally present as chloride salts. They are the only group of flavonoids that gives plants colors (all other flavonoids are colorless). Anthocyanins are glycosides of anthocyanidins. Sugar units are bound mostly to position 3 of the C ring and they are often conjugated with phenolic acids, such as ferulic acid.

The color of the anthocyanins depends on the pH and also by methylation or acylation at the hydroxyl groups on the A and B rings.

Chalcones

Chalcones and dihydrochalcones are flavonoids with open structure; they are classified as flavonoids because they have similar synthetic pathways.

Table 15: Chemical Identification Tests for Flavonoids

Test	Principle	Reagent Used	Positive Observation	Inference
Shinoda Test	Flavonoids are reduced by magnesium in acidic medium to form coloured compounds	Magnesium turnings + Conc. HCl	Pink, crimson, or red colour	Presence of flavonoids
Alkaline Reagent Test	Flavonoids form coloured salts in alkaline medium	10% NaOH solution	Intense yellow colour that disappears on adding dilute HCl	Presence of flavonoids
Ferric Chloride Test	Phenolic hydroxyl groups of flavonoids react with ferric ions	5% Ferric chloride solution	Green, blue, or black colour	Presence of phenolic flavonoids
Lead Acetate Test	Flavonoids form insoluble complexes with lead ions	10% Lead acetate solution	Yellow precipitate	Presence of flavonoids
Zinc-HCl Reduction Test	Flavonoids are reduced in acidic medium by zinc	Zinc dust + Conc. HCl	Red or pink colour	Presence of flavonoids
Ammonia Test	Flavonoids produce fluorescence in alkaline medium	Dilute ammonia solution	Yellow fluorescence under UV light	Presence of flavonoids

VOLATILE OILS

Terpenoids

It represents hydrocarbons as well as their oxygenated derivatives and also regarded as derivatives of polymer of Isoprene (C5H8)n.

Isoprene unit-

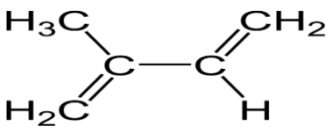


Figure 12: 2-methyl-1,3-butadiene

These units are joined by Head to tail, it is called as Isoprene rule. These are widely distributed in plant kingdom.

Occurrence- These are mainly found in essential oils which have pleasant odour and present in almost all parts of a plant.

Table 16: Classification-depending on the number of Isoprene unit-

S. No.	Name of class	Number of units	Formula	Example
1.	Hemiterpene/Isoprene	1	C5H8	Not found in nature
2.	Monoterpene	2	C10H16	Geraniol, Menthol
3.	Sesquiterpene	3	C15H24	Zingiberene
4.	Diterpene	4	C20H32	Phytol, VitaminA
5.	Sesterpenes	5	C25H40	CybastacinesA, B
6.	Triterpenes	6	C30H48	Squalene
7.	Tetraperpenes/Carotenoids	8	C40H56	Alpha and Betacarotene
8.	Polyterpene/ Rubber	n	(C5H8)n	Rubber

Volatile oils-

The odorous volatile principles of plants and animals sources are known as volatile oils. They evaporate when exposed to air at ordinary room temperature, so also called as ethereal oils. They represent essence or active constituents of plant so called as essential oils. Chemically they are derived from terpenes and their oxygenated derivatives and generally made up of mono, sesqui and diterpenes.

Properties-

a. Soluble in alcohol, ether, and lipid solvents and insoluble in water.
b. Generally lighter than water.
c. They have characteristic odour and high refractive index
d. Optically active compounds.
e. They are secreted in special structures such as ducts, cells, trichomes and Lysigenous glands.

Isolation-

- **By Hydrodistillation**- It includes water distillation, water and steam distillation & steam distillation used for extraction of volatile oil from herbal drugs. The fresh crude drug is subjected to hydrodistillation for volatile oil isolation. The apparatus used is Clevenger apparatus.

- **Enfluerage method**- It is used for extraction of delicate perfumes. For this fresh flower petals are mechanically spread on fatty material layer. It was allowed to imbibe and the exhausted petals are replaced with fresh petals. The process is continued till the fatty material layer is saturated with volatile oil which is further extracted with lipid solvents.
- **Eucelle method**- it is used for extraction of citrus oils. In this the oil cells are ruptured mechanically using pointed projections by twisting raw material over them in clockwise direction either mechanically or manually.
- **By using liquid Carbon-dioxide**- CO_2 is liquefied under pressure and it act as solvent for extraction of essential oils. It reverse back to gaseous nature when pressure is reduced and leaving no any residue of solvent.
- **Sfumatrice method**- It is a cold expression method of volatile oil isolation from Citrus fruits. The equipment consist of a metallic chain that is drawn by two horizontal ribbed rollers. The peels are passed through these rollers and pressed and bent to release their oil. This oil is then washed, separated, centrifuged and purified.
- **Cohobation method**- It is a procedure that can only be used during water distillation or Water & Steam Distillation**.** In this, the distilled water returns to the distillation flask after the oil has been separated from it, so that it can be re-boiled. The principal behind it is to minimize the loss of oxygenated compounds which dissolve in the distilled water.

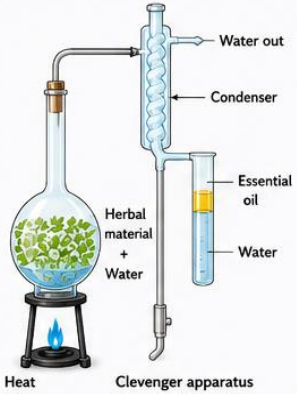
Uses-

- As flavouring and perfuming agents.
- For medicinal uses like- Carminative (Cardamom), anthelmintic (Chenopodium), Local anaesthetic (Clove), Antiseptic (Eucalyptus) etc.
- Citral is obtained from Lemon grass oil and Citral is used for synthesis of vitamin A.
- Terpeneless volatile oils are used for high priced perfumes because of their specificity and stability. These are prepared by removing hydrocarbons and undesired components by fractional distillation.

METHODS OF EXTRACTION OF VOLATILE OILS

1 BY HYDRODISTILLATION

(Water Distillation / Water & Steam Distillation / Steam Distillation)

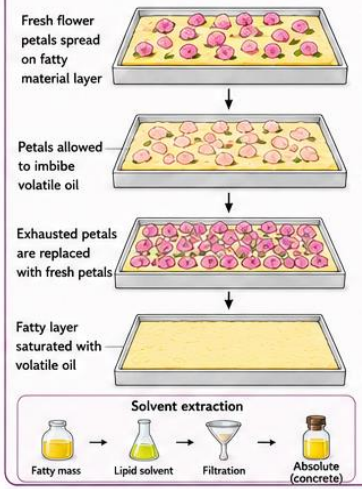


- It includes water distillation, water and steam distillation & steam distillation used for extraction of volatile oils from herbal drugs.
- The fresh crude drug is subjected to hydrodistillation for volatile oil isolation.
- The apparatus used is Clevenger apparatus.

Types

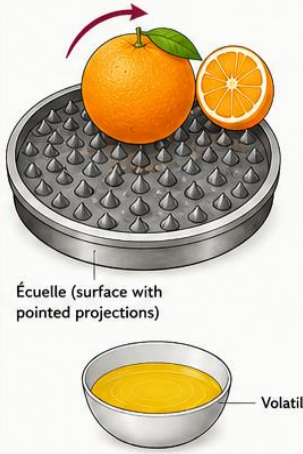
- Water distillation
- Water and steam distillation
- Steam distillation

2 ENFLEURAGE METHOD



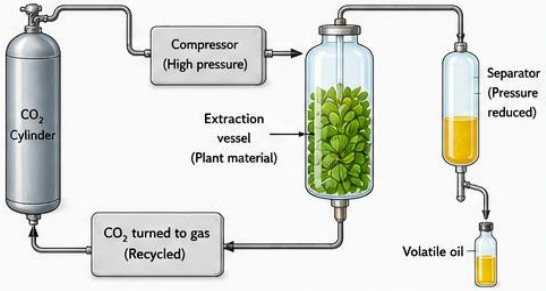
- It is used for extraction of delicate perfumes from fresh flowers.
- Fresh flower petals are mechanically spread over a layer of purified fat.
- The fat absorbs the volatile oil.
- The exhausted petals are replaced with fresh petals.
- The process is continued till the fatty layer is saturated with volatile oil.
- The volatile oil is then extracted with suitable lipid (organic) solvents.

3 ÉCUELLE METHOD



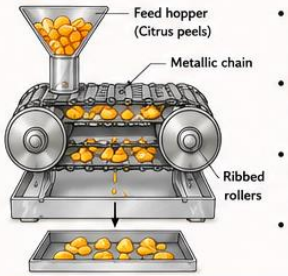
- It is used for extraction of citrus oils.
- In this method, the oil glands present in the peel are mechanically ruptured using pointed projections.
- The raw material (citrus fruit) is twisted over the projections in clockwise direction either manually or mechanically.
- The volatile oil is released from the oil glands.

4 BY USING LIQUID CARBON DIOXIDE (CO_2)



- Carbon dioxide (CO_2) is liquefied under high pressure and acts as a solvent for extraction of essential oils.
- When the pressure is reduced, CO_2 returns to its gaseous state leaving no solvent residue in the extract.

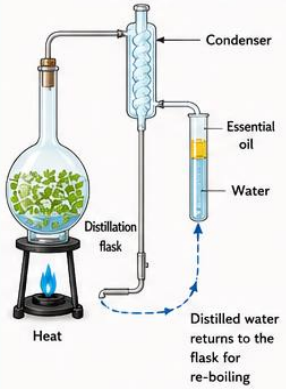
5 SFUMATRICE METHOD



- It is a cold expression method used for extraction of volatile oils from Citrus fruits.
- The equipment consists of a metallic chain drawn by two horizontal ribbed rollers.
- The peels are passed through these rollers and pressed and bent to release their oil.
- The oil is then washed, separated, centrifuged and purified.

6 COHOBATION METHOD

(Used in Water Distillation or Water & Steam Distillation)



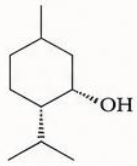
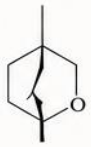
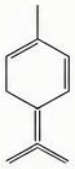
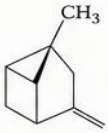
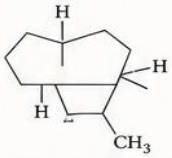
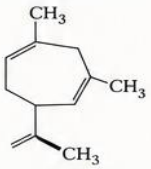
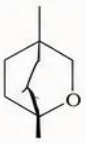
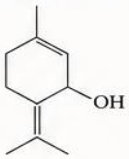
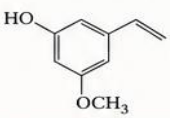
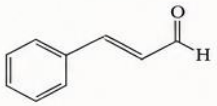
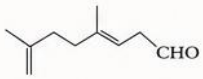
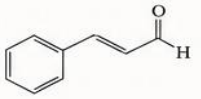
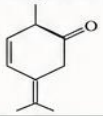
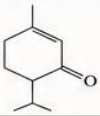
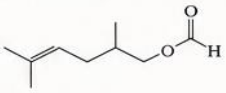
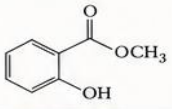
- After separation of volatile oil, the distilled water is returned to the distillation flask and re-boiled.
- The principle behind cohobation is to minimize the loss of oxygenated compounds which dissolve in the distilled water.
- This improves the yield and quality of volatile oil components.

These methods are used for the isolation of volatile oils (essential oils) from herbal drugs, flowers, fruits and other plant materials. The choice of method depends on nature of the drug, stability of oil and its intended use.

Herbal Drugs | Flowers | Citrus Fruits | Volatile Oil

Figure 13: Methods of Extraction of Volatile oils

Classification of Volatile Oils

Group (Type)	Example (Plant Source)	Chemical Structure (Major Constituents)	Use / Activity
1. Terpenoid Oils (Contain terpenes or their oxygenated derivatives)	• **Peppermint** *(Mentha piperita)*  • **Eucalyptus** *(Eucalyptus globulus)* 	**Menthol** *(Monoterpene alcohol)*  **1,8-Cineole** *(Monoterpene ether)* 	• Carminative, stomachic • Antimicrobial • Expectorant, decongestant • Used in inhalants, toothpaste, flavouring agents
2. Monoterpene Hydrocarbon Oils (Contain monoterpene hydrocarbons)	• **Lemon** *(Citrus limon)*  • **Turpentine** *(Pinus roxburghii)* 	**Limonene** *(Monoterpene hydrocarbon)*  **α-Pinene** *(Monoterpene hydrocarbon)* 	• Carminative • Antiseptic • Used in perfumery, flavouring • Solvent and paint industry
3. Sesquiterpene Hydrocarbon Oils (Contain sesquiterpene hydrocarbons)	• **Sandalwood** *(Santalum album)*  • **Cedrus** *(Cedrus deodara)* 	**β-Caryophyllene** *(Sesquiterpene hydrocarbon)*  **α-Humulene** *(Sesquiterpene hydrocarbon)* 	• Anti-inflammatory • Antiseptic • Sedative • Used in perfumes and incense
4. Oxygenated Terpenoid Oils (Contain oxygenated terpenes)	• **Rosemary** *(Rosmarinus officinalis)*  • **Tea tree** *(Melaleuca alternifolia)* 	**1,8-Cineole** *(Monoterpene ether)*  **Terpinen-4-ol** *(Monoterpene alcohol)* 	• Antimicrobial • Expectorant • Antioxidant • Used in aromatherapy and pharmaceutical preparations
5. Phenylpropanoid Oils (Contain derivatives of phenylpropanoid pathway)	• **Clove** *(Syzygium aromaticum)*  • **Basil** *(Ocimum basilicum)* 	**Eugenol** *(Phenylpropanoid)*  **Cinnamaldehyde** *(Phenylpropanoid)* 	• Antiseptic • Analgesic • Antimicrobial • Used in dental preparations, perfumes, flavouring agents
6. Aldehydic Oils (Contain aldehydes as major constituents)	• **Lemongrass** *(Cymbopogon flexuosus)*  • **Cinnamon bark** *(Cinnamomum verum)* 	**Citral** *(Monoterpene aldehyde)*  **Cinnamaldehyde** *(Aromatic aldehyde)* 	• Antimicrobial • Antispasmodic • Insect repellent • Used in flavouring, cosmetics and soaps
7. Ketonic Oils (Contain ketones as major constituents)	• **Spearmint** *(Mentha spicata)*  • **Caraway** *(Carum carvi)* 	**Carvone** *(Monoterpene ketone)*  **Pulegone** *(Monoterpene ketone)* 	• Carminative • Digestive • Antimicrobial • Used in flavouring and perfumery
8. Ester Oils (Contain esters as major constituents)	• **Lavender** *(Lavandula angustifolia)*  • **Wintergreen** *(Gaultheria procumbens)* 	**Linalyl acetate** *(Monoterpene ester)*  **Methyl salicylate** *(Phenylpropanoid ester)* 	• Sedative • Analgesic • Antispasmodic • Used in perfumery, flavouring and medicinal liniments

Note: Volatile oils are complex mixtures. The structures shown represent the major or characteristic constituents (basic moieties).

