Pharmacognosy

CHAPTERWISE NOTES

Classification of Crude Drugs

Classification on the basis of Plant family, Animal and Insects classification, Pharmacognostic reagents and their role

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PHARMACOGNOSY

Classification of Crude Drugs

➤ Classification of Crude Drugs:

Criteria for Classification: A good classification system should be:

- **Simple**
- **Easy to use**
- **Free from confusion and ambiguities**

➤ Type of Classfication:

Alphabetical classification ↓
Drugs listed in alphabetical order. Simple but lacks relationships between drugs

Taxonomical classification ↓
Based on scientific classification (family, genus, species). Focuses on biological relationships.

Morphological classification ↓
Based on physical characteristics (e.g., shape, size).

Pharmacological classification ↓
Groups by therapeutic action (e.g., analgesics, antipyretics)

Chemical classification ↓
Based on chemical composition (e.g., alkaloids, terpenoids)

Chemo-taxonomical classification ↓
Combines chemical properties and taxonomic relationships.

Sero-taxonomical classification ↓
Based on biological markers or specific characteristics to define plant taxonomy.

Classification Type	Definition	Examples
Alphabetical Classification	Drugs arranged in alphabetical order (Latin, English, or vernacular names).	Acacia, Benzoin, Cinchona, Dill, Ergot, Fennel, Opium, Senna.
Taxonomical Classification	Classification based on morphological, microscopical, and genetic characteristics.	Kingdom: Plants, Family: Asteraceae, Genus: Tridax.
Morphological Classification	Categorizes based on external characteristics of plant or animal parts.	Organized: Leaves (Senna), Roots (Aconite); Unorganized: Gums (Acacia), Waxes (Beeswax).
Pharmacological Classification	Grouped by pharmacological action or therapeutic use.	Cardiovascular: Digitalis, Antimalarial: Cinchona, CNS depressant: Opium.
Chemical Classification	Based on active chemical constituents (alkaloids, glycosides, etc.).	Alkaloids: Morphine (Opium), Glycosides: Digitalis (Foxglove).
Chemo-taxonomical Classification	Based on chemical similarity to define plant relationships (specific secondary metabolites).	Tropane alkaloids in Solanaceae, Berberine in Berberis.
Sero-taxonomical Classification	Uses serology (antigen-antibody reactions) for classification.	Antibodies derived from plant proteins for comparison.

(A) Alphabetical Classification of Crude Drugs:

- **Definition:** Crude drugs are arranged in **alphabetical order** of their **Latin, English,** or **vernacular names.?**
- **References**:
  - Indian Pharmacopoeia
  - British Pharmacopoeia
  - British Herbal Pharmacopoeia
  - United States Pharmacopoeia (USP)
  - European Pharmacopoeia
  - British Pharmaceutical Codex
- **Merits:**
  - **Simple** and **quick** to use.
  - No **repetition** of entries.
  - **Easy to locate,** trace, and add drug entries.
- **Demerits:**

  No **relationship** between consecutive drug entries.

  Examples: Acacia, Benzoin, Cinchona, Dill, Ergot, Fennel, Gentian, Hyoscyamus, Ipecacuanha, Jalap, Kurchi, Liquorice, Mints, Nux vomica, Opium, Podophyllum, Quassia, Rauwolfia, Senna, Vasaka, Wool fat, Yellow beeswax, Zeodary.

Official and Unofficial Drugs:

In pharmacognosy, drugs are classified into **official** and **unofficial** categories based on their recognition by regulatory authorities and their inclusion in pharmacopeias.

Official Drugs:

Definition: Official drugs are those that are recognized by national or international pharmacopoeias (such as the Indian Pharmacopoeia (IP), United States Pharmacopeia (USP), and British Pharmacopoeia (BP)).

Characteristics:

- They have a standard definition, quality, and consistency.
- These drugs are legally required to be used in medical practice.
- They undergo rigorous testing for identity, purity, potency, and quality.

Examples:
- **Aloe** (*Aloe vera*)
- **Opium** (*Papaver somniferum*)
- **Cinchona** (*Cinchona officinalis*)
- **Senna** (*Senna alexandrina*)

Unofficial Drugs:

- **Definition:** Unofficial drugs are those that are not recognized in official pharmacopeias but may still be used in medical practice, traditional medicine, or herbal medicine.
- **Characteristics:**
  - These drugs may not meet the strict standards of official drugs.

