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Introduction to Pharmacognosy

BP105T — B.Pharm Semester I

Concept Mastery Notes

Deep concepts for GPAT & competitive exams — nothing missed

As per PCI B.Pharm (NEP 2020) syllabus

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BP105T — Introduction to Pharmacognosy

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Unit I — Fundamentals of Pharmacognosy

What pharmacognosy actually is

Pharmacognosy is the scientific study of crude drugs obtained from natural sources — plants, animals, minerals, microbes and marine organisms — covering their history, cultivation, collection, processing, storage, identification, evaluation and therapeutic use.

The word comes from Greek: pharmakon (drug) + gnosis (knowledge). The term was first used by C. A. Seydler in 1815 in his work *Analecta Pharmacognostica*. That name-and-year pair is a permanent 2-mark question; learn it the way you learn a phone number.

A crude drug is the dried, unprepared natural material used as medicine — leaves, bark, roots, seeds, gums, resins, oils. "Crude" does not mean low quality; it means the material has not been processed into a purified chemical. Senna leaflets in a sack at a mandi are a crude drug. Digoxin tablets are not — digoxin is a pure compound isolated from a crude drug (*Digitalis*).

GPAT angle: Examiners love asking who coined "pharmacognosy" (Seydler, 1815) right next to who isolated the first alkaloid (Sertürner, morphine, 1804). The two dates sit close together and students mix them up. Keep them separate: 1815 = the word, 1804 = the first isolated alkaloid.

A short history of the subject (and why it matters for exams)

Pharmacognosy did not start in a laboratory. It started wherever humans chewed a leaf and noticed something happen. The milestones below are the ones your syllabus names — but knowing the story behind each makes them stick.

- Ancient roots. Egypt's Ebers Papyrus (~1550 BCE) lists hundreds of plant remedies. In India, the Charaka Samhita and Sushruta Samhita codified Ayurvedic plant use. China had Shen Nung's herbal (~2700 BCE). In the Greco-Roman world, Dioscorides wrote *De Materia Medica* (~78 CE, about 600 plants) and Galen developed methods of preparing plant medicines — preparations still called galenicals.
- The isolation era (1800s). Sertürner's morphine (1804) proved that a plant's activity lives in one chemical compound, not in some vague "plant spirit". That single idea created modern pharmacognosy — and eventually the whole pharmaceutical industry.
- The dip (mid-1900s). Synthetic chemistry took over. Why grow foxglove when you can synthesize drugs in a factory? Pharmacognosy departments shrank; the subject looked old-fashioned.

- The revival (1960s to today). Four things brought it back: (1) microbes and tumours started resisting synthetic drugs; (2) patients worried about synthetic side effects; (3) the WHO formally backed traditional medicine (Alma-Ata, 1978); (4) plant-derived blockbusters — reserpine, vincristine, taxol, artemisinin — proved nature still invents molecules chemists cannot easily design. Tu Youyou's 2015 Nobel Prize for artemisinin was pharmacognosy's loudest comeback announcement.

Present status: roughly half of all modern drugs trace back to a natural product or a natural-product-inspired structure. Drug discovery pipelines still screen plant, marine and microbial extracts because evolution has spent millions of years doing the "medicinal chemistry" for us.

Scope — where a pharmacognosist actually works

Area	What the work looks like
Herbal industry	Raw-material identification, QC of incoming crude drugs, standardizing extracts so every batch matches
Drug discovery	Screening extracts, isolating leads (the taxol and artemisinin route)
Regulation	Writing and enforcing pharmacopoeial monographs, catching adulteration
Traditional medicine	Scientific validation of Ayurveda, Unani, Siddha formulations — proving what the texts claim
Academia & research	Tissue culture, biosynthesis studies, chemotaxonomy, herb-drug interaction research

Sources of drugs — the six your syllabus names

Learn this as a 6-row table. Examiners ask: "Give one example of a drug from each natural source."

Source	Meaning	Example (and why it fits)
Plants	Whole plant or parts — leaf, bark, root, seed, flower, fruit	Senna leaf (laxative sennosides); Cinchona bark (quinine)
Animals	Animal products, secretions, organs	Honey (demulcent, wound dressing); cod-liver oil (vitamins A & D); musk (perfume/fixative)
Microbial	Antibiotics and metabolites from bacteria and fungi	Penicillin (<i>Penicillium notatum</i>); streptomycin (<i>Streptomyces griseus</i>)