Figure 14: Classification of Volatile oils on the basis of basic moiety

Table 17: Chemical Identification Tests for Volatile (Essential) Oils

Test	Principle	Reagent Used	Positive Observation	Inference
Filter Paper (Spot) Test	Volatile oils evaporate completely without leaving a permanent greasy stain	Filter paper	Temporary translucent spot disappears on drying	Presence of volatile oils
Sudan III Test	Volatile oils dissolve in fat-soluble dyes	Sudan III reagent	Orange-red or red coloration	Presence of volatile oils
Vanillin–Sulfuric Acid Test	Terpenoid constituents of volatile oils react with vanillin in acidic medium	Vanillin–H_2SO_4 reagent	Pink, red, violet, or blue colour	Presence of volatile oils
Salkowski Test	Terpenoid components react with concentrated sulfuric acid	Chloroform + Conc. H_2SO_4	Reddish-brown colour at the interface	Presence of terpenoid-containing volatile oils
Liebermann–Burchard Test	Unsaturated terpenoids react with acetic anhydride and sulfuric acid	Acetic anhydride + Conc. H_2SO_4	Blue-green or green colour	Presence of terpenoid constituents

TANNINS

These are complex organic, non-nitrogenous phenolic compounds of high molecular weight and posses the property to tan i. e. convert hide and skin into leather. The term tannin was first applied by Seguin in 1796. These are detected qualitatively by a tanning test (the gold beater‘s skin test) in determined quantitatively by its absorption on standard hide powder.

These are widely distributed in plant kingdom, in almost every plant family. When tannins occur in appreciable quantity, they are usually localized in specific plant parts such as leaves, fruits, barks and stems. Although often found in immature fruits, tannins usually disappear during the ripening process. In plant metabolism, tannins probably serve as protective during certain stages of growth and finally they are destroyed or deposited as end products of metabolism in certain dead tissues to the mature plant (outer bark, hard wood).

Chemically tannins contain the mixture of complex organic substances in which polyphenols are present, generally with ortho dihydroxy or ortho trihydroxy groups on a phenyl ring.

Properties-

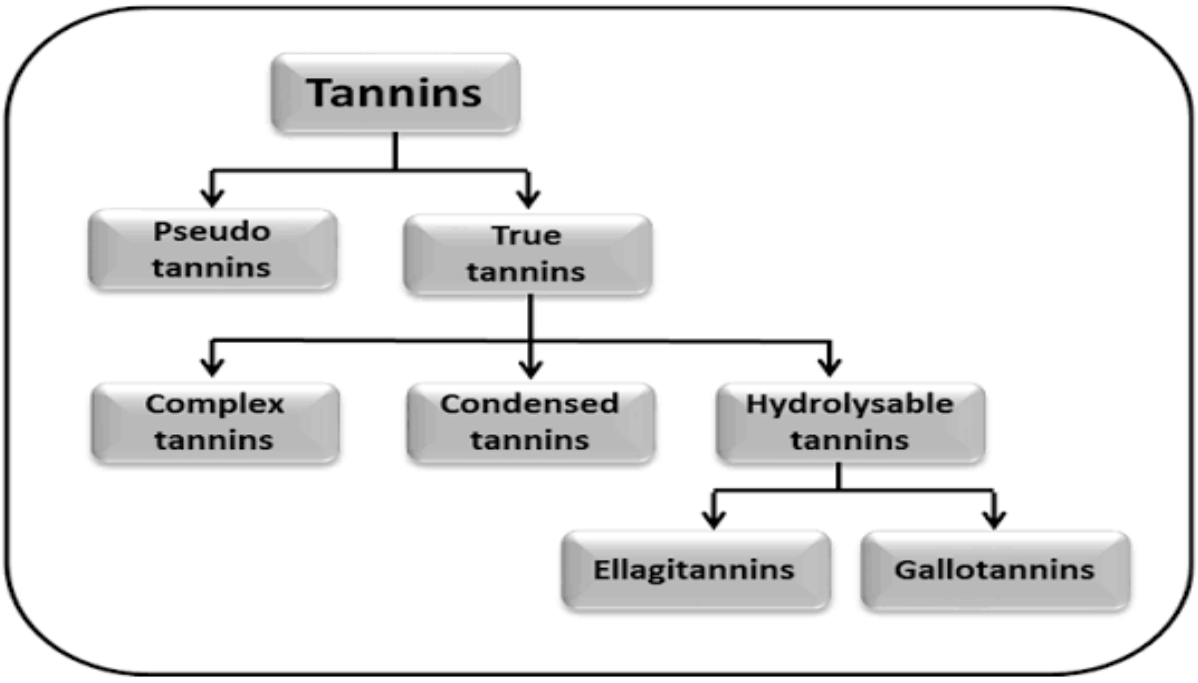
- They are amorphous in nature and form colloidal solution with water and re noncrystalline.
- These are mixture of complex organic substances in which polyphenols are present, generally with ortho dihydroxy or ortho trihydroxy groups on a phenyl ring.
- High molecular weight and not contain nitrogen atom.

- Show acidic reaction due to phenol in soluble form.
- Soluble in alcohol, glycerine and dil alkali but practically insoluble in organic solvents except acetone, sparingly soluble in chloroform and ethyl acetate. Phlobaphenes are soluble in alcohol but practically insoluble in water.
- They precipitate proteins from solution and are able to combine with them rendering them resistant to proteolytic enzymes. This property is known as astringent action and many tannins containing drugs are used as astringent medicinally.
- Have sharp puckering (Astringent/ acidic) taste.

Extraction and isolation-

Hydrolysable tannins- Plant twigs are extracted with a mixture of ether and alcohol (4:1). To the extract water is added. Alcoholic aq extract separated from ether layer. Ether layer on evaporation gives gallic acid and aq alcoholic layer on evaporation gives tannic acid. Both are isolated by fractional distillation or chromatography.

Condensed tannins- Leaves and twigs are put into a large pan with full of boiling water. Boiled for 3 hours and stirred well. Then leaves and twigs are separated from extract by decantation. Marc is pressed and the expressed extract is combined with above decanted extract. It was evaporated till it become thick mass, then cool with stirring. Semisolid mass produced which is further purified by fractional distillation or chromatography.



Classification of Tannins

(Based on the Chemical Nature of Tannins)

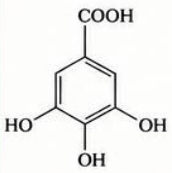
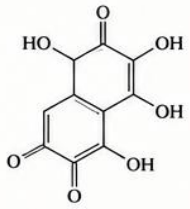
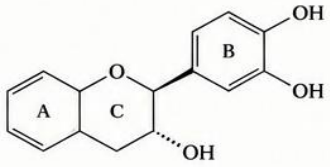
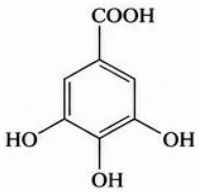
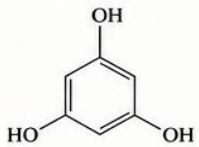
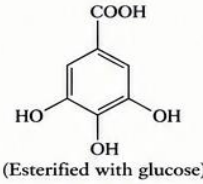
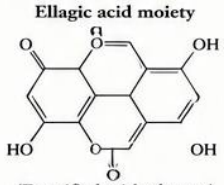
Group (Type)	Example (Plant Source)	Picture of Plant / Drug	Chemical Structure (Basic Moiety)	Use / Activity
1. Hydrolysable Tannins (On hydrolysis yield gallic acid or ellagic acid and a sugar)	• **Galls of Oak** (*Quercus infectoria*) – Phytoconstituents: Tannic acid, Gallic acid • **Harad** (*Terminalia chebula*) – Phytoconstituents: Chebulagic acid, Chebulinic acid	 Oak galls  Harad (fruits)	Gallic acid moiety  Ellagic acid moiety 	• Astringent • Antidiarrheal • Antimicrobial • Wound healing • Used in leather tanning and ink manufacture
2. Condensed Tannins (Non-hydrolysable; polymers of flavan-3-ol units)	• **Catechu** (*Acacia catechu*) – Phytoconstituents: Catechin, Epicatechin • **Tea leaves** (*Camellia sinensis*) – Phytoconstituents: Catechin, Epigallocatechin	 Catechu heartwood  Tea leaves	Flavan-3-ol (Catechin) moiety 	• Astringent • Antioxidant • Antimicrobial • Anti-inflammatory • Used in treatment of diarrhea and bleeding
3. Complex Tannins (Hydrolysable tannins linked with other compounds like alkaloids, proteins etc.)	• **Nutgalls** (*Quercus infectoria*) – Phytoconstituents: Tannic acid, Gallic acid, Methyl gallate • **Sumac leaves** (*Rhus coriaria*) – Phytoconstituents: Gallic acid, Flavonoids	 Nutgalls  Sumac leaves	Basic moiety (Gallic acid unit) 	• Astringent • Antimicrobial • Anti-inflammatory • Used in dyeing, leather industry and as mordant
4. Phlobatannins (Polymer of phloroglucinol units)	• **Myrobalan** (*Terminalia bellirica*) – Phytoconstituents: Phlobaphenes, Phloroglucinol • **Kino** (*Pterocarpus marsupium*) – Phytoconstituents: Phlobaphenes, Pterocarpans	 Myrobalan fruits  Kino heartwood	Phloroglucinol moiety 	• Astringent • Hemostatic • Antidiarrheal • Antimicrobial • Used in tanning and as styptic
5. Gallotannins (Esters of gallic acid with glucose)	• **Pomegranate rind** (*Punica granatum*) – Phytoconstituents: Punicalagin, Granatin • **Geranium leaves** (*Pelargonium graveolens*) – Phytoconstituents: Geraniin	 Pomegranate rind  Geranium leaves	Gallic acid ester moiety  (Esterified with glucose)	• Astringent • Antioxidant • Antimicrobial • Used in diarrhea, dysentery and urinary disorders
6. Ellagitannins (Esters of hexahydroxydiphenic acid (ellagic acid) with glucose)	• **Bael fruit** (*Aegle marmelos*) – Phytoconstituents: Marmelosin, Ellagic acid • **Strawberry leaves** (*Fragaria vesca*) – Phytoconstituents: Pedunculagin	 Bael fruit  Strawberry leaves	Ellagic acid moiety  (Esterified with glucose)	• Astringent • Anticancer • Antioxidant • Hepatoprotective • Used in chronic diarrhea and bleeding disorders

Figure 15 a and b : Classification of tannins

Uses-

- Used in the tanning process of animal hides to convert them into leather.
- Aqueous solution is used to precipitate gelatin, protein and alkaloids in laboratory.
- As healing agents in inflammation, leucorrhoea, gonorrhea, burns, piles and diarrhea.
- Used as antidote in treatment of alkaloid poisoning.
- These form deep red coloured complex with iron salts that is used in manufacturing of inks.
- Antiseptic effect on mucous membrane and skin due to phenolic compounds.
- As astringent

Table 18: Chemical Identification Tests for Tannins

Test	Principle	Reagent Used	Positive Observation	Inference
Ferric Chloride Test	Tannins form coloured complexes with ferric ions	5% Ferric chloride ($FeCl_3$)	Blue-black (hydrolysable tannins) or greenish-black (condensed tannins) colour	Presence of tannins
Gelatin Test	Tannins precipitate proteins	1% Gelatin solution containing NaCl	White or buff precipitate	Presence of tannins
Lead Acetate Test	Tannins form insoluble lead tannates	10% Lead acetate solution	White or yellowish precipitate	Presence of tannins
Goldbeater's Skin Test	Tannins tan animal membrane	2% HCl, Goldbeater's skin, $FeSO_4$ solution	Brown or black coloration of the membrane	Presence of true tannins
Potassium Dichromate Test	Tannins form insoluble complexes with potassium dichromate	10% Potassium dichromate solution	Yellow or brown precipitate	Presence of tannins
Vanillin-HCl Test	Condensed tannins react with vanillin in acidic medium	Vanillin-HCl reagent	Pink or red colour	Presence of condensed tannins
Matchstick Test	Catechin (condensed tannins) reacts with concentrated HCl on heating	Matchstick + Conc. HCl	Red or pink colour at the tip of the matchstick	Presence of catechin (condensed tannins)
Phenazone Test	Tannins form insoluble complexes with phenazone	Sodium acid phosphate + Phenazone solution	Bulky buff precipitate	Presence of tannins

RESINS

These are amorphous products of complex chemical nature. These are amorphous mixtures of essential oils, oxygenated products of terpenes and carboxylic acids. These are found as exudation from the trunk of various trees.

Properties

- These are transparent or translucent solids, semisolids or liquid substances containing large number of carbon atoms.
- On heating they are softened and then melted if in solid form.
- They are practically insoluble in water but dissolve in organic solvents like alcohol, ether and chloroform. Also soluble in volatile and fixed oils.
- They are hard, electrically non-conductive and combustible masses.
- They produce smoky flame on burning.
- They are usually formed in schizogenous or schizolysogenous cavities of ducts as end products of metabolism.