- They may lack standardization and consistent quality.
- They are typically derived from local or folk medicine and might not be tested according to pharmacopoeial standards.

Examples:
- **Ginseng** (*Panax ginseng*)
- **Echinacea** (*Echinacea purpurea*)
- **St. John's Wort** (*Hypericum perforatum*)

(B) Taxonomical Classification of Crude Drugs:

- Taxonomical classification is a system used to categorize plants based on their **morphological, microscopical, chemical, embryological, serological, and genetic characteristics.**
- The classification is hierarchical, ranging from Kingdom down to Cultivar. It helps in understanding the evolutionary relationships among plants.

Classification Hierarchy:

1. **Kingdom:** Plantae – All plants belong to this kingdom.
2. **Subkingdom:** Tracheobionta – Vascular plants (have specialized tissue for conducting water and nutrients).
3. **Superdivision:** Spermatophyta – Seed plants.
4. **Division:** Magnoliophyta – Flowering plants (Angiosperms). Gymnospermae – Non-flowering seed plants (Gymnosperms).
5. **Class**
   5.1. Angiospermae – Flowering plants.
   5.2. Gymnospermae – Non-flowering plants (used in some systems as a class instead of division).
6. **Subclass**
   6.1. Dicotyledonae – Dicots (plants with two seed leaves).
   6.2. Monocotyledonae – Monocots (plants with one seed leaf).
7. **Superorder:** ***Example:*** Asteridae, Rosidae – Groups of related plant families.
8. **Order:** ***Example:*** Asterales – Contains related families.
9. **Family:** ***Example:*** Asteraceae – Plants sharing common botanical features.
10. **Subfamily:** Further divisions within a family. Example: Subfamilies within Asteraceae.
11. **Tribe:** A division within a subfamily based on smaller botanical differences.
12. **Subtribe:** A more refined division, mostly for specialist use.
13. **Genus:** ***Example:*** Tridax – A group of species with similar traits.
14. **Species:** ***Example:*** *Tridax procumbens* – A specific plant within the genus.
15. **Variety:** ***Example:*** Variation within a species, like flower color.
16. **Form:** Minor differences in physical appearance, such as leaf shape or size.
17. **Cultivar:** A cultivated variety, selected for specific traits and maintained through cultivation.

Examples:
- **Kingdom:** Plants
- **Subkingdom:** Tracheobionta (vascular plants)
- **Superdivision:** Spermatophyta (seed plants)

- **Division:** Magnoliophyta (flowering plants)
- **Class:** Magnoliopsida (Dicotyledons)
- **Subclass:** Asteridae
- **Order:** Asterales
- **Family:** Asteraceae (Aster family)
- **Genus:** Tridax L.
- **Species:** Tridax L.

➤ **Merits:**

✶ **Evolutionary Studies:** Helps trace the evolutionary development of plants and their interrelations.

➤ **Demerits:**

✶ **Chemical-Biological Activity Link:** This system does not correlate the chemical constituents of plants with their biological activities, making it less useful in pharmacological research.

➤ **(C) Morphological Classification of Crude Drugs:**

✶ Morphological classification categorizes drugs based on the external characteristics of plant or animal parts used in the drug.

✶ It distinguishes between organized and unorganized drugs, depending on whether cellular plant tissues are present.

1. Organized Drugs:

Drugs derived from specific plant parts that contain cellular tissues.

Examples include:

Category	Plant/Material
Woods	Quassia, Sandalwood, Red Sandalwood
Leaves	Digitalis, Eucalyptus, Mint, Senna
Barks	Arjuna, Ashoka, Cascara, Cinnamon
Flowers	Clove, Saffron, Chamomile
Fruits	Amla, Anise, Bael, Tamarind
Seeds	Bitter Almond, Black Mustard, Nutmeg
Roots and Rhizomes	Aconite, Ashwagandha, Ginger, Turmeric
Plants and Herbs	Ergot, Ephedra, Bacopa
Hair and Fibers	Cotton, Hemp, Silk

2. Unorganized Drugs:

Drugs that are obtained through intermediate physical processes, like drying or extraction, and lack cellular tissues.