Source	Meaning	Example (and why it fits)
Marine	Drugs from sea organisms	Agar (red algae <i>Gelidium</i> spp. — laxative, microbiology cultures); carrageenan; anticancer leads from sponges and tunicates
Mineral	Inorganic substances used as drugs	Talc (dusting-powder base); kaolin (adsorbent in diarrhoea); bentonite (suspending agent)
Plant tissue culture	Drugs produced by growing plant cells/tissues in sterile lab conditions	Shikonin (from <i>Lithospermum</i> cell cultures — wound-healing naphthoquinone)

Plant tissue culture — worth a deeper look

The logic rests on totipotency: a single plant cell carries the full genetic programme, so in principle it can make every compound the whole plant makes. In practice you grow callus (undifferentiated cell mass) or cell suspensions in flasks, sometimes "hairy root" cultures using *Agrobacterium rhizogenes*, and you can push production up with elicitation (adding stress signals like jasmonic acid that trick cells into making more defensive secondary metabolites).

Why bother? Uniform, contamination-free supply; no dependence on season or climate; a lifeline for slow-growing or endangered species (imagine harvesting enough Pacific yew bark for the world's taxol — the tree would go extinct). Limits: expensive, contamination-prone, and scaling from flask to factory fermenter is genuinely hard. That is why tissue culture today supplements rather than replaces field cultivation.

Trap alert: Students write "tissue culture gives identical drugs to the plant". Not always — cultured cells sometimes make different or lower amounts of metabolites because the whole-plant environment (light, microbes, stress) is missing. Elicitation exists precisely to fix this.

Historical milestones in drug discovery — the syllabus eight

This is a favourite 5-mark question: drug → biological source → discoverer/year → significance. Learn the story, not just the row.

Drug	Source	The milestone
Morphine	Opium, <i>Papaver somniferum</i>	Isolated by Sertürner (1804) — the first alkaloid ever isolated. Proved plant activity sits in a single compound. Named after Morpheus, god of dreams. Strong analgesic.

Drug	Source	The milestone
Quinine	Cinchona bark	Isolated by Pelletier and Caventou (1820). First effective antimalarial; legend traces it to the Countess of Chinchon cured by "Jesuit's bark" in Peru. Led to synthetic antimalarials like chloroquine.
Aspirin	Willow bark (salicin → salicylic acid)	Hoffmann at Bayer (1897) acetylated salicylic acid → acetylsalicylic acid. The first semi-synthetic blockbuster: anti-inflammatory, antipyretic, antiplatelet (COX inhibition).
Warfarin	Spoiled sweet clover (dicoumarol)	Karl Link (University of Wisconsin) traced a cattle bleeding disease to dicoumarol formed in spoilt Melilotus hay. Warfarin = WARF (Wisconsin Alumni Research Foundation) + coumarin. First a rat poison, then an anticoagulant.
Penicillin	Penicillium notatum mould	Fleming (1928) saw the mould killing staphylococci; Florey and Chain turned it into a medicine in WWII. Started the antibiotic era; Nobel 1945.
Cephalosporin	Cephalosporium acremonium (now Acremonium chrysogenum), fungus from Sardinian seawater	Brotzu isolated it; Florey and Abraham developed it. Gave the whole cephalosporin antibiotic family — the answer when patients are penicillin-allergic.
Taxol (paclitaxel)	Bark of Pacific yew, Taxus brevifolia	Wani and Wall (1971) via the US National Cancer Institute's plant-screening programme. Anticancer (ovarian, breast) that stabilizes microtubules. The supply crisis (stripping bark kills the tree) forced semi-synthesis from needles — a sustainability lesson.
Artemisinin	Sweet wormwood, Artemisia annua ("qinghao")	Tu Youyou (Project 523) followed Ge Hong's 4th-century Chinese text and used cold ether extraction — heat destroys the endoperoxide bridge that kills the malaria parasite. Nobel Prize 2015. Backbone of ACT (artemisinin combination therapy).

GPAT angle: Three Nobel-linked facts get asked repeatedly: Fleming/Florey/Chain (1945, penicillin), Tu Youyou (2015, artemisinin), and the Wani-Wall/taxol NCI screening story. Also remember why cold extraction mattered for artemisinin — it tests whether you understand the chemistry (heat-labile endoperoxide), not just the history.