Classification-

a. Depending upon the type of constituents present, resins are classified as-
   - **Resin acids**- These are mixture of oxy acids, carboxylic acids and phenolic acids. They are present in Free State or as esters. They are soluble in aqueous alkaline solution which form soap like froth on shaking. Ex- Abietic acid in colophony resin, Copaivic acid and Oxycopaivic acid in Copaiba, Guaiconic acid in Guiac resin.
   - **Resin alcohols**- These are complex molecules with high molecular weight. They are present in either free state or as esters of simple aromatic acids ex benzoic acid, Salicylic acid and Cinnamic acid. Resin alcohols are further divided into resinotannols and resinols. **Resinotannols** are tannins and form blue colour with ferric chloride. Ex. Aloe resinotannol from aloe, Suma resinotannol from Benzoin. **Resinols** does not contain tannins. Ex. Benzoresinol from Benzoin, Storesinol from storex.
   - **Resenes**- they are complex neutral compound which do not respond to any chemical reaction. They are insoluble in acids and alcohols and do not form any salt and not get hydrolysed. Ex. Asafoetida, Colophony, Dammar.

b. Classification on the basis of their occurrence in combination with other compounds-
   - Oleoresin- Resins and oils in homogenous mixtures. Ex. Copaiba capsicum, Canada balsam.
   - Oleo-gum-resin- Homogenous mixture of oil, gum and resin. Ex. Guggul, Asafoetida.
   - Glycoresins- Mixture of resins with sugar. Ex. Jalap, Ipomoea
   - Balsams- If resin contains benzoic acid or cinnamic acid. Ex. Balsam of tolu, Balsam of Peru, Storex

Classification of Resins

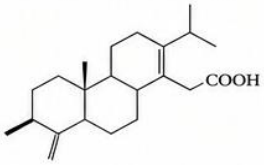
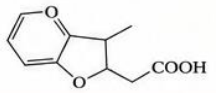
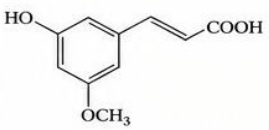
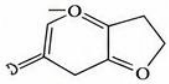
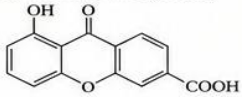
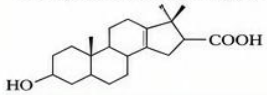
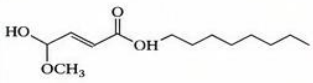
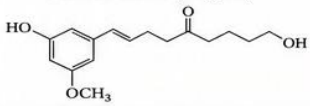
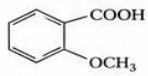
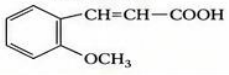
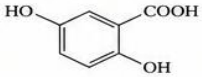
Group (Type)	Example (Plant Source)	Picture of Plant / Drug	Chemical Nature / Structure (Basic Moiety)	Use / Activity
1. True Resins (Oleo-resins) Resins in which resin acids are in combination with essential oils.	• **Turpentine** **Plant Source (Drug):** *Pinus roxburghii* **Phytoconstituents:** Abietic acid, α-Pinene, β-Pinene • **Copaiba Balsam** **Plant Source (Drug):** *Copaifera langsdorffii* **Phytoconstituents:** Copaivic acid, β-Caryophyllene	 Pinus (Turpentine)  Copaiba (Balsam)	**Diterpenoid** (Abietic acid)  **Sesquiterpenoid** (Copaivic acid) 	• Expectorant • Antiseptic • Rubefacient • Used in liniments, ointments and inhalants
2. Oleo-Gum-Resins (Gum-resins) Resins in which resin is combined with gum and essential oil.	• **Asafoetida** **Plant Source (Drug):** *Ferula asafoetida* **Phytoconstituents:** Ferulic acid, Asaresinotannol, Essential oil (disulfides) • **Myrrh** **Plant Source (Drug):** *Commiphora myrrha* **Phytoconstituents:** Furanoeudesma-1,3-diene, Curzerene, Essential oil	 Ferula (Asafoetida)  Myrrh (Oleogum-resin)	**Phenylpropanoid** (Ferulic acid)  **Sesquiterpenoid** (Furanoeudesma-1,3-diene) 	• Carminative • Antispasmodic • Expectorant • Used in perfumery and incense • Anti-inflammatory
3. Gum-Resins Resins in which resin is combined with gum but without essential oil.	• **Gamboge** **Plant Source (Drug):** *Garcinia morella* **Phytoconstituents:** Gambogic acid • **Ammoniacum** **Plant Source (Drug):** *Dorema ammoniacum* **Phytoconstituents:** Resin acids, Polysaccharides	 Garcinia (Gamboge)  Ammoniacum (Gum-resin)	**Xanthone** (Gambogic acid)  **Triterpenoid** (Resin acid type) 	• Purgative • Antimicrobial • Used in paints and varnishes • Adhesive (in industry)
4. Oleo-Resins Resins in which resin is combined with essential oil but without gum.	• **Capsicum Oleoresin** **Plant Source (Drug):** *Capsicum annuum* **Phytoconstituents:** Capsaicin, Capsanthin, Essential oil • **Ginger Oleoresin** **Plant Source (Drug):** *Zingiber officinale* **Phytoconstituents:** Gingerols, Shogaols, Essential oil	 Capsicum (Oleoresin)  Ginger (Oleoresin)	**Amide** (Capsaicin)  **Phenolic ketone** (Gingerol) 	• Stimulant • Carminative • Rubefacient • Used in liniments, creams and pepper sprays
5. Balsams Resins which are soft or liquid at normal room temperature.	• **Benzoin** **Plant Source (Drug):** *Styrax benzoin* **Phytoconstituents:** Benzoic acid, Cinnamic acid derivatives • **Tolu Balsam** **Plant Source (Drug):** *Myroxylon balsamum* **Phytoconstituents:** Cinnamic acid, Benzoic acid derivatives	 Benzoin (Balsam)  Tolu Balsam	**Benzoic acid derivative** (Benzoin)  **Cinnamic acid derivative** (Tolu Balsam) 	• Antiseptic • Expectorant • Used in perfumery and incense • Used in pharmaceutical preparations
6. Resin Glycosides Resin in which resin is combined with sugar(s).	• **Jalap** **Plant Source (Drug):** *Ipomoea purga* **Phytoconstituents:** Jalapin (glycoside of jalapenolic acid)	 Jalap root	**Resorcylic acid derivative** (Jalapenolic acid) 	• Drastic purgative • Used in treatment of constipation • Cathartic

Figure 16: Classification of Resins

Extraction and isolation-

- By extraction with alcohol and precipitation with water.
- By distillation for separation of oil.
- By heating the plant part.
- As plant exudates by incision.
- By collecting fossil resins.

Uses-

- Carminative and stimulant (Ginger, Asafoetida)
- Antiseptic (Benzoin, Tolu balsam)
- Expectorant (Tolu balsam)
- Flavoring species (Ginger, Turmeric)
- Diuretic (Benzoin)
- Industrial uses- as perfumes, chewing gum and confectionary preparation

Table 19: Chemical Identification Tests for Resins

Test	Principle	Reagent Used	Positive Observation	Inference
Acetone Test	Resins are soluble in organic solvents	Acetone	Resin dissolves completely	Presence of resins
Water Test	Resins are insoluble in water and precipitate when alcoholic solution is added to water	Alcoholic extract + Distilled water	Turbidity or white precipitate	Presence of resins
Copper Acetate Test	Resin acids react with copper acetate	Copper acetate solution	Emerald green colour	Presence of resin acids
Ferric Chloride Test	Phenolic resins form coloured complexes with ferric ions	5% Ferric chloride solution	Green, blue, or black colour	Presence of phenolic resins
Liebermann–Burchard Test	Resin alcohols and triterpenoid constituents react with acetic anhydride and sulfuric acid	Acetic anhydride + Conc. H_2SO_4	Blue-green or green colour	Presence of triterpenoid resins
Salkowski Test	Terpenoid constituents of resins react with concentrated sulfuric acid	Chloroform + Conc. H_2SO_4	Reddish-brown colour at the interface	Presence of terpenoid resins
Vanillin–Sulfuric Acid Test	Resin constituents produce characteristic colours in acidic medium	Vanillin–H_2SO_4 reagent	Pink, red, violet, or purple colour	Presence of resins

TRADITIONAL SYSTEMS OF MEDICINE

Drugs of natural origin continue to be important for the treatment of many diseases worldwide. Pharmacognosy, a long-established pharmaceutical science, has played a diverse role in the discovery, characterisation, production and standardisation of these drugs. The relevance of this discipline in terms of research and teaching has increased in the last decade as members of the public in developed countries have turned to the use of herbal remedies for the self-medication for minor diseases. However, many phytomedicines require further investigation for their clinical effectiveness, while others need to be thoroughly investigated for their potential health risks or interactions with prescription drugs. Yet, herbal drugs are playing important role as allopathic system drugs and also drugs of traditional system of medicine. The famous traditional system of medicine and their basic concept are following-

AYURVEDA- INDIAN SYSTEM OF MEDICINE

Ayurveda is one of the world's oldest systems of medicine, originating in India over 5,000 years ago. The term **Ayurveda** is derived from the Sanskrit words **"Ayur"** meaning *life* and **"Veda"** meaning *knowledge or science*; thus, Ayurveda means **"The Science of Life."** It emphasizes the maintenance of health, prevention of disease, and treatment of illness through a holistic approach that integrates the body, mind, spirit, and environment. Ayurveda utilizes medicinal plants, minerals, dietary regulation, lifestyle modification, detoxification therapies, and rejuvenation techniques to restore health.

Principle of Ayurveda

The fundamental principle of Ayurveda is that health is maintained by the equilibrium of the three Doshas i.e. Tridoshas—Vata, Pitta, and Kapha, while disease results from their imbalance.

- **Vata (Air + Ether):** Governs movement, breathing, circulation, nervous system functions, speech, elimination, and sensory activities.
- **Pitta (Fire + Water):** Controls digestion, metabolism, enzyme activity, hormone regulation, vision, body temperature, and intellect.
- **Kapha (Earth + Water):** Provides body structure, lubrication, stability, immunity, growth, and nourishment.

Ayurveda also considers the balance of:

- **Agni (Digestive fire):** Responsible for digestion and metabolism.

- **Dhatus (Seven body tissues):** Rasa, Rakta, Mamsa, Meda, Asthi, Majja, and Shukra.
- **Malas (Waste products):** Urine, feces, and sweat.
- **Ama (Toxins):** Accumulation of undigested metabolic waste is considered a major cause of disease.
- **Prakriti (Body constitution):** Every individual has a unique constitutional makeup that determines susceptibility to diseases and guides personalized treatment.

Concept of Sapta Dhatus (Seven Body Tissues)

The body is nourished and maintained by seven fundamental tissues (**Dhatus**):

- Rasa (Plasma)
- Rakta (Blood)
- Mamsa (Muscle)
- Meda (Fat)
- Asthi (Bone)
- Majja (Bone marrow and nervous tissue)
- Shukra (Reproductive tissue)

Diagnosis in Ayurveda

Diagnosis in Ayurveda aims to identify the root cause of disease rather than merely treating symptoms. It involves a comprehensive assessment of the individual's physical, mental, and constitutional status.

Common diagnostic methods include:

- Assessment of Prakriti (body constitution) and Vikriti (current imbalance).
- Nadi Pariksha (Pulse examination) to assess Dosha imbalance.
- Jihva Pariksha (Tongue examination) to evaluate digestion and toxin accumulation.
- Mutra Pariksha (Urine examination) and Mala Pariksha (Stool examination).
- Examination of the eyes, skin, voice, nails, and overall appearance.
- Evaluation of appetite, digestion, sleep, lifestyle, and mental health.
- Assessment of the patient's medical history and environmental factors.

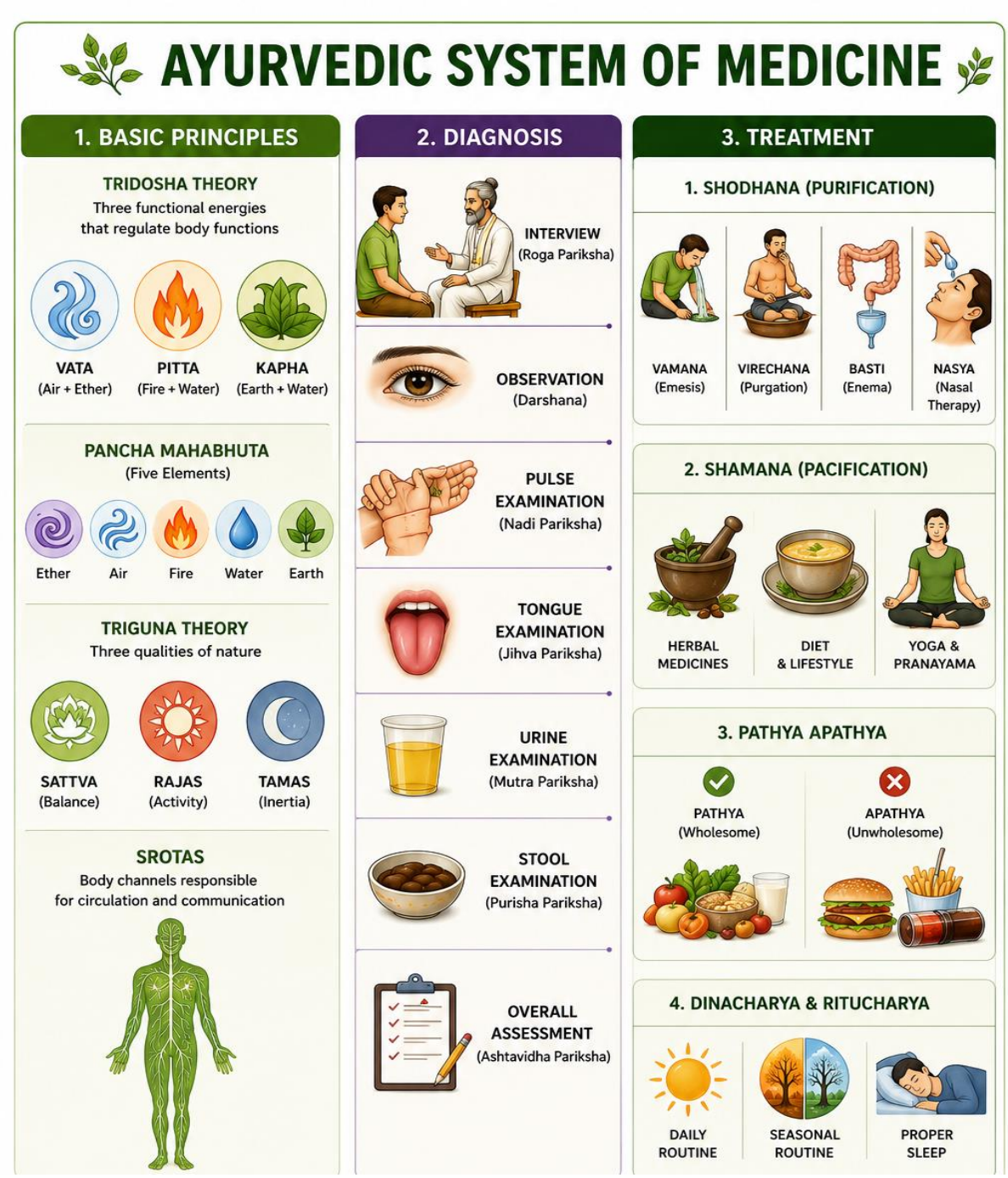


Figure 17: Basic Principle, Diagnosis and Treatment of Ayurveda

Treatment in Ayurveda

The treatment approach in Ayurveda is individualized and aims to restore the balance of Doshas, improve digestion, eliminate toxins, and strengthen the body's natural healing capacity.

Major treatment modalities include:

1. **Shodhana (Purification Therapy):** Detoxification through **Panchakarma**, which includes Vamana (therapeutic emesis), Virechana (purgation), Basti (medicated enema), Nasya (nasal therapy), and Raktamokshana (bloodletting in selected conditions).
2. **Shamana (Palliative Therapy):** Use of herbal medicines, mineral preparations, dietary regulation, and lifestyle modifications to alleviate symptoms and restore balance.
3. **Rasayana Therapy:** Rejuvenation therapy to enhance immunity, vitality, longevity, and resistance to disease.
4. **Dietary Management (Pathya and Apathya):** Personalized diet based on the patient's Dosha and disease condition.
5. **Lifestyle Modification (Dinacharya and Ritucharya):** Adoption of healthy daily and seasonal routines, regular exercise, yoga, meditation, and adequate sleep.
6. **Herbal Medicines:** Administration of medicinal plants and classical formulations such as Churna, Kwatha, Asava, Arishta, Ghrita, Taila, and Vati.

Ayurveda emphasizes prevention, early diagnosis, and holistic treatment, aiming not only to cure disease but also to promote long-term health, balance, and overall well-being.