Examples include:

Category	Materials
Dried Latex	Opium, Papain
Dried Juices	Aloe, Kino
Extracts	Agar, Pectin
Waxes	Beeswax, Spermaceti
Gums	Acacia, Guar gum
Resins	Asafoetida, Benzoin
Volatile Oils	Turpentine, Anise, Eucalyptus
Fixed Oils and Fats	Castor, Coconut, Olive
Animal Products	Honey, Gelatin, Beeswax
Minerals	Bentonite, Kaolin, Talc

➤ **Merits:**

- **Adulteration Detection:** Useful for identifying and detecting adulteration of crude drugs.
- **Practical Use:** Convenient for study, especially when the chemical composition of drugs is not fully understood.

➤ **Demerits:**

- **Lack of Chemical-Action Correlation:** This system does not correlate the chemical constituents with the therapeutic actions of the drugs.
- **Repetition:** Some plants or drugs may be repeated in different categories, leading to redundancy.

➤ **(D) Pharmacological Classification of Crude Drugs:**

- Pharmacological classification groups drugs based on their pharmacological action, the therapeutic use, or the most important constituent.
- This system is widely used in practice, as it is based on the drug's effect on the body rather than its plant origin or chemical components.
- For example, drugs like digitalis, squill, and strophanthus are classified together for their cardiotonic effects, irrespective of their plant part or phytoconstituents.

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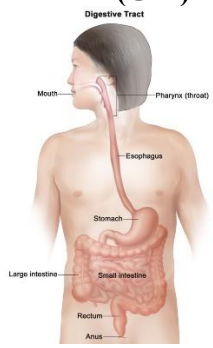
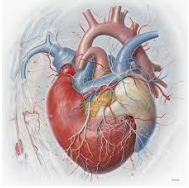
✴ Pharmacological Categories & Examples:

System	Category	Drugs / Sources
Gastrointestinal Tract (GIT) 	Bitter	Cinchona, Quassia, Gentian
	Carminative	Fennel, Cardamom, Mentha
	Emetic	Ipecac
	Antiamoebic	Kurchi, Ipecac
	Laxative	Agar, Isabgol, Banana
	Purgative	Senna, Castor oil
	Cathartic	Senna
Respiratory System 	Expectorant	Vasaka, Liquorice, Ipecac
	Antitussive	Opium (Codeine)
	Bronchodilator	Ephedra, Tea
Cardiovascular System 	Cardiotonic	Digitalis, Strophanthus, Squill
	Cardiac depressant	Cinchona, Veratrum
	Vasoconstrictor	Ergot
	Antihypertensive	Rauwolfia
Autonomic Nervous System 	Adrenergic	Ephedra
	Cholinergic	Physostigma, Pilocarpus
	Anticholinergic	Datura, Belladonna
Central Nervous System (CNS) 	Central Analgesic	Opium (Morphine)
	CNS Depressant	Belladonna, Opium, Hyoscyamus
	CNS Stimulant	Tea, Coffee
	Analeptic	Nux vomica, Camphor, Lobelia
	Antispasmodic	Datura, Hyoscyamus, Opium, Curare
Others	Anticancer	Vinca, Podophyllum, Taxus
	Antirheumatic	Aconite, Colchicum, Guggal
	Anthelmintic	Quassia, Vidang

	Astringent	Catechu, Myrobalans
	Antimalarial	Cinchona, Artemisia
	Immunomodulatory	Ginseng, Ashwagandha, Tulsi
	Immunizing Agents	Vaccines, Sera, Antitoxins
	Drugs on Skin Membranes	Beeswax, Wool fat, Balsam of Tolu
	Chemotherapeutic Agents	Antibiotics
	Local Anesthetic	Coca

➤ **Merits:**

✶ **Substitute Suggestions:** This system can help suggest substitutes for drugs, especially when a particular drug is unavailable.

➤ **Demerits:**

✶ **Ambiguity and Confusion:** Some drugs may fit multiple categories based on different actions, leading to confusion.

✶ For example, Cinchona is classified as antimalarial due to quinine but could also be placed under cardiovascular drugs due to its antiarrhythmic effects from quinidine.