Six systems of crude-drug classification

Alphabetical <i>Basis: Latin/English name, A to Z</i> Use: quick dictionary-style lookup Fails: neighbours unrelated; unscientific	Morphological <i>Basis: plant part used (organized vs unorganized)</i> Use: practical ID of the part in hand Fails: chemically unrelated drugs share a group	Taxonomical <i>Basis: botanical family / genus / species</i> Use: shows evolutionary relationships Fails: needs botanical expertise; chemistry ignored
Chemical <i>Basis: main active constituent class</i> Use: links chemistry to action (exam favourite) Fails: drugs with two constituent classes fit nowhere	Pharmacological <i>Basis: therapeutic action / effect</i> Use: action-oriented; doctor/pharmacist friendly Fails: drugs with two actions confuse; chemistry lost	Chemotaxonomic <i>Basis: chemistry as a taxonomic marker</i> Use: catches adulteration; finds new sources Fails: costly lab analysis; not a routine tool

Six systems of crude-drug classification compared

Herbal and traditional pharmacopoeias

A pharmacopoeia is an official book of drug standards: it fixes a drug's identity, the tests it must pass, and how pure it must be. The syllabus names six — learn one line on each:

- 1 Indian Pharmacopoeia (IP) — published by the Indian Pharmacopoeia Commission, Ghaziabad; first edition 1955, currently the 9th edition (IP 2022). Covers synthetic and herbal drugs; the legal standard for drug quality in India.
- 2 British Herbal Pharmacopoeia (BHP) — standards specifically for herbal medicines used in the UK (British Herbal Medicine Association).
- 3 United States Pharmacopeia — Herbal Medicines and Dietary Supplements — USP quality standards for botanicals and dietary supplements sold in the US.
- 4 Ayurvedic Pharmacopoeia of India (API) — Government of India, Ministry of AYUSH; Part I monographs raw drugs of Ayurveda, Part II covers formulations.
- 5 Unani Pharmacopoeia of India (UPI) — standards for Unani (Greco-Arab) medicines, also under AYUSH.
- 6 American Herbal Pharmacopoeia (AHP) — non-profit body publishing detailed, science-heavy monographs on botanicals sold in North America.

Trap alert: "Pharmacopoeia" vs "formulary" — students swap them. A pharmacopoeia sets quality standards (identity, purity, tests). A formulary (like the National Formulary of India) guides prescribing — which drugs to use and how. Standards vs guidance.

What a herbal monograph actually contains

When a drug becomes official, its pharmacopoeial monograph becomes its legal identity card. A typical IP herbal monograph runs in this order:

Section	What it fixes
Definition	Botanical name, family, part used — the drug's legal identity
Characters / Identification	Macroscopic description plus microscopic features (the Unit III toolkit, written into law)
Tests	Foreign organic matter, ash values, extractive values, moisture content — each with a numerical limit
Assay	Minimum content of a marker constituent, measured by TLC/HPLC
Storage	How it must be kept (cool, dry, protected from light)
Labelling	What the label must declare

Why this matters: "official" is not an honour, it is a contract. Once Senna is official in the IP, every batch sold in India must clear those limits. That is the bridge between Unit I and Unit III — the monograph lists the parameters, the QC lab runs them, and the evaluator in Unit III is simply enforcing the monograph.

Official vs non-official; codified vs non-codified

Two different axes — do not mix them:

- Official drugs are listed in an official pharmacopoeia (IP, BP, USP). Example: Senna (in IP).
- Non-official drugs are not in any pharmacopoeia but are still used — many folk remedies.
- Codified drugs are described in classical, codified traditional texts — Charaka Samhita, Sushruta Samhita — or in an official pharmacopoeia. Their identity and use are written down in an authoritative book.
- Non-codified drugs come from folk/tribal medicine, passed on by oral tradition, not written in any classical text.

Trap alert: A drug can be codified but non-official — present in the Charaka Samhita yet absent from the IP. "Official" answers which pharmacopoeia lists it?; "codified" answers is it written in a classical authoritative text? Examiners set this as a 2-marker precisely because students treat the two pairs as synonyms.

Classification of crude drugs — the six systems

Classification arranges crude drugs into groups so thousands of drugs become studyable. The syllabus names six. For exams, learn each as basis + example + one merit + one limitation — that is almost guaranteed as a 5- or 10-mark question.

System	Basis	Example	Merit	Limitation
Alphabetical	Latin/English name, A-Z	Acacia, Benzoin, Cinchona...	Easiest quick reference, like a dictionary	Neighbouring drugs unrelated; tedious and unscientific
Morphological	Plant part used; organized vs unorganized drugs	Leaves: Senna; barks: Cinchona; roots: Rauwolfia; unorganized: gums, oils, resins	Matches practical study — you identify the part in hand	Chemically unrelated drugs sit together (one leaf holds alkaloids, the next glycosides)
Taxonomical	Botanical family/genus/species	Solanaceae: Belladonna, Datura, Stramonium	Scientific; reveals evolutionary relationships	Needs botanical expertise; chemically different drugs from one family get grouped together
Chemical	Main active constituent class	Alkaloids: Nux vomica, Ergot; glycosides: Senna, Digitalis; volatile oils: Clove	Links chemistry to action — exactly the source → constituent → use exam pattern	A drug with two constituent classes fits nowhere cleanly; morphological identity is lost
Pharmacological	Therapeutic action	Laxatives: Senna, Castor oil; cardiotonics: Digitalis, Strophanthus; bitters: Gentian, Chirata	Action-oriented — directly useful to prescribers and pharmacists	Drugs with two actions create confusion; chemically unrelated drugs grouped together
Chemotaxonomic	Distribution of constituents across taxa — chemistry used as a taxonomic marker	Alkaloid/glycoside patterns confirming identity and relationships	Modern and scientific; detects adulteration; finds new drug sources in related species	Needs sophisticated analysis; expensive and technical for routine use