Table 20: Dosage Forms used in Ayurvedic System of Medicine

Dosage Form	Description	Example
Churna	Powder	Triphala Churna
Vati/Gutika	Tablet/Pill	Chandraprabha Vati
Kwatha/Kashaya	Decoction	Dashamoola Kwatha
Phanta	Hot infusion	Fennel infusion
Hima	Cold infusion	Coriander Hima
Asava/Arishta	Fermented preparation	Ashokarishta
Avaleha/Lehya	Herbal confection	Chyawanprash
Taila	Medicated oil	Mahanarayana Taila
Ghrita	Medicated ghee	Brahmi Ghrita
Bhasma	Calcined preparation	Swarna Bhasma
Pishti	Levigated mineral preparation	Mukta Pishti
Satva	Water-soluble extract	Guduchi Satva
Rasayana	Rejuvenative formulation	Brahma Rasayana
Syrups	Oral liquid	Herbal cough syrup
Ointments/Creams	Topical preparation	Neem ointment
Capsules/Tablets	Standardized herbal dosage form	Ashwagandha Capsule

Balance Between Mind, Body, and Spirit

Ayurveda considers physical, mental, emotional, and spiritual health equally important. Mental disturbances such as stress, anxiety, anger, fear, and grief can contribute to disease. Therefore, treatment includes meditation, yoga, ethical living, and mental discipline along with medicines.

Prevention is Better Than Cure

Ayurveda strongly emphasizes disease prevention by promoting:

- Balanced nutrition
- Daily routine (**Dinacharya**)
- Seasonal regimen (**Ritucharya**)
- Personal hygiene
- Exercise and Yoga
- Adequate sleep
- Stress management
- Healthy lifestyle practices

SIDDHA SYSTEM OF MEDICINE

The Siddha System of Medicine is one of the oldest traditional systems of medicine, originating in South India, particularly in the state of Tamil Nadu. The word "Siddha" is derived from the Tamil word "Siddhi," meaning perfection or attainment of ultimate knowledge. The system is believed to have been developed by enlightened sages known as Siddhas, who attained profound spiritual wisdom and extensive knowledge of medicine, alchemy, yoga, and pharmacology.

Siddha medicine emphasizes the maintenance of health, prevention of diseases, and treatment of illnesses through a holistic approach. **It considers the human body as an integral part of nature and believes that health depends upon harmony between the body, mind, soul, and the environment.** The system primarily employs herbal, mineral, and metallic preparations, along with dietary regulation, yoga, and lifestyle modifications to restore health.

Principle of Siddha System

The Siddha system is based on the principle that **the human body is composed of the same five basic elements (Panchabhutas) that constitute the universe**, and health is maintained

when the body's physiological forces remain in equilibrium. Disease develops when this natural balance is disturbed due to improper diet, unhealthy lifestyle, environmental factors, or aging.

The major principles of Siddha medicine include:

1. Theory of Panchabhutas (Five Basic Elements)

According to Siddha philosophy, all living and non-living things are composed of five fundamental elements:

- **Earth (Prithvi):** Provides strength, stability, and structural support.
- **Water (Appu):** Maintains fluid balance, lubrication, and nourishment.
- **Fire (Thee):** Responsible for digestion, metabolism, body temperature, and transformation.
- **Air (Vayu):** Governs movement, respiration, circulation, and nervous activities.
- **Space (Aagayam):** Creates space within organs and facilitates physiological functions.

These five elements combine in different proportions to form the human body and regulate its normal functions.

2. Theory of Three Humours (Mukkutram)

The physiological functions of the body are controlled by three vital humours known as **Mukkutram**:

- **Vatham (Air + Space):** Regulates movement, respiration, circulation, nervous system functions, speech, and elimination.
- **Pitham (Fire):** Controls digestion, metabolism, body temperature, vision, appetite, and intellectual functions.
- **Kabham (Earth + Water):** Provides body structure, lubrication, growth, stability, immunity, and nourishment.

A healthy individual maintains a proper balance among these three humours. Any disturbance in their equilibrium leads to disease.

Figure 18: Basic Principle, Diagnosis and Treatment of Siddha System of Medicine

3. Concept of Udal Thathukkal (Seven Body Tissues)

The body is sustained by seven fundamental tissues known as **Udal Thathukkal**:

- Saaram (Plasma)
- Cheneer (Blood)
- Oon (Muscle)

- Kozhuppu (Fat)
- Enbu (Bone)
- Moolai (Bone marrow and nervous tissue)
- Sukkilam/Suronitham (Reproductive tissue)

These tissues are formed sequentially from digested food and are responsible for nourishment, growth, and maintenance of the body.

4. Concept of Agni (Digestive Fire)

Proper digestion and metabolism are essential for maintaining health. Efficient digestive fire ensures complete digestion, absorption, and utilization of nutrients. Impaired digestion leads to accumulation of toxins and development of disease.

5. Concept of Waste Products (Malam)

The body produces three major waste products:

- Faeces
- Urine
- Sweat

Regular elimination of these wastes is necessary to maintain normal physiological functions and prevent disease.

6. Individual Constitution

Every individual possesses a unique constitutional makeup determined by the predominance of Vatham, Pitham, and Kabham. Treatment is therefore personalized according to the patient's constitution, age, occupation, climate, diet, and disease condition.

7. Holistic Approach

Siddha medicine considers the **body, mind, and soul** as inseparable components of health. Emotional disturbances, stress, and unhealthy habits are believed to contribute to disease. Therefore, mental well-being, ethical conduct, meditation, and yoga are integral components of therapy.

8. Prevention is Better than Cure

Siddha strongly emphasizes disease prevention through:

- Balanced diet

- Healthy lifestyle
- Personal hygiene
- Regular physical activity
- Yoga and meditation
- Seasonal dietary modifications
- Proper sleep
- Avoidance of harmful habits

9. Use of Natural Medicines

Medicines are prepared from:

- Medicinal plants
- Minerals
- Metals
- Marine products
- Animal products

After proper purification and processing, these are formulated into various dosage forms such as powders, tablets, decoctions, medicated oils, and calcined preparations.

10. Rejuvenation Therapy (Kayakalpa)

One of the unique features of Siddha medicine is **Kayakalpa**, a rejuvenation therapy designed to delay aging, improve immunity, increase vitality, enhance longevity, and maintain physical and mental health through specialized medicines, diet, yoga, and disciplined lifestyle.

Diagnosis in Siddha System

Diagnosis in Siddha medicine aims to determine the imbalance of **Vatham, Pitham, and Kabham** and identify the root cause of disease. It emphasizes careful clinical examination rather than relying solely on laboratory investigations.

Common diagnostic methods include:

- Examination of the patient's medical history.
- Assessment of body constitution.
- Pulse examination (Naadi) to determine humoural imbalance.
- Examination of the tongue, eyes, skin, and voice.
- Evaluation of appetite, digestion, sleep, and bowel habits.

- Urine examination (Neerkuri and Neikuri), where the physical characteristics of urine and the pattern formed by an oil drop on urine are observed.
- Examination of stool and other bodily functions.
- Assessment of mental status and lifestyle.

The Eight-fold Diagnostic Method (Envagai Thervu) is commonly used, which includes:

- Pulse (Naadi)
- Touch (Sparisam)
- Tongue (Naa)
- Colour (Niram)
- Voice (Mozhi)
- Eyes (Vizhi)
- Stool (Malam)
- Urine (Moothiram)

Treatment in Siddha System

The treatment of disease in Siddha aims to restore the balance of the three humours, eliminate toxins, strengthen body tissues, and improve the body's natural healing capacity.

Major treatment modalities include:

1. **Herbal Medicines:** Administration of medicinal plants in the form of powders, decoctions, tablets, syrups, medicated oils, and herbal extracts.
2. **Mineral and Metallic Preparations**: Carefully purified and processed formulations such as Parpam (calcined powders), Chendooram (red oxide preparations), Chunnam (alkaline preparations), and Mezhugu (wax-based formulations).
3. **Diet Therapy (Pathiyam):** Individualized dietary recommendations based on body constitution and disease condition, while avoiding foods that aggravate the affected humour.
4. **Lifestyle Modification:** Maintenance of proper daily routine, adequate sleep, physical activity, stress management, and personal hygiene.
5. **Yoga and Meditation:** Used to improve physical fitness, mental health, and spiritual well-being.
6. **External Therapies:** Therapeutic massage, medicated oil application, steam therapy, fomentation, and other external treatments to relieve pain and improve circulation.

7. **Kayakalpa Therapy:** Rejuvenation therapy employing specialized medicines, nutrition, yoga, and disciplined living to promote longevity, vitality, and disease resistance.

Table 21: Dosage Forms in the Siddha System of Medicine

Dosage Form	Tamil Name	Description
Powder	Chooranam	Finely powdered herbal or mineral preparation taken orally.
Decoction	Kudineer	Herbal extract prepared by boiling medicinal plants in water.
Medicated Ghee	Nei	Ghee processed with medicinal herbs for oral use.
Medicated Oil	Thailam (Ennai)	Herbal oil used internally or externally.
Electuary/Herbal Jam	Leghiyam (Ilagam)	Semi-solid sweet herbal preparation used as a tonic.
Tablet/Pill	Mathirai	Compressed herbal or herbo-mineral tablets.
Paste	Kalkam	Fresh herbal paste used internally or externally.
Medicated Butter	Venney	Butter processed with medicinal ingredients.
Distillate	Theeneer	Distilled herbal liquid preparation.
Syrup	Manapagu	Sweet liquid herbal preparation.
Medicated Wax	Mezhugu	Soft wax-like herbo-mineral preparation.
Parpam	Parpam	Fine calcined mineral or metal ash prepared through purification and incineration.
Chendooram	Chendooram	Highly potent red-colored calcined mineral preparation used in very small doses.
Chunnam	Chunnam	Alkaline or calcinated preparation obtained after purification.
Kulambu	Kulambu	Semi-solid medicinal preparation, mainly for external application.
Liniment	Poochu	External liquid preparation applied to relieve pain and inflammation.
Fumigation	Pugai	Medicinal smoke inhaled or used for environmental purification.
Nasal Drops	Nasiyam	Herbal oil or liquid administered through the nostrils.
Eye Preparation	Mai	Collyrium or ophthalmic preparation for eye disorders.

Broad Classification

- **Oral dosage forms:** Chooranam, Kudineer, Leghiyam, Mathirai, Nei, Manapagu, Mezhugu, Parpam, Chendooram, Chunnam.
- **Topical dosage forms:** Thailam, Kalkam, Kulambu, Poochu.
- **Special dosage forms:** Nasiyam (nasal), Mai (eye preparations), Pugai (fumigation).

These dosage forms are prepared according to traditional Siddha pharmaceutics and are selected based on the patient's body constitution (*Uyir Thathukkal*), disease condition, age, and stage of illness.

HOMEOPATHIC SYSTEM OF MEDICINE

Homeopathy is a holistic system of medicine developed by the German physician **Dr. Samuel Hahnemann** in **1796**. The term **Homeopathy** is derived from the Greek words **"Homoios"**

meaning *similar* and **"Pathos"** meaning *suffering or disease*. Thus, Homeopathy means **"similar suffering."**

Homeopathy is based on the belief that the body possesses an inherent ability to heal itself. It uses highly diluted natural substances derived from plants, minerals, and animals to stimulate the body's self-healing mechanisms. Treatment is individualized, considering not only the physical symptoms but also the mental, emotional, and constitutional characteristics of the patient.

Principle of Homeopathy

Homeopathy is founded on several fundamental principles that guide the selection and administration of medicines.

1. Law of Similars (Similia Similibus Curentur)

The fundamental principle of Homeopathy is **"Similia Similibus Curentur,"** meaning **"Like cures like."**

According to this principle, a substance capable of producing certain symptoms in a healthy person can cure similar symptoms in a diseased person when administered in highly diluted doses.

Example: Onion (*Allium cepa*) causes watering of the eyes and a runny nose in healthy individuals; therefore, a homeopathic preparation of *Allium cepa* is used to treat similar symptoms associated with allergic rhinitis and common cold.

2. Law of Minimum Dose

Homeopathy believes that medicines should be administered in the **smallest effective dose** capable of stimulating the body's healing response.

Medicines undergo repeated dilution and vigorous shaking (succussion), a process called **potentization**, which is believed to enhance the therapeutic effect while minimizing toxicity and adverse effects.

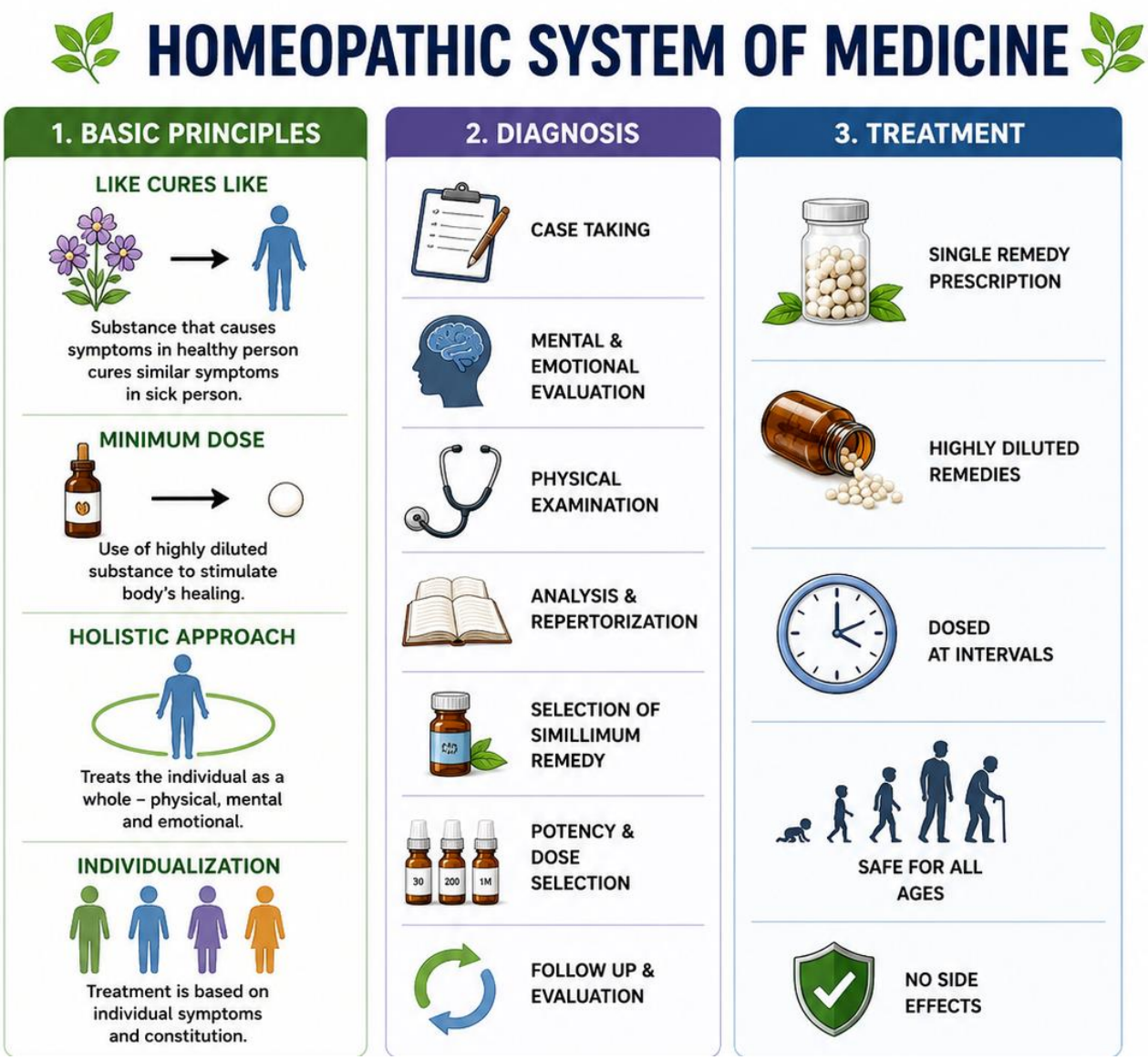


Figure 19: Basic Principle, Diagnosis and Treatment of Homeopathic System of Medicine

3. Principle of Individualization

Homeopathy recognizes that every individual is unique. Therefore, treatment is based on the **totality of symptoms** rather than the disease name alone.