➤ **(E) Chemical Classification:**

✶ Depending upon the active constituents, the crude drugs are classified. The plants contain various constituents in them like alkaloids, glycosides, tannins, carbohydrates, saponins, etc.

✶ Irrespective of the morphological or taxonomical char-acters, the drugs with similar chemical constituents are grouped into the same group. The examples are shown in this table.

S. No.	Chemical constituent group	Examples
1.	**Alkaloids**	Cinchona, Datura, Vinca, Ipecac Nux vomica
2.	**Glycosides**	Senna, Aloe, Ginseng, Glycyrrhiza, Digitalis
3.	**Carbohydrates and its derived products**	Acacia, Tragacanth, Starch, Isabgol
4.	**Volatile oil**	Clove, Coriander, Fennel, Cinnamon, Cumin
5.	**Resin and Resin combination**	Benzoin, Tolu Balsam, Balsam of peru
6.	**Tannins**	Catechu, Tea
7.	**Enzymes**	Papain, Caesin, Trypsin
8.	**Lipids**	Beeswax, Kokum butter, Lanolin

➤ **Merits:**

✶ It is a popular approach for phytochemical studies.

➤ **Demerits:**

✶ Ambiguities arise when particular drugs possess a number of compounds belonging to different groups of compounds.

➤ (F) Chemotaxonomical Classification:

- ✶ Chemotaxonomical classification is based on the chemical similarity between different plants, focusing on the presence of specific chemical constituents that characterize certain plant families or genera.
- ✶ This system uses the chemical composition of plants to determine their taxonomic relationships, status, and evolutionary lineage.
- ✶ **Concept:** The classification system relies on identifying certain secondary metabolites or compounds that are unique to specific plant groups. These chemical markers help in understanding the evolutionary relationships between plants.
  - **Examples:**
    - ○ **Tropane alkaloids** are found in plants of the *Solanaceae* family, serving as a chemotaxonomic marker.
    - ○ **Berberine alkaloid** is present in plants like *Berberis* and *Argemone*.
    - ○ **Rutin** is found in members of the *Rutaceae* family.
    - ○ **Ranunculaceae alkaloids** are characteristic of the *Ranunculaceae* family.
- ✶ **Significance:** Chemotaxonomy aids in understanding the biosynthesis of plant chemicals and their potential therapeutic effects, making it an important tool in modern plant classification and pharmacognosy.

➤ Serotaxonomical Classification:

- ✶ **Serotaxonomy** refers to the application of serology to solve taxonomical problems.
- ✶ Serology is the study of antigen-antibody reactions, where **antigens** stimulate the production of **antibodies**—specific proteins produced by plasma cells in the immune system.
- ✶ **Antigens:** Substances that trigger the production of antibodies.
- ✶ **Antibodies:** Specific proteins produced by the immune system in response to antigens.

In serotaxonomy, **proteins** are commonly used as antigens, carrying taxonomical information. This technique is used to compare **non-morphological characteristics** (like proteins) to help classify plants and resolve taxonomical relationships.

➤ Key Points:

1. **Similarity & Dissimilarity:** Serotaxonomy identifies the similarities and differences among various taxa (species, genera, families) based on antigen-antibody reactions.
2. **Protein Comparison:** This method helps compare proteins from different plant taxa, providing valuable data for classification.
3. **Non-Morphological Data:** Unlike traditional morphology-based classification, serotaxonomy relies on protein-based data, offering an additional layer of information in taxonomy.

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Classification of Crude Drugs Based on Plant Families

1. Solanaceae

Biological Source	Uses
Nicotiana tabacum (Tobacco)	Smoking, nicotine replacement therapy
Atropa belladonna (Belladonna)	Anti-cholinergic, mydriatic
Solanum tuberosum (Potato)	Food, starch source
Capsicum annuum (Chilli)	Rubefacient, pungent agent (capsaicin)
Datura stramonium (Datura)	Anti-asthmatic, anti-spasmodic
Solanum lycopersicum, Solanum melongena (Tomato, Eggplant)	Food
Duboisia myoporoides	Mydriatic (used in eye preparations)
Hyoscyamus niger (Henbane)	Anti-spasmodic, sedative
Withania somnifera (Ashwagandha)	Adaptogen, anti-stress, immunomodulator