Two finer points that lift your answer above the average:

- Organized vs unorganized drugs (inside the morphological system): organized drugs are direct plant parts with cellular structure — leaves, bark, roots, seeds. Unorganized drugs are plant products without cellular structure — gums, resins, fixed and volatile oils, juices, extracts. If you can see cells under the microscope, it is organized; if not, unorganized.
- Which system should you actually use? Chemical and pharmacological classifications dominate pharmacy teaching because they connect constituent to action. But no single system is "correct" — a pharmacopoeia uses alphabetical order for lookup, a QC lab uses chemical/microscopic identity, and a prescriber thinks pharmacologically.

Trap alert: Chemical classification vs chemotaxonomy — the classic confusion. Chemical classification groups drugs by what active constituent they contain (all alkaloid drugs together). Chemotaxonomy uses chemistry as a tool to classify plants themselves (this species belongs in that genus because its alkaloid pattern matches). One organizes drugs; the other organizes plants. Say that sentence in the exam and you are safe.

Very short questions (2 marks)

- 1 Who coined the term pharmacognosy, and in which year?
- 2 Define a crude drug. Give one example each of an organized and an unorganized drug.
- 3 Name the discoverer and year of isolation for morphine and for quinine.
- 4 Distinguish between official and codified drugs with one example of a drug that is codified but non-official.
- 5 Who developed warfarin from dicoumarol, and what was the original natural source of dicoumarol?

Short questions (5 marks)

- 1 Describe the scope of pharmacognosy in the herbal industry and in drug regulation.
- 2 Write short notes on any two: (a) plant tissue culture as a source of drugs, (b) marine sources of drugs, (c) mineral sources of drugs.
- 3 Explain the historical milestones of penicillin and artemisinin in drug discovery, including why cold extraction was critical for artemisinin.

Long questions (10 marks)

- 1 Describe the six systems of classification of crude drugs with their basis, merits and limitations. Which system is most useful for pharmacy students, and why?
- 2 Discuss the definition, history, present status and scope of pharmacognosy. Support your answer with at least four historical milestones in drug discovery.

How to approach these answers

- Very-short Q1: name + year only, plus the book title for the extra half mark.

- Very-short Q2: one-line definition, then the organized/unorganized distinction in a phrase each.
- Very-short Q3: two name-year pairs; keep the 1804/1820 dates apart from 1815.
- Very-short Q4: two one-line definitions, then the codified-but-non-official example as the clincher.
- Very-short Q5: name the scientist, then the spoiled-sweet-clover story in one line.
- Short Q1: open with one line on scope, then split industry vs regulation with 3 points each.
- Short Q2: for each chosen source — definition, one product example, one merit, one limitation.
- Short Q3: two mini-stories in parallel (source → discoverer → significance); close with the endoperoxide/heat point for artemisinin.
- Long Q1: structure — intro line, a six-row table (basis/merit/limitation), then a paragraph defending your choice; mention the chemotaxonomy trap.
- Long Q2: structure — definition, history in four phases, present status with revival reasons, scope as a table, four milestones as evidence; conclude with the Nobel-2015 line.

Unit II — Cultivation, Collection, Processing and Storage of Drugs of Natural Origin

Why cultivate instead of just collecting from the wild?

Wild collection is free, but it is a gamble: the collector may pick the wrong species, the wrong part, at the wrong season, and wipe out the local population doing it. Cultivation — growing medicinal plants as a crop — gives steady supply, uniform quality, correct identity and traceability. Industry needs tonnes of the same-quality material every month; only cultivation delivers that.

There is one honest trade-off to mention in exams: wild plants often contain more secondary metabolites, because stress (drought, pests, poor soil) switches on the plant's chemical defences. Cultivated plants are pampered, so they may be chemically lazier. Good cultivation therefore deliberately reintroduces mild stress or selects high-yielding varieties — which is exactly what the breeding tools later in this unit are for.