Factors considered include:

- Physical symptoms
- Mental and emotional state
- Personality and temperament
- Sleep pattern
- Appetite and thirst
- Food preferences
- Environmental sensitivity
- Family and medical history

Two patients with the same disease may receive different medicines depending on their individual symptom profile.

4. Potentization

Potentization is the process of preparing homeopathic medicines through **serial dilution** and **succussion (vigorous shaking)**.

This process is believed to:

- Enhance the therapeutic properties of the medicine.
- Reduce toxicity.
- Increase the medicine's ability to stimulate the body's vital force.

Potencies are commonly expressed as **X (decimal)** and **C (centesimal)** scales.

5. Vital Force

Homeopathy proposes that every living organism possesses a **Vital Force**, an invisible life energy responsible for maintaining health.

Disease is considered a disturbance of this vital force. Homeopathic medicines aim to restore its balance, allowing the body to heal naturally.

6. Holistic Approach

Homeopathy treats the **patient as a whole** rather than focusing only on the affected organ or disease.

Equal importance is given to:

- Physical health
- Mental health
- Emotional well-being
- Lifestyle
- Environmental influences

The objective is to restore harmony between the body and mind.

7. Single Remedy Principle

Homeopathy generally advocates the use of **one carefully selected medicine at a time**.

The selected remedy should closely match the patient's complete symptom picture to produce the maximum therapeutic effect.

8. Prevention and Health Promotion

Homeopathy emphasizes:

- Strengthening the body's natural resistance.
- Maintaining overall health through constitutional treatment.
- Lifestyle modification and healthy habits.
- Early intervention to prevent disease progression.

Diagnosis in Homeopathy

Diagnosis in Homeopathy involves a detailed evaluation of the patient's overall condition rather than focusing solely on laboratory findings or disease diagnosis.

Common diagnostic methods include:

- Detailed medical history.
- Assessment of the patient's physical symptoms.
- Evaluation of mental and emotional characteristics.
- Study of personality, temperament, and behaviour.
- Assessment of appetite, thirst, sleep, and bowel habits.
- Identification of factors that aggravate or relieve symptoms.
- Family history and past illnesses.
- Clinical examination and, when necessary, laboratory investigations to confirm the diagnosis.

The physician prepares a complete **symptom profile (case taking)**, which forms the basis for selecting the appropriate homeopathic remedy.

Treatment in Homeopathy

The aim of treatment is to stimulate the body's natural healing ability by administering an individualized homeopathic medicine.

Major treatment approaches include:

1. **Individualized Remedy Selection:** Medicine is selected based on the totality of symptoms rather than the disease name.

2. **Highly Diluted Medicines:** Remedies prepared through potentization are administered in appropriate potencies according to the patient's condition.
3. **Single Remedy Administration:** Usually one medicine is prescribed at a time, and its response is carefully observed before changing the prescription.
4. **Constitutional Treatment:** Long-term therapy aimed at correcting the individual's constitutional tendencies and reducing susceptibility to disease.
5. **Acute Treatment:** Medicines are prescribed for short-term illnesses such as fever, cough, cold, allergies, and minor injuries.
6. **Lifestyle and Dietary Advice:** Patients are advised to follow healthy dietary habits, maintain hygiene, avoid known aggravating factors, and adopt a balanced lifestyle to support recovery.

Table 22: Common dosage forms used in the Homeopathic System of Medicine include:

Dosage Form	Route of Administration	Common Use
Medicated globules (pellets)	Oral	Most common dosage form
Liquid dilutions	Oral	Acute and chronic conditions
Mother tinctures (Q)	Oral	Herbal preparations
Triturations	Oral	Insoluble medicines
Tablets	Oral	Convenient administration
Oral solutions	Oral	Drops in water
Ointments	Topical	Skin disorders
Creams	Topical	Dermatological conditions
Gels	Topical	Local application
Lotions	Topical	Skin and scalp conditions
Eye drops	Ophthalmic	Eye conditions (where approved)
Nasal drops/sprays	Nasal	Nasal ailments
Suppositories	Rectal/Vaginal	Specialized applications

For teaching or presentation purposes, these dosage forms can be broadly classified as:

- **Oral dosage forms:** Globules, liquid dilutions, mother tinctures, triturations, tablets, oral solutions.
- **Topical dosage forms:** Ointments, creams, gels, lotions.
- **Specialized dosage forms:** Eye drops, nasal drops/sprays, suppositories.

UNANI SYSTEM OF MEDICINE

The Unani System of Medicine is one of the oldest traditional systems of medicine, with its roots in ancient Greece. It was developed by renowned Greek physicians such as **Hippocrates (Father of Medicine) and Galen**, and was later enriched by Arab and Persian scholars, particularly Ibn Sina (Avicenna), whose famous work *The Canon of Medicine (Al-Qanun fi al-*

Tibb) became a landmark in medical science. The word "Unani" is derived from the Arabic word "Yunan," meaning Greece.

Unani medicine is a holistic system that emphasizes the prevention and treatment of diseases by maintaining the natural balance of the body. It utilizes herbal, mineral, and animal-derived medicines along with dietary regulation and regimental therapies. In India, Unani is recognized as one of the **AYUSH** systems of medicine.

Principle of Unani Medicine

The fundamental principle of Unani medicine is that health is maintained by the balance of the four body humours (Akhlat), while disease occurs due to their imbalance. Every individual possesses a unique temperament (Mizaj), and treatment is aimed at restoring the normal equilibrium of the humours.

1. Theory of Four Elements (Arkan)

According to Unani philosophy, the human body and the universe are composed of four basic elements:

- **Earth (Ard):** Provides stability, strength, and structure.
- **Water (Ma):** Maintains moisture and fluid balance.
- **Air (Hawa):** Responsible for movement and vitality.
- **Fire (Nar):** Produces heat, energy, and metabolic activity.

Each element possesses characteristic qualities such as hot, cold, moist, or dry, which influence the body's physiological functions.

2. Theory of Four Humours (Akhlat)

The four elements combine to produce four body humours that regulate all physiological activities:

- **Dam (Blood):** Hot and moist; responsible for nourishment, vitality, and growth.
- **Balgham (Phlegm):** Cold and moist; provides lubrication, cooling, and nourishment.
- **Safra (Yellow Bile):** Hot and dry; regulates digestion, metabolism, and body temperature.
- **Sauda (Black Bile):** Cold and dry; provides stability, concentration, and structural integrity.

Health depends upon maintaining the proper proportion of these humours. Excess or deficiency of any humour leads to disease.

3. Concept of Mizaj (Temperament)

Every individual has a unique **Mizaj (temperament)** determined by the predominance of one or more humours. The four basic temperaments are:

- Sanguine (Damavi)
- Phlegmatic (Balghami)
- Choleric (Safravi)
- Melancholic (Saudavi)

The patient's temperament influences susceptibility to disease, choice of medicine, diet, and lifestyle recommendations.

4. Concept of Quwwat-e-Mudabbira-e-Badan (Self-Regulating Power)

Unani believes that the human body possesses an inherent **self-healing and self-regulating power**, known as **Quwwat-e-Mudabbira-e-Badan**, which maintains normal physiological functions and combats disease.

Treatment aims to strengthen this natural healing power rather than merely suppress symptoms.

5. Concept of Asbab-e-Sitta Zarooriyah (Six Essential Factors)

According to Unani medicine, health depends upon maintaining balance in six essential factors:

- Pure air
- Food and drink
- Physical activity and rest
- Mental activity and emotional balance
- Sleep and wakefulness
- Proper elimination and retention of body wastes

6. Individualized Treatment

Every patient is treated according to:

- Temperament (Mizaj)
- Age
- Sex

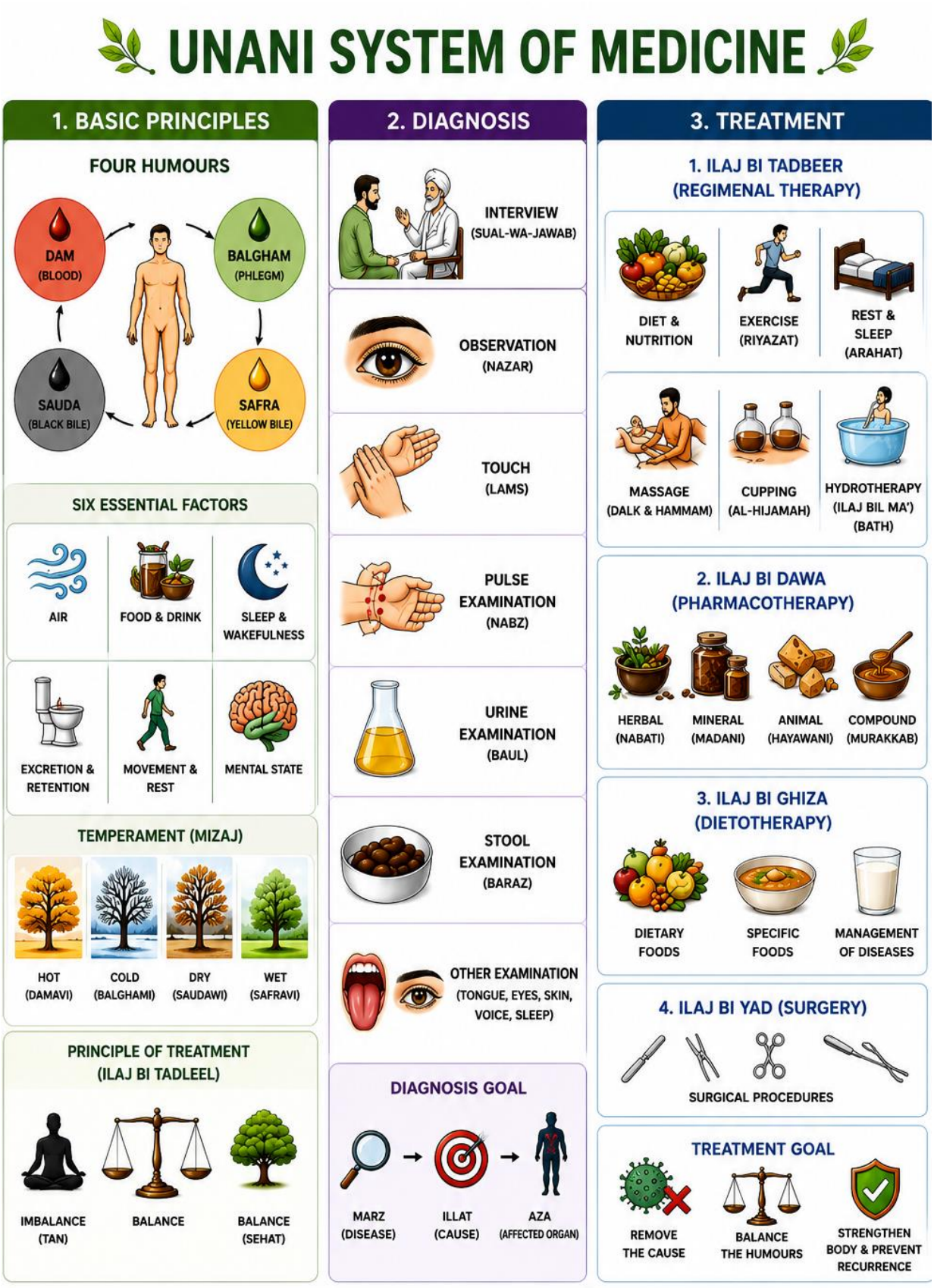


Figure 20: Basic Principle, Diagnosis and Treatment of Unani System of Medicine

- Climate
- Occupation
- Diet
- Nature and severity of disease

Thus, treatment is personalized rather than disease-specific.

8. Holistic Approach

Unani medicine considers the **body, mind, and environment** as interconnected. Emotional disturbances, unhealthy habits, and environmental factors are believed to contribute to disease. Therefore, treatment addresses both physical and psychological health. Disturbance in any of these factors may lead to disease.

Diagnosis in Unani Medicine

Diagnosis in Unani medicine focuses on identifying the imbalance of humours and evaluating the patient's overall constitution.

Common diagnostic methods include:

- Detailed medical history.
- Assessment of Mizaj (temperament).
- Pulse examination (Nabz).
- Examination of urine (**Baul**) and stool (**Baraz**).
- Observation of skin colour, eyes, tongue, and body appearance.
- Assessment of appetite, digestion, sleep, and bowel habits.
- Evaluation of mental and emotional state.
- Physical examination and, when required, laboratory investigations for confirmation.

The physician determines which humour is disturbed before planning appropriate treatment.

Treatment in Unani Medicine

The primary objective of treatment is to restore the balance of humours, strengthen the body's natural healing power, and eliminate the underlying cause of disease.

Major treatment approaches include:

1. Ilaj-bil-Ghiza (Dietotherapy)

- Treatment through appropriate dietary modification.

- Specific foods are recommended or restricted according to the patient's temperament and disease condition.

2. Ilaj-bil-Dawa (Pharmacotherapy)

- Administration of herbal, mineral, and animal-derived medicines.
- Medicines are available as powders, decoctions, syrups, tablets, oils, ointments, and other dosage forms.

Table 23: Dosage Forms in the Unani System of Medicine

Dosage Form	Unani Name	Description
Powder	Safoof	Finely powdered medicine administered orally.
Tablet/Pill	Qurs (Hab)	Solid compressed tablets or pills for oral use.
Decoction	Joshanda	Herbal preparation made by boiling crude drugs in water.
Infusion	Zulal	Prepared by steeping medicinal herbs in hot or cold water.
Syrup	Sharbat	Sweet liquid preparation containing medicinal ingredients.
Electuary	Majoon	Semi-solid preparation made with herbs and sugar or honey.
Linctus	Laooq	Thick paste used mainly for cough and respiratory disorders.
Confection	Jawarish	Digestive herbal confection with sugar or honey.
Paste	Khamira	Soft, semisolid preparation used as a tonic and rejuvenator.
Distillate	Arq	Distilled aromatic water prepared from medicinal plants.
Medicated Oil	Roghan	Herbal oil for internal or external use.
Ointment	Marham	Semi-solid topical preparation for wounds and skin diseases.
Liniment	Tila	External liquid or semi-solid preparation applied by rubbing.
Eye Drops/Collyrium	Kohl (Surma)	Ophthalmic preparation for eye ailments.
Gargle/Mouthwash	Mazmaza	Liquid preparation used for oral and throat conditions.
Enema	Huqna	Rectal preparation for cleansing or therapeutic purposes.
Nasal Drops	Saoot	Medicinal drops administered through the nostrils.
Inhalation/Fumigation	Bakhoor	Medicinal vapors or smoke inhaled for respiratory conditions.