2. Liliaceae (Note: Many species now reclassified into Amaryllidaceae and Asparagaceae)

Biological Source	Uses
Colchicum autumnale (Colchicum)	Anti-gout (colchicine)
Aloe barbadensis (Aloe vera)	Laxative (anthraquinones), wound healing
Urginea indica / Drimia maritima (Indian/European Squill)	Cardiotonic (scillaren A)
Allium cepa (Onion)	Hypoglycemic, anti-atherosclerotic
Allium sativum (Garlic)	Anti-hypertensive, lipid-lowering

3. Umbelliferae (Apiaceae)

Biological Source	Uses
Cuminum cyminum (Cumin)	Carminative, digestive
Apium graveolens (Celery)	Carminative, flavouring
Coriandrum sativum (Coriander)	Carminative, digestive
Carum carvi (Caraway)	Carminative, digestive
Ferula asafoetida (Asafoetida)	Anti-flatulent, expectorant
Foeniculum vulgare (Fennel)	Galactagogue, antispasmodic
Anethum graveolens (Dill)	Carminative, digestive

4. Gramineae (Poaceae)

Biological Source	Uses
Zea mays (Corn starch/oil)	Binder in tablets, food source
Oryza sativa (Rice bran oil)	Edible oil, antioxidant
Triticum aestivum (Wheat germ oil)	Edible oil, antioxidant
Cymbopogon winterianus (Citronella)	Mosquito repellent
Cymbopogon citratus (Lemongrass)	Antiseptic, flavouring
Cymbopogon martini (Palmarosa)	Anti-bacterial, perfumery
Vetiveria zizanioides (Vetiver)	Cooling agent, fragrance

5. Zingiberaceae

Biological Source	Uses
Zingiber officinale (Ginger)	Anti-emetic, anti-inflammatory
Elettaria cardamomum (Cardamom)	Carminative, flavouring
Alpinia galanga (Chinese Ginger)	Digestive stimulant

6. Fabaceae (Leguminosae)

Biological Source	Uses
Cassia angustifolia (Senna)	Stimulant laxative
Sesbania grandiflora	Fodder, green manure
Saraca asoca (Ashoka)	Uterine tonic
Acacia arabica (Acacia)	Demulcent, astringent
Glycyrrhiza glabra (Liquorice)	Anti-ulcer, demulcent
Psoralea corylifolia	Used for vitiligo, photosensitizer
Abrus precatorius (Abrus)	Used in homeopathy, toxic seeds
Tephrosia purpurea	Hepatoprotective, studied for anticancer properties
Various pulses (e.g. lentils, chickpeas)	Protein source
Myroxylon spp. (Peru & Tolu Balsam)	Expectorant, flavouring, fragrance

7. Myristicaceae

Biological Source	Uses
Myristica fragrans (Nutmeg)	Carminative, flavouring, mild sedative

8. Podophyllaceae

Biological Source	Uses
Podophyllum peltatum (Mayapple)	Cytotoxic (podophyllotoxin → anticancer drugs like etoposide)

9. Iridaceae

Biological Source	Uses
Crocus sativus (Saffron)	Colouring agent, anti-depressant, anti-spasmodic

10. Myrtaceae

Biological Source	Uses
Melaleuca alternifolia (Tea tree oil)	Antiseptic, antifungal
Syzygium aromaticum (Clove)	Dental analgesic (eugenol), antiseptic
Eucalyptus globulus (Eucalyptus)	Expectorant, decongestant

Classification of Crude Drugs Based on Family (Insects/Animals)