Broad Classification

- **Oral dosage forms:** Safoof, Qurs (Hab), Joshanda, Zulal, Sharbat, Majoon, Laooq, Jawarish, Khamira, Arq.
- **Topical dosage forms:** Roghan, Marham, Tila.
- **Special dosage forms:** Kohl (Surma), Mazmaza (gargle), Huqna (enema), Saoot (nasal drops), Bakhoor (fumigation).

These dosage forms are prescribed according to the patient's **temperament (Mizaj)**, the nature of the disease, and the principles of Unani therapeutics.

3. Ilaj-bil-Tadbeer (Regimental Therapy)

This involves non-drug therapeutic procedures such as:

- Massage (Dalk)
- Exercise (Riyazat)
- Cupping therapy (Hijama)
- Steam bath
- Turkish bath (Hammam)
- Leech therapy
- Venesection
- Fomentation

These therapies improve circulation, eliminate toxins, and restore physiological balance.

4. Ilaj-bil-Yad (Surgery)

Minor and major surgical procedures are performed when necessary for conditions that cannot be managed by medical treatment alone.

5. Lifestyle Modification

Patients are advised to:

- Follow a balanced diet.
- Maintain regular physical activity.
- Ensure adequate sleep.
- Manage stress effectively.
- Avoid habits that disturb humoural balance.

YOGA AND NATUROPATHY

Yoga and Naturopathy is one of the recognized systems under AYUSH that focuses on the promotion of health, prevention of disease, and restoration of well-being through natural methods. Yoga originated in ancient India more than 5,000 years ago and is primarily based on the teachings of **Maharishi Patanjali**, who compiled the Yoga Sutras. The word "Yoga" is derived from the Sanskrit root **"Yuj," meaning "to unite" or "to join,"** signifying the union of the body, mind, and spirit.

Naturopathy is a drugless system of medicine that believes in the body's inherent ability to heal itself through natural therapies. Together, Yoga and Naturopathy emphasize holistic health by combining physical exercises, breathing techniques, meditation, balanced nutrition, hydrotherapy, mud therapy, massage, fasting, and healthy lifestyle practices. The primary

objective is to maintain harmony between the body, mind, and nature, thereby preventing disease and promoting overall wellness.

Principle of Yoga and Naturopathy

The fundamental principle of Yoga and Naturopathy is that **the body possesses an inherent self-healing capacity**, and health can be maintained by preserving harmony among the body, mind, spirit, and environment. Disease is considered the result of unhealthy lifestyle, improper diet, mental stress, environmental factors, and disturbance of the body's natural balance.

1. Self-Healing Power of the Body

The body has a natural ability to repair and regenerate itself. Yoga and Naturopathy aim to stimulate this healing power by removing the causes of disease rather than merely suppressing symptoms.

2. Holistic Approach

Health is regarded as the harmonious balance of **physical, mental, emotional, social, and spiritual well-being**. Treatment focuses on the individual as a whole rather than treating only the affected organ or disease.

3. Harmony with Nature

Human beings are considered an integral part of nature. Good health is achieved by living in accordance with natural laws through fresh air, pure water, sunlight, nutritious food, adequate rest, and regular physical activity.

4. Prevention is Better than Cure

A major objective is the prevention of disease through:

- Balanced diet
- Regular yoga practice
- Physical exercise
- Personal hygiene
- Adequate sleep
- Stress management
- Healthy lifestyle habits

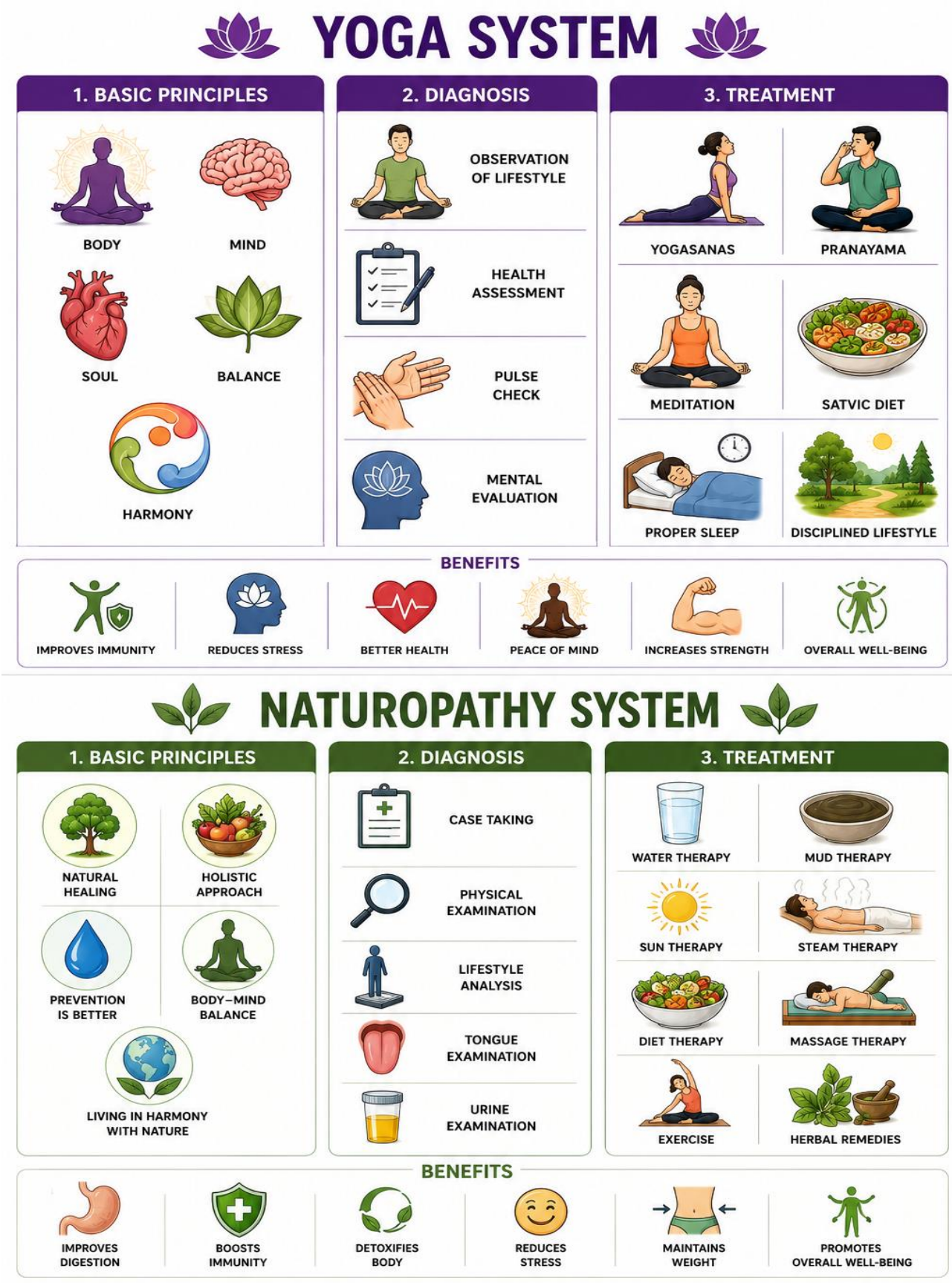


Figure 21: Basic Principle, Diagnosis and Treatment of Yoga and Naturopathy

5. Purification and Detoxification

The accumulation of toxins due to poor diet and unhealthy habits is considered a major cause of disease. Natural therapies such as fasting, hydrotherapy, mud therapy, and yogic cleansing techniques (**Shatkarmas**) help eliminate toxins and restore normal body functions.

6. Individualized Treatment

Treatment is planned according to the patient's:

- Age
- Physical condition
- Mental status
- Lifestyle
- Disease condition
- Individual health needs

7. Importance of Mind–Body Connection

Mental stress, anxiety, anger, fear, and emotional disturbances are believed to contribute significantly to disease. Yoga strengthens the connection between the body and mind through meditation, breathing exercises, and relaxation techniques.

8. Lifestyle Modification

Yoga and Naturopathy emphasize adopting healthy daily habits, including:

- Balanced nutrition
- Regular exercise
- Good posture
- Adequate sleep
- Avoidance of tobacco, alcohol, and other harmful habits
- Positive thinking and emotional balance

9. Eight Limbs of Yoga (Ashtanga Yoga)

According to Patanjali, Yoga consists of eight interconnected components:

1. **Yama** – Ethical restraints
2. **Niyama** – Personal discipline
3. **Asana** – Physical postures
4. **Pranayama** – Breathing control

5. **Pratyahara** – Withdrawal of the senses
6. **Dharana** – Concentration
7. **Dhyana** – Meditation
8. **Samadhi** – State of self-realization or enlightenment

These eight limbs promote physical health, mental stability, emotional balance, and spiritual growth.

Diagnosis in Yoga and Naturopathy

Diagnosis aims to identify the underlying causes of disease, particularly lifestyle-related factors that disturb the body's natural balance.

Diagnostic methods include:

- Detailed medical history.
- Assessment of dietary habits and nutrition.
- Evaluation of lifestyle and daily routine.
- Physical examination.
- Assessment of posture, flexibility, body weight, and fitness.
- Evaluation of stress, anxiety, sleep, and emotional health.
- Observation of bowel habits, digestion, and hydration.
- Laboratory investigations and modern diagnostic tests, when required, to confirm the diagnosis.

The diagnosis focuses on identifying factors that interfere with the body's natural healing mechanisms.

Treatment in Yoga and Naturopathy

The primary goal of treatment is to restore health by enhancing the body's self-healing ability through natural therapies and lifestyle modification.

Major treatment modalities include:

1. Yoga Therapy

Practice of:

- **Asanas (physical postures)** to improve flexibility, strength, and organ function.

- **Pranayama (breathing exercises)** to improve lung capacity, oxygenation, and mental calmness.
- **Meditation (Dhyana)** for stress reduction and emotional well-being.
- **Relaxation techniques** such as Shavasana and Yoga Nidra.

2. Diet Therapy

- Consumption of balanced, natural, and nutritious foods.
- Increased intake of fruits, vegetables, whole grains, sprouts, and adequate water.
- Avoidance of processed foods, excessive sugar, unhealthy fats, tobacco, and alcohol.

3. Hydrotherapy

Use of water in various forms such as:

- Cold and hot compresses
- Steam bath
- Sitz bath
- Spinal bath
- Full-body bath

Hydrotherapy improves circulation, relieves pain, and promotes detoxification.

4. Mud Therapy

Application of therapeutic mud packs or mud baths to:

- Reduce inflammation
- Improve circulation
- Detoxify the body
- Relieve pain

5. Massage Therapy

Therapeutic massage improves:

- Blood circulation
- Muscle relaxation
- Lymphatic drainage
- Stress reduction

6. Fasting Therapy

Short-term therapeutic fasting under medical supervision helps:

- Improve digestion
- Promote detoxification
- Enhance metabolic efficiency

7. Sun and Air Therapy

Controlled exposure to sunlight and fresh air helps improve:

- Vitamin D synthesis
- Circulation
- Immunity
- General health

8. Lifestyle Counselling

Patients are encouraged to:

- Maintain regular sleep patterns.
- Engage in daily physical activity.
- Practice stress management.
- Develop positive mental attitudes.
- Follow healthy daily routines.

TRADITIONAL CHINESE MEDICINE (TCM)

Traditional Chinese Medicine (TCM) is one of the oldest holistic systems of healthcare, originating in **China** over **2,500 years ago**. It has evolved through centuries of observation, clinical practice, and philosophical development. TCM is based on the belief that the human body functions as an integrated whole and that health depends on maintaining harmony between the body, mind, and the surrounding environment.

The central concept of TCM is the balanced flow of **Qi (pronounced "chee")**, the body's vital life energy. Disease occurs when the flow of Qi is blocked or when the balance between opposing yet complementary forces, **Yin and Yang**, is disturbed. TCM employs various therapeutic methods, including herbal medicines, acupuncture, moxibustion, cupping therapy, massage (Tui Na), dietary therapy, and therapeutic exercises such as **Tai Chi** and **Qigong**, to restore health and prevent disease.

Principle of Traditional Chinese Medicine (TCM)

The fundamental principle of TCM is that **health is maintained by the smooth flow of Qi and the harmonious balance of Yin and Yang within the body**, whereas disease develops due to imbalance, blockage, or deficiency of Qi and disruption of the body's internal harmony.

1. Theory of Qi (Vital Energy)

Qi is considered the vital life force that circulates throughout the body and sustains all physiological functions.

According to TCM:

- Qi provides energy for growth, metabolism, movement, and organ function.
- It circulates through specific pathways called **Meridians (Jing Luo)**.
- Free and balanced flow of Qi is essential for maintaining health.
- Obstruction, deficiency, or excess of Qi leads to disease and dysfunction.

2. Theory of Yin and Yang

Yin and Yang are two opposite but complementary forces that exist in everything in nature.

- **Yin** represents cold, rest, darkness, nourishment, structure, and internal functions.
- **Yang** represents heat, activity, light, energy, movement, and external functions.

Both forces are interdependent and continuously transform into one another. Health exists when Yin and Yang remain in dynamic equilibrium. An excess or deficiency of either results in disease.

3. Theory of Five Elements (Wu Xing)

TCM explains physiological functions and disease processes through the interaction of **Five Elements**:

- **Wood** – Associated with growth, flexibility, liver, and gallbladder.
- **Fire** – Associated with heat, circulation, heart, and small intestine.
- **Earth** – Associated with nourishment, digestion, spleen, and stomach.
- **Metal** – Associated with respiration, lungs, and large intestine.
- **Water** – Associated with storage of energy, kidneys, and urinary bladder.

These elements interact through generating and controlling cycles, maintaining balance among body organs. Disturbance in these relationships may lead to illness.

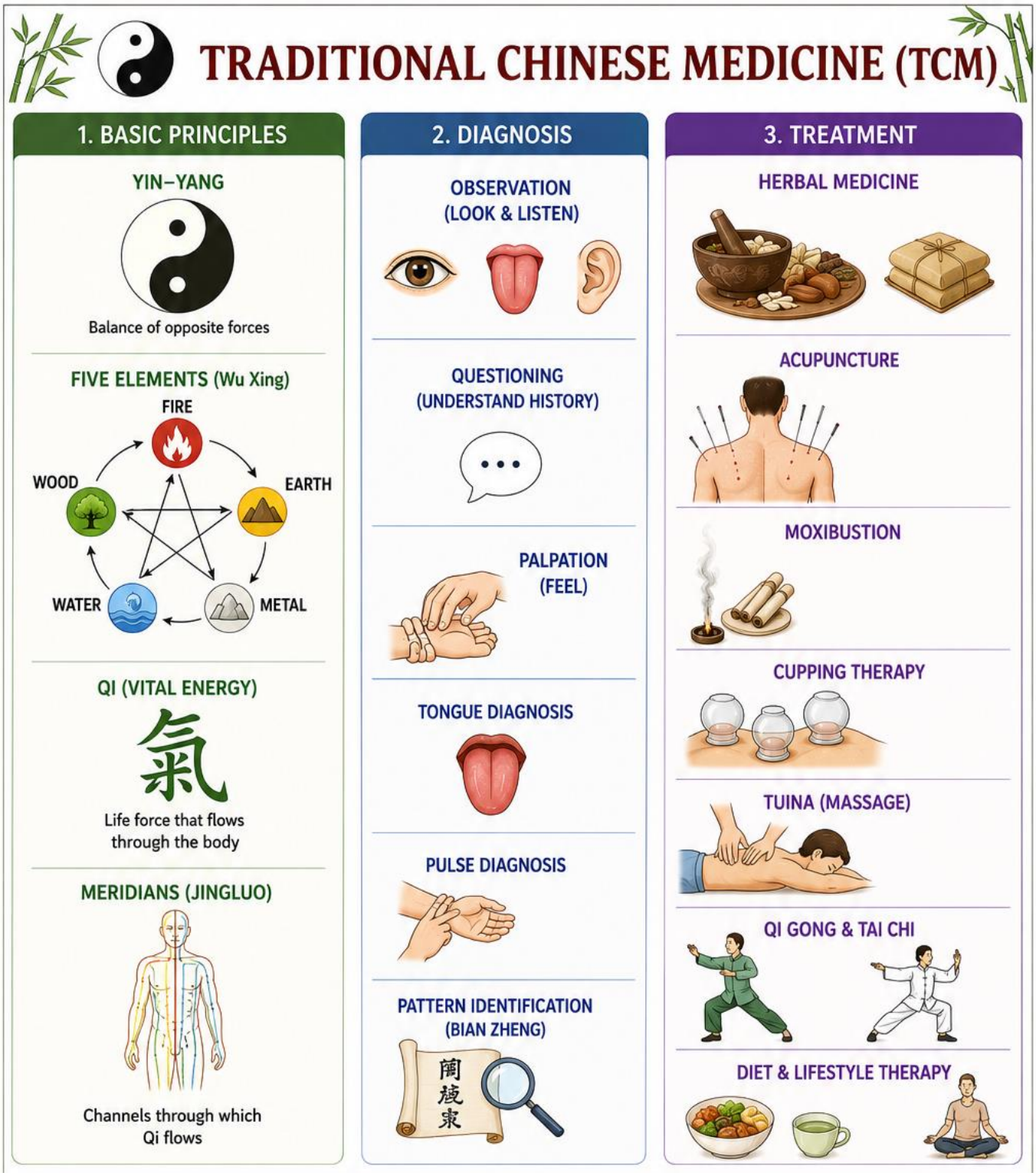


Figure 22: Basic Principle, Diagnosis and Treatment of TCM

4. Theory of Yin and Yang

TCM classifies internal organs into:

Yin Organs:

- Heart
- Liver
- Spleen
- Lungs
- Kidneys

These organs store vital substances such as Qi, Blood, and Essence.

Yang Organs:

- Stomach
- Small intestine
- Large intestine
- Gallbladder
- Urinary bladder
- San Jiao (Triple Burner)

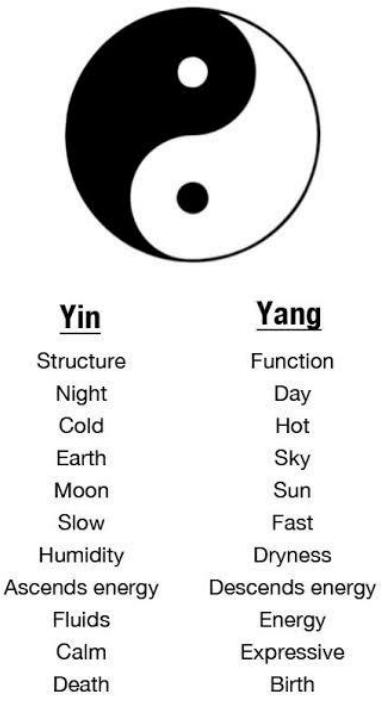


Figure 23: Yin and Yang components

These organs receive, digest, transport, and excrete substances.

Disease is believed to occur when the functions of these organs become imbalanced.

5. Theory of Meridians (Jing Luo)

Meridians are invisible channels through which Qi and Blood circulate throughout the body.

- They connect internal organs with different body parts.
- They maintain communication between organs and tissues.
- Blockage of meridians leads to pain and disease.
- Acupuncture and acupressure restore the normal flow of Qi through these channels.

6. Concept of Balance and Holistic Health

TCM views the body as an integrated system where physical, emotional, mental, and environmental factors are interconnected.

Health depends upon:

- Harmony between body and mind.
- Balance between Yin and Yang.
- Proper circulation of Qi and Blood.
- Adaptation to seasonal and environmental changes.

7. Individualized Treatment

Every patient is considered unique.

Treatment depends upon:

- Nature of Qi imbalance.
- Yin-Yang status.
- Organ involvement.
- Age and constitution.
- Lifestyle and dietary habits.
- Environmental conditions.

Therefore, patients with the same disease may receive different treatments based on their individual syndrome pattern.

8. Prevention is Better than Cure

TCM strongly emphasizes prevention by:

- Maintaining a balanced diet.
- Regular physical activity.
- Tai Chi and Qigong exercises.
- Stress management.
- Adequate sleep.
- Seasonal lifestyle modifications.
- Strengthening the body's natural resistance against disease.

Diagnosis in Traditional Chinese Medicine

Diagnosis in TCM aims to identify the pattern of imbalance rather than simply naming the disease.

The Four Diagnostic Methods are:

1. Inspection (Looking)

- Observation of facial complexion.
- Examination of tongue colour, shape, and coating.
- Assessment of body posture and overall appearance.

2. Listening and Smelling

- Evaluation of voice, breathing, and cough.
- Detection of abnormal body odours.

3. Inquiry (Questioning)

- Detailed history regarding symptoms.
- Appetite and digestion.
- Sleep pattern.
- Emotional condition.
- Menstrual history.
- Lifestyle and environmental exposure.

4. Palpation

- **Pulse diagnosis** at different wrist positions.
- Palpation of painful areas and meridians.
- Assessment of body temperature and tenderness.

Based on these findings, the practitioner determines the pattern of Qi, Blood, Yin-Yang, and organ imbalance.

Treatment in Traditional Chinese Medicine

The objective of treatment is to restore the balance of Yin and Yang, regulate Qi and Blood, strengthen body functions, and eliminate the underlying cause of disease.

Major treatment modalities include:

1. Herbal Medicine

Use of single herbs or polyherbal formulations prepared as:

- Decoctions
- Powders
- Tablets

- Capsules
- Pills
- Syrups
- Herbal teas

These medicines regulate Qi, nourish organs, and restore physiological balance.

2. Acupuncture

Fine sterile needles are inserted into specific acupuncture points along the meridians to:

- Restore Qi flow.
- Relieve pain.
- Improve organ function.
- Promote healing.

3. Moxibustion

Dried **mugwort (Artemisia vulgaris)** is burned near acupuncture points to provide therapeutic heat, improve circulation, and stimulate Qi.

4. Cupping Therapy

Glass, bamboo, or silicone cups create suction on the skin to:

- Improve blood circulation.
- Relieve muscle pain.
- Remove stagnation.
- Promote healing.

5. Tui Na Massage

A specialized therapeutic massage that manipulates muscles and meridians to restore the normal flow of Qi and relieve pain.

6. Dietary Therapy

Diet is prescribed according to the patient's constitution and disease pattern, emphasizing foods that restore Yin-Yang balance and support organ function.

7. Tai Chi and Qigong

Gentle exercises combined with breathing techniques and meditation help improve:

- Qi circulation.

- Balance and flexibility.
- Mental relaxation.
- Overall health.

Table 24: Dosage Forms in the Traditional Chinese Medicine (TCM) System

Traditional Chinese Medicine (TCM) uses a wide range of dosage forms prepared from herbal, mineral, and animal-derived ingredients.

Dosage Form	Chinese Name	Description
Decoction	Tang	Herbal preparation obtained by boiling medicinal herbs in water; the most common dosage form.
Powder	San	Finely powdered herbs taken orally or applied externally.
Pills	Wan	Small spherical pills prepared from powdered herbs and binders such as honey.
Tablets	Pian	Compressed herbal tablets for oral administration.
Capsules	Jiaonang	Powdered or granulated herbal medicines enclosed in capsules.
Granules	Keli	Instant herbal granules dissolved in hot water before use.
Oral Liquid	Koufuye	Ready-to-use liquid herbal formulation.
Syrup	Tangjiang	Sweet liquid preparation used mainly for respiratory disorders.
Tincture	Jiuji	Herbal extracts prepared in alcohol.
Medicated Wine	Yaojiu	Herbal medicines infused in wine for internal or external use.
Paste/Electuary	Gao	Thick semi-solid herbal preparation used as a tonic.
Ointment	Gaoji	Semi-solid topical preparation for skin and musculoskeletal disorders.
Plaster	Tiegao	Adhesive herbal patch applied externally for pain relief.
Liniment	Chajiji	Liquid preparation applied externally to muscles and joints.
Medicated Oil	Yaoyou	Herbal oil for massage and external application.
Suppositories	Shuanji	Rectal or vaginal herbal preparations.

Broad Classification

- **Oral dosage forms:** Tang, San, Wan, Pian, Jiaonang, Keli, Koufuye, Tangjiang, Jiuji, Yaojiu, Gao.
- **Topical dosage forms:** Gaoji, Tiegao, Chajiji, Yaoyou.
- **Special dosage forms:** Suppositories, nasal drops/sprays, eye drops/washes.

These dosage forms are selected according to **Traditional Chinese Medicine principles**, including **syndrome differentiation (Bian Zheng)**, the patient's constitution, and the balance of **Yin–Yang** and **Qi**.

ROLE OF PHARMACOGNOSY IN ALLOPATHY AND TRADITIONAL SYSTEMS OF MEDICINE (AYUSH AND TCM)

Pharmacognosy is the branch of pharmaceutical science that deals with the study of crude drugs obtained from natural sources such as plants, animals, minerals, and microorganisms. It serves as a bridge between traditional knowledge and modern medicine by facilitating the discovery, standardization, quality control, and rational use of natural products. Pharmacognosy plays a significant role in both **allopathic medicine** and **traditional systems of medicine** such as **AYUSH** and **Traditional Chinese Medicine (TCM)**.

Role of Pharmacognosy in Allopathy

1. **Drug Discovery:** Natural products serve as valuable sources of lead molecules for the development of new drugs.
2. **Isolation of Active Constituents:** Pharmacognosy enables the isolation and characterization of bioactive compounds such as alkaloids, glycosides, flavonoids, terpenoids, and phenolics.
3. **Quality Control and Standardization:** It establishes standards for the identification, purity, potency, and safety of crude drugs and herbal medicines.
4. **Development of Modern Medicines:** Several allopathic drugs have been developed directly or indirectly from plant-derived compounds.
5. **Pharmacological Evaluation:** Natural products are screened for antimicrobial, anticancer, antidiabetic, anti-inflammatory, antioxidant, and other biological activities.
6. **Pharmaceutical Applications:** Plant-derived compounds are used as active pharmaceutical ingredients, excipients, flavouring agents, colouring agents, and preservatives.
7. **Ensuring Safety:** Pharmacognosy helps detect adulteration, contamination, and counterfeit herbal materials, ensuring safe therapeutic use.
8. **Biotechnological Applications:** Techniques such as plant tissue culture and metabolic engineering are employed to enhance the production of valuable medicinal compounds.

Table 25: Examples of Plant-Derived Allopathic Drugs

Drug	Source Plant	Therapeutic Use
Morphine	*Papaver somniferum*	Analgesic
Quinine	*Cinchona species*	Antimalarial
Digoxin	*Digitalis purpurea*	Cardiotonic
Atropine	*Atropa belladonna*	Anticholinergic

Vincristine	*Catharanthus roseus*	Anticancer
Paclitaxel	*Taxus species*	Anticancer
Artemisinin	*Artemisia annua*	Antimalarial

Role of Pharmacognosy in Traditional Systems of Medicine (AYUSH and TCM)

1. **Authentication of Medicinal Plants:** Ensures correct identification of medicinal plants used in traditional formulations.
2. **Quality Assurance:** Establishes standards for purity, identity, strength, and quality of herbal raw materials.
3. **Standardization of Herbal Formulations:** Promotes consistency, efficacy, and safety of traditional medicines.
4. **Validation of Traditional Knowledge:** Scientific evaluation confirms the therapeutic claims of traditional remedies.
5. **Conservation of Medicinal Plants:** Encourages sustainable cultivation, harvesting, and conservation of medicinal plant resources.
6. **Isolation of Bioactive Constituents:** Identifies active principles responsible for therapeutic effects.
7. **Development of Herbal Medicines:** Supports the formulation of safe, effective, and evidence-based herbal products.
8. **Research and Innovation:** Integrates traditional knowledge with modern scientific techniques for the discovery of novel therapeutic agents.
9. **Quality Control:** Detects adulterants, substitutes, contaminants, and ensures compliance with pharmacopoeial standards.
10. **Global Acceptance:** Scientific validation through pharmacognostic studies enhances the international recognition and acceptance of traditional medicines.

Role of Pharmacognosy in Individual Branches of AYUSH and TCM

Pharmacognosy is the branch of pharmaceutical science that deals with the study of drugs obtained from natural sources, including plants, animals, minerals, and marine organisms. It plays a vital role in traditional systems of medicine by ensuring the correct identification, quality, safety, efficacy, and standardization of medicinal materials. The role of pharmacognosy varies according to the principles and therapeutic approaches of each traditional system.

1. Ayurveda

Ayurveda relies predominantly on medicinal plants, although mineral and animal products are also used. Pharmacognosy provides the scientific basis for the selection, authentication, and quality control of these raw materials.

Role of Pharmacognosy

- Identification and authentication of medicinal plants mentioned in Ayurvedic texts.
- Prevention of adulteration and substitution of crude drugs.
- Cultivation and conservation of medicinal plant species.
- Standardization of herbal formulations such as **Churna, Asava, Arishta, Kwatha, Avaleha, Ghrita,** and **Taila**.
- Evaluation using organoleptic, microscopic, physicochemical, and phytochemical methods.
- Isolation and characterization of bioactive constituents.
- Development of herbal medicines with consistent quality and therapeutic efficacy.
- Scientific validation of traditional Ayurvedic claims through pharmacological and phytochemical studies.