Sr. No.	Family	Biological Source	Uses
1	**Apidae**	***Honey Bee (Apis spp.) → Honey, Beeswax***	•**Honey:** Sweetener, demulcent, wound healing, anti-oxidant •**Beeswax:** Ointment base, coating agent
2	**Bombycidae**	***Silk Worm (Bombyx mori) → Silk***	Used in ophthalmic surgery (sutures), cosmetics, textile
3	**Bovidae**	***Cattle → Suet, Hydrous wool fat (Lanolin), Fat wool, Chymotrypsin, Rennin, Trypsin***	•**Lanolin:** Topical emollient, skin protectant •**Enzymes:** Digestive aid, clotting agent, clinical use in surgery
4	**Castoridae**	***Castor → Castoreum***	Used as natural flavouring, fixative in perfumes, medicine
5	**Coccidae**	***Cochineal Insect (Dactylopius coccus)***	Source of carmine dye (natural dye), used in food and cosmetics
6	**Elapidae**	***Snake → Cobra venom (Naja naja)***	Blood coagulation studies, antivenom production, research
7	**Clupeidae**	***Fish (Clupea spp.) → Protamine sulfate***	Anti-coagulant, antidote (heparin reversal), anti-inflammatory

8	**Gadidae**	***Cod fish → Cod liver oil***	Vitamin A & D supplement, bone health, rheumatoid arthritis, anti-inflammatory
9	**Hirudinidae**	***Leech (Hirudo medicinalis)***	Used in microsurgery for bloodletting, anticoagulation, improving blood flow (prevents clotting)
10	**Lacciferidae**	***Lac insect (Laccifer lacca) → Shellac***	Tablet coating, varnishes, adhesives, paint industry
11	**Meloidae**	***Spanish fly (Cantharis vesicatoria) → Cantharidin***	Aphrodisiac (historically), topical veterinary use, wart treatment
12	**Physeteridae**	***Sperm whale → Spermaceti, Ambergris***	• **Spermaceti:** Used in ointment base, candle wax • **Ambergris:** Perfume fixative
13	**Pleuronectidae**	***Halibut fish → Halibut liver oil***	Rich source of Vitamin A and D, used in bone health
14	**Salmonidae**	***Salmon fish → Protamine sulfate***	Heparin antidote (similar to Clupeidae)
15	**Viverridae**	***African civet (Civettictis civetta) Civet cat → Civet*** ***Asian palm civet→ Civet***	• **African civet:** Used in perfumes as fixative, very expensive. • **Asian palm civet**: used in specialty coffee Kopi Luwak production

Pharmacognostic Reagents and Their Roles

Pharmacognostic Reagent	Role / Use
Alcohol	Preservative, Decolourising agent.
Glycerine	Humectant, mounting agent (maintains humidity & moisture)
Chloral hydrate	Clearing agent (dissolves chlorophyll, used in plant tissue microscopy)
Chromic acid solution	Disintegrating and isolating agent, Strong oxidizer; used carefully due to corrosiveness.
Picric acid	Astringent, due to explosive and toxic nature, now less commonly used.
Phloroglucinol + HCl	Test for lignin (stains lignified tissues red)
Sudan III / Sudan IV	Stains fixed oils and fats (orange-red colour)
Iodine solution	Test for starch (blue-black colour)

Dragendorff's reagent	Test for alkaloids (orange-red ppt)
Mayer's reagent	Test for alkaloids (cream-colored ppt)
Wagner's reagent	Test for alkaloids (brown/reddish ppt)
Ferric chloride ($FeCl_3$)	Test for phenolic compounds and tannins (blue, green or black color)
Vanillin-HCl reagent	Test for tannins and catechins, specifically reacts with **condensed tannins** (catechins); not effective for hydrolysable tannins.
Ninhydrin reagent	Test for amino acids (purple color)
Aniline sulfate	Test for lignin (yellow color)
Ruthenium Red	Test for mucilage (pink color)
Dilute HCl / H_2SO_4	Test for calcium oxalate crystals (dissolves crystals)

Marine Products: Novel Medicinal Agents From Marine Sources

➤ Introduction:

- ✶ Marine pharmacognosy is the study of naturally occurring substances of medicinal value from marine sources. The oceans cover over 70% of the Earth's surface, hosting diverse organisms with medicinal potential.
- ✶ Ancient civilizations (Greece, Japan, China, India) have long recognized the therapeutic value of marine life. Western medicine has derived compounds like agar, carrageenan, cod liver oils, and protamine sulphate from marine sources.