Significance:

Pharmacognosy helps preserve Ayurvedic heritage while ensuring the safety, efficacy, and global acceptance of Ayurvedic medicines.

2. Yoga & Naturopathy

Although Yoga is primarily a non-drug system, medicinal plants and natural products are widely used in Naturopathy for disease prevention and health promotion. Pharmacognosy supports these therapies by providing scientific evidence for natural remedies.

Role of Pharmacognosy

- Identification and quality evaluation of medicinal herbs used in naturopathic therapies.
- Standardization of herbal supplements and nutraceuticals.
- Scientific evaluation of plant-based detoxification and rejuvenation products.
- Quality control of herbal teas, juices, powders, and dietary supplements.
- Research on antioxidant, adaptogenic, anti-inflammatory, and immunomodulatory herbs.
- Promotion of safe use of medicinal plants alongside yoga practices.

- Conservation of medicinal plant biodiversity.

Significance:

Pharmacognosy strengthens the scientific foundation of natural therapies and promotes evidence-based use of medicinal plants for maintaining health and preventing disease.

3. Unani System of Medicine

Unani medicine utilizes herbal, mineral, and animal-origin drugs based on the concept of maintaining the balance of the body's temperament (*Mizaj*). Pharmacognosy ensures the authenticity and quality of these medicinal substances.

Role of Pharmacognosy

- Authentication of herbal, mineral, and animal-derived raw materials.
- Microscopic and physicochemical evaluation of crude drugs.
- Detection of adulteration and substitution.
- Standardization of Unani dosage forms such as **Safoof, Majoon, Sharbat, Arq, Roghan, Jawarish,** and **Laooq**.
- Phytochemical investigation of medicinal plants used in Unani medicine.
- Development of quality standards for raw materials and finished products.
- Scientific validation of traditional Unani formulations.
- Conservation and cultivation of medicinal plants used in Unani practice.

Significance:

Pharmacognosy ensures the purity, safety, and therapeutic consistency of Unani medicines while facilitating their modernization and international acceptance.

4. Siddha System of Medicine

The Siddha system extensively employs herbs, minerals, and metals in various formulations. Pharmacognosy plays an important role in the quality assurance and scientific validation of Siddha medicines.

Role of Pharmacognosy

- Identification and authentication of medicinal plants used in Siddha.
- Standardization of formulations such as Chooranam, Kudineer, Mathirai, Leghiyam, Parpam, Chendooram, and Mezhugu.
- Evaluation of raw materials using botanical, microscopic, and chemical methods.

- Detection of adulterants and contaminants.
- Phytochemical profiling of medicinal plants.
- Scientific assessment of traditional Siddha formulations.
- Conservation and cultivation of medicinal plant resources.
- Support for quality control and regulatory compliance.

Significance:

Pharmacognosy enhances the scientific credibility and quality assurance of Siddha medicines while preserving traditional therapeutic knowledge.

5. Homeopathy

Homeopathy utilizes medicines prepared from plant, animal, mineral, and other natural sources. Pharmacognosy primarily contributes to the correct identification and quality assessment of natural source materials used in homeopathic preparations.

Role of Pharmacognosy

- Botanical authentication of medicinal plants used for preparing mother tinctures.
- Identification and quality evaluation of crude drugs.
- Standardization of raw materials before potentization.
- Detection of adulteration and substitution.
- Pharmacognostic evaluation through macroscopic, microscopic, and physicochemical studies.
- Cultivation and sustainable collection of medicinal plants.
- Documentation of medicinal plant characteristics.
- Support in establishing pharmacopeial standards for homeopathic drugs.

Significance:

Pharmacognosy ensures that homeopathic medicines are prepared from authentic and standardized source materials, thereby maintaining quality and consistency.

6. Traditional Chinese Medicine (TCM)

Traditional Chinese Medicine (TCM) employs a vast number of medicinal plants along with minerals, fungi, and animal-derived substances. Pharmacognosy is fundamental to the authentication, standardization, and scientific evaluation of these natural medicines.

Role of Pharmacognosy

- Authentication of Chinese medicinal herbs, fungi, minerals, and animal-derived materials.
- Botanical, microscopic, and molecular identification of crude drugs to avoid substitution and adulteration.
- Standardization of TCM formulations such as Tang (decoctions), Wan (pills), San (powders), Keli (granules), Gao (pastes), and Tiegao (plasters).
- Phytochemical screening and isolation of active constituents such as flavonoids, alkaloids, saponins, terpenoids, and polysaccharides.
- Quality control using modern analytical techniques including **HPLC, HPTLC, GC-MS, LC-MS, DNA barcoding,** and chromatographic fingerprinting.
- Evaluation of safety by detecting heavy metals, pesticide residues, microbial contamination, and toxic constituents.
- Scientific validation of traditional formulations through pharmacological and clinical research.
- Conservation, cultivation, and Good Agricultural and Collection Practices (GACP) for Chinese medicinal plants.
- Support for the development of standardized herbal medicines for global healthcare.

Significance:

Pharmacognosy bridges traditional Chinese medicinal knowledge with modern pharmaceutical science by ensuring the identity, purity, quality, safety, and efficacy of TCM drugs, thereby facilitating their acceptance in evidence-based medicine worldwide.

Introduction to Metabolites of Plant Origin & Traditional Systems of Medicine

Multiple Choice Questions (MCQs)

1.

Plant metabolites are:

A. Inorganic compounds only

B. Chemical compounds produced by plants

C. Animal-derived compounds

D. Synthetic compounds

2.

Primary metabolites are directly involved in:

A. Plant defense

B. Plant growth and development

C. Pollination only

D. Drug adulteration

3.

Which of the following is a primary metabolite?

A. Alkaloid

B. Flavonoid

C. Protein

D. Terpenoid

4.

Carbohydrates primarily function as:

A. Defense compounds

B. Energy source and storage materials

C. Pigments

D. Hormones

5.

Lipids are mainly involved in:

A. Structural and energy storage functions

B. Plant coloration

C. Defense only

D. Reproduction only

6.

Secondary metabolites are generally associated with:

A. Growth and reproduction only

B. Plant defense and adaptation

C. Photosynthesis only

D. Respiration only

7.

Which of the following is a secondary metabolite?

A. Glucose

B. Protein

C. Alkaloid

D. Starch

8.

Alkaloids are characterized by the presence of:

A. Sulfur

B. Nitrogen

C. Chlorine

D. Phosphorus

9.

Morphine is classified as:

A. Glycoside

B. Alkaloid

C. Terpenoid

D. Tannin

10.

Glycosides consist of:

A. Protein and lipid

B. Sugar and aglycone

C. Alkaloid and sugar

D. Tannin and lipid

11.

Flavonoids are well known for their:

A. Antioxidant activity

B. Laxative action only

C. Antibiotic action only

D. Sedative action only

12.

Tannins possess:

A. Sweet taste

B. Astringent property

C. Pungent odor

D. Volatile nature

13.

Terpenoids are biosynthesized from:

A. Isoprene units

B. Amino acids only

C. Fatty acids only

D. Sugars only

14.

Volatile oils are responsible for:

A. Aroma of plants

B. Protein synthesis

C. Seed formation

D. Root growth

15.

Resins are generally:

A. Plant exudates

B. Proteins

C. Carbohydrates

D. Vitamins

16.

Which metabolite is responsible for plant defense?

A. Protein

B. Lipid

C. Secondary metabolite

D. Starch

17.

Examples of primary metabolites include:

A. Alkaloids and tannins

B. Carbohydrates and proteins

C. Glycosides and terpenoids

D. Flavonoids and resins

18.

Quinine belongs to:

A. Glycosides

B. Alkaloids

C. Terpenoids

D. Resins

19.

Digitalis contains:

A. Alkaloids

B. Cardiac glycosides

C. Volatile oils

D. Tannins

20.

The study of drugs from natural sources is:

A. Pharmacology

B. Pharmacognosy

C. Pharmaceutics

D. Pathology

21.

AYUSH includes:

A. Ayurveda

B. Yoga & Naturopathy

C. Unani, Siddha, Homeopathy

D. All of the above

22.

TCM stands for:

A. Traditional Chinese Medicine

B. Therapeutic Clinical Medicine

C. Traditional Clinical Method

D. Traditional Complementary Medicine

23.

The basic principle of TCM includes:

A. Gene therapy

B. Yin and Yang balance

C. Organ transplantation

D. Vaccination

24.

Ayurveda emphasizes:

A. Balance of Doshas

B. Genetic modification

C. Radiation therapy

D. Chemotherapy

25.

Which is an AYUSH dosage form?

A. Churna

B. Asava

C. Arishta

D. All of the above

26.

Churna is:

A. Powder dosage form

B. Liquid dosage form

C. Ointment

D. Injection

27.

Asava is:

A. Fermented liquid preparation

B. Tablet

C. Capsule

D. Powder

28.

Arishta belongs to:

A. Fermented preparations

B. Oils

C. Powders

D. Pills

29.

Pharmacognosy contributes to:

A. Drug discovery

B. Herbal drug standardization

C. Traditional medicine validation

D. All of the above

30.

Which system forms part of AYUSH?

A. Siddha

B. Unani

C. Homeopathy

D. All of the above

31.

Proteins are composed of:

A. Amino acids

B. Fatty acids

C. Isoprene units

D. Sugars

32.

Starch is a:

A. Lipid

B. Protein

C. Carbohydrate

D. Alkaloid

33.

Volatile oils are also known as:

A. Fixed oils

B. Essential oils

C. Mineral oils

D. Animal oils

34.

Which compound is known for antioxidant activity?

A. Flavonoids

B. Proteins

C. Lipids

D. Starch

35.

Tannins are commonly used because of their:

A. Astringent action

B. Sedative action

C. Antacid action

D. Expectorant action

36.

Resins are generally insoluble in:

A. Organic solvents

B. Alcohol

C. Water

D. Ether

37.

Secondary metabolites contribute mainly to:

A. Survival and adaptation

B. Cell division only

C. Protein synthesis only

D. Respiration only

38.

Which is NOT a secondary metabolite?

A. Alkaloid

B. Flavonoid

C. Protein

D. Terpenoid

39.

The aglycone part of a glycoside is also called:

A. Genin

B. Starch

C. Protein

D. Sugar

40.

Plant metabolites are useful in:

A. Medicine

B. Cosmetics

C. Nutraceuticals

D. All of the above

41.

The term pharmacognosy was derived from:

A. Greek words

B. Latin words

C. Sanskrit words

D. Arabic words

42.

Homeopathy is included under:

A. AYUSH

B. TCM

C. Allopathy

D. Naturopathy only

43.

The therapeutic value of medicinal plants is mainly due to:

A. Secondary metabolites

B. Water content

C. Minerals only

D. Fibers only

44.

Volatile oils are generally obtained by:

A. Distillation

B. Fermentation

C. Calcination

D. Incineration

45.

Which is a phenolic secondary metabolite?

A. Tannin

B. Starch

C. Protein

D. Lipid

46.

Alkaloids often possess:

A. Pharmacological activity

B. Nutritional value only

C. Structural role only

D. Storage role only

47.

The major role of carbohydrates is:

A. Energy storage

B. Defense

C. Pigmentation

D. Hormonal regulation

48.

TCM originated in:

A. India

B. China

C. Egypt

D. Greece

49.

Ayurveda is based on:

A. Tridosha concept

B. Yin-Yang concept

C. Germ theory

D. Cell theory

50.

Pharmacognosy acts as a bridge between:

A. Traditional medicine and modern medicine

B. Physics and chemistry

C. Anatomy and physiology

D. Botany and zoology

Answer Key

Q. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Answer	B	B	C	B	A	B	C	B	B	B	A	B	A	A	A	C	B	B	B	B	D	A	B	A	D

Q. No.	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Answer	A	A	A	D	D	A	C	B	A	A	C	A	C	A	D	A	A	A	A	A	A	A	B	A	A

Next: Chapter B – Quality Control of Drugs of Natural Origin (WHO Guidelines) (50 MCQs).

2 Marks Questions

Q. No.	**Question**	**Cognitive Domain**
1	Define primary metabolites with one example.	Remembering
2	What are secondary metabolites? Give one example.	Remembering
3	Name any two classes of secondary metabolites.	Remembering
4	What is AYUSH?	Remembering
5	Define Pharmacognosy.	Remembering
6	Apply the knowledge of primary and secondary metabolites to classify different plant constituents with suitable examples.	Applying

7	Analyze the therapeutic significance of flavonoids in medicinal plants with suitable examples.	Analyzing
8	Analyze the importance of alkaloids as plant metabolites in relation to their pharmacological activities.	Analyzing
9	Evaluate the therapeutic significance of a medicinal plant containing both alkaloids and flavonoids, and justify its potential medicinal uses.	Evaluating
10	Design a suitable AYUSH dosage regimen for the management of a chronic disease and justify the selection of the traditional dosage forms.	Creating

5 Marks Questions

Q. No.	**Question**	**Cognitive Domain**
1	Discuss the general properties of plant metabolites.	Understanding
2	Describe primary metabolites with suitable examples.	Understanding
3	Explain secondary metabolites and their classification.	Understanding
4	Write a note on alkaloids and glycosides as plant metabolites.	Remembering
5	Discuss the basic principles of AYUSH systems of medicine.	Understanding
6	Apply the knowledge of primary and secondary metabolites to classify plant constituents with suitable examples.	Applying
7	Analyze the therapeutic importance of flavonoids, tannins, and terpenoids in medicinal plants.	Analyzing
8	Analyze the role of Pharmacognosy in the validation and standardization of traditional systems of medicine.	Analyzing
9	Evaluate how knowledge of secondary metabolites can facilitate the discovery and development of new drugs from medicinal plants.	Evaluating
10	Design a herbal formulation based on AYUSH principles and justify the selection of suitable dosage forms to optimize therapeutic outcomes.	Creating

10 Marks Questions

Q. No.	Question	Cognitive Domain
1	Describe the definition, classification, and general properties of plant metabolites.	Remembering
2	Discuss primary metabolites with respect to carbohydrates, proteins, and lipids.	Remembering
3	Explain the classification and importance of secondary metabolites with suitable examples.	Remembering
4	Write detailed notes on alkaloids, glycosides, flavonoids, tannins, terpenoids, volatile oils, and resins.	Remembering
5	Discuss the basic principles of treatment in AYUSH and Traditional Chinese Medicine (TCM).	Remembering
6	Apply the knowledge of biosynthesis, functions, and medicinal importance to compare primary and secondary metabolites.	Understanding
7	Analyze the therapeutic significance of various classes of secondary metabolites in medicinal plants.	Understanding
8	Analyze the role of Pharmacognosy in the scientific validation and integration of Allopathy, AYUSH, and Traditional Chinese Medicine (TCM).	Understanding
9	Evaluate the potential of secondary metabolites as lead molecules for the development of modern medicines in pharmaceutical research.	Applying
10	Design a strategy for integrating AYUSH and Traditional Chinese Medicine (TCM) with modern healthcare using Pharmacognosy, and justify your approach.	Applying