➤ Importance of Marine Organisms in Drug Discovery:

- ✶ The oceans contain over 200,000 invertebrates and algal species, many of which have biological activities.
- ✶ Marine organisms provide diverse compounds, including terpenes, peptides, alkaloids, and polyketides, which have antimicrobial, anti-inflammatory, anticancer, and other therapeutic potentials.
- ✶ Despite the vast resource, marine products remain underutilized compared to terrestrial drugs.

Key Categories of Marine-Derived Therapeutic Agents

Category	Compound(s)	Source	Activity/Use
Antiviral Agents	Ara-A (Vidarabine)	***Tethya crypta (sponge)***	Herpesvirus treatment
	Eudistomins	***Eudistoma olivaceum (ascidian)***	Antiviral (β-carboline derivatives)
	Didemnins	***Trididemnum spp. (tunicate)***	Antiviral and antitumor

	Avarol, Avarones	***Disidea avara (sponge)***	Anti-HIV activity
	Patellazole B	***Lissoclinum patella (ascidian)***	Effective against Herpes simplex virus
	Fucoidan	***Laminaria (brown algae)***	Anti-HIV and anti-herpes activity
Antimicrobial Agents	Various compounds	***Sponges, algae, corals***	Broad-spectrum activity (bacteria, fungi, protozoa)
Antiparasitic Agents	α-Kainic Acid	***Digenia simplex (red algae)***	Anthelmintic against roundworms/tapeworms
	Domoic Acid	***Chondria armata (red algae)***	Anthelmintic activity
	Laminine	***Marine algae***	Antiparasitic, hypotensive, muscle relaxant
	Bengamide F	***Marine sponge***	Strong antiparasitic activity
	Cucumechinoside F	***Sea cucumber***	Antiprotozoal activity
Anticancer Agents	Ara-C (Cytarabine)	***Cryptotethya crypta (sponge)***	Used for leukemia (Cytosar)
	Bryostatin I	***Bugula neritina (bryozoan)***	Potent antineoplastic activity
Antispasmodics	Agelasidine A	***Agelas sp. (sponge)***	Antispasmodic with guanine and sulfone units
Cardiovascular Agents	Eledoisin	***Eledone moschata (cephalopod)***	Potent vasodilator and hypotensive (50× stronger than ACh)
	Octopamine	***Octopus vulgaris***	Cardiotonic activity
	Laminine	***Laminaria angustata***	Hypotensive effect
Anti-inflammatory	Bio-indoles	***Rivularia firma (cyanobacteria)***	Anti-inflammatory activity
	Butanolides	***Euplexaura flava (gorgonian coral)***	Anti-inflammatory effects
	Carrageenan	***Chondrus crispus (red algae)***	Used in inflammation models (research)
Insecticides	Nereistoxin, Cartap	***Lumbriconereis heteropoda (annelid)***	Insecticidal (Cartap used in Japan)

Anticoagulants	Carrageenans	***Chondrus crispus***	Inhibits thrombin
	Fucoidan	***Fucus vesiculosus (brown algae)***	Anticoagulant via heparin cofactor II
Prostaglandins	Prostaglandins (PGE2, PGF2α)	***Plexaura homomalla, Gracilaria lichenoides***	Various therapeutic effects
	Punaglandin	***Telesto riisei (coral)***	Anti-tumor activity (halogenated prostanoid)
	Chlorovulone I	***Clavularia viridis (coral)***	Antiproliferative (leukemia cells)
Marine Toxins	Tetrodotoxin	***Pufferfish, marine species***	Neurotoxin, used experimentally in cardiovascular/neuro studies
	Saxitoxin	***Saxidomus giganteus (clam)***	Hypotension at low doses
	Ciguatoxin	***Gambierdiscus toxicus (dinoflagellate)***	Causes ciguatera; affects heart and nerves
	Maitotoxin	***Gambierdiscus toxicus***	Potent calcium channel activator
	Holothurin A	***Helix pomatia (sea cucumber)***	Hemolytic and neurotoxic
	Aplysins	***Aplysia depilans (sea hare)***	Toxic; causes paralysis in cold-blooded animals
	Lophotoxin	***Lophogorgia (coral)***	Irreversible neuromuscular blockade
	Lyngbyatoxin, Debromoaplysiatoxin	***Lyngbya majuscula (cyanobacteria)***	Dermatitis (“swimmer’s itch”), antineoplastic (derivatives)