Methods of plant cultivation

Method	How it works	Strength	Weakness	Example
Sexual propagation (seeds)	Sow seeds, grow seedlings	Cheap, easy over large areas	Genetic variation — every seedling differs, so constituent content varies batch to batch	Senna, Isabgol
Asexual / vegetative propagation	Cuttings, grafting, layering, stolons, suckers	Genetically identical clones → uniform constituent content	Slower multiplication; carries diseases from the parent	Mint stolons, sugarcane setts
Micropropagation (tissue culture)	Sterile lab multiplication from tiny explants	Huge numbers of disease-free, uniform plantlets from elite mother plants	Expensive; needs a lab and trained staff	Orchids, Artemisia elite lines

Exam logic: if the question is about uniformity of active constituents, the answer is vegetative propagation or tissue culture, because seeds reshuffle genes every generation.

Good Agricultural and Collection Practices — WHO GACP

Trap alert: The syllabus writes "WHO / GAP / GCP guidelines". The actual WHO document is titled Good Agricultural and Collection Practices (GACP) for medicinal plants. GACP covers growing and collecting. *GCP — Good Clinical Practice — belongs to clinical trials on humans, not to plants.* If the examiner quotes the syllabus phrase, use it; but add one line showing you know the correct term is GACP. That single line separates toppers from the crowd.

The core idea of GACP: quality starts in the field, not in the QC lab. No amount of testing can fix a drug grown in lead-contaminated soil or dried into a mouldy lump. Key requirements:

Stage	GACP requirement	Why it matters
Site selection	Soil tested free of heavy metals, pesticide residues, industrial pollutants; clean irrigation water	Plants absorb whatever is in soil and water — contamination is invisible but permanent
Seeds / propagation material	Botanically identified, disease-free, from authenticated sources	Wrong species at sowing = wrong drug at harvest, a year's work wasted
Cultivation	No banned pesticides; fertilizer and pesticide use recorded; crop rotation	Residues end up in the medicine; records give traceability

Stage	GACP requirement	Why it matters
Collection	Correct species, correct part, correct season and time of day; trained collectors	Constituent content peaks at specific growth stages and hours
Post-harvest	Prompt proper drying, cleaning, grading; protection from moisture, pests, light	Most quality is lost after harvest through bad drying and storage
Documentation	Every batch traceable — where grown, when harvested, how processed	Recalls and audits are possible only with paper trails

Factors influencing cultivation, collection and storage

Examiners ask this as "factors affecting the quality of crude drugs". Group them into four buckets — it makes a 5-mark answer write itself.

1. Environmental (before harvest):

- Climate and altitude — temperature, rainfall, humidity decide where a plant thrives. Cinchona needs tropical highlands; it will not produce quinine in the plains.
- Soil — pH, minerals, drainage. Liquorice grown in different soils varies measurably in glycyrrhizin.
- Light and day length — flowering and constituent formation respond to photoperiod.

2. Biological:

- Age and growth stage — constituents peak at a particular stage. Belladonna leaf alkaloids are highest at flowering; collect earlier or later and you get a weaker drug.
- Pests and diseases — cut yield and can introduce toxins (fungal aflatoxins are the nightmare case).

3. Collection-stage:

- Time of collection — volatile-oil plants are collected in the morning, when oil content peaks before the day's heat evaporates it. Barks are collected in spring when the cambium is active and bark strips easily. Roots are collected in autumn when the plant has stored reserves underground. Flowers are collected just before pollination.
- Method — the correct part only, with no look-alike species mixed in. This is where adulteration usually begins — not in the factory, but in the collector's basket.

4. Post-harvest:

- Drying — the most underestimated step. Too slow → mould and fermentation. Too hot/fast → volatile oils evaporate, glycosides get hydrolysed by the plant's own enzymes, and the surface hardens while the inside stays wet ("case hardening"). Rule of thumb: shade-dry leaves and flowers (protect colour and volatile oils), sun-dry barks and roots (tough parts that need heat).

- Storage — moisture invites mould and activates enzymes that destroy glycosides; light bleaches and degrades constituents; insects eat stored drugs. Store cool, dry, dark, airtight — and inspect periodically.

GPAT angle: "Why are volatile-oil drugs collected in the morning?" and "Why shade-dry leaves but sun-dry barks?" are classic reasoning questions. The answers are evaporation physics and tissue toughness — not memorized facts but reasons. Examiners reward the reason.

Plant hormones and their applications

Phytohormones are the plant's internal signal chemicals. Growers use synthetic versions to steer cultivation — and every use below is really about raising uniform, high-yielding planting material, which downstream means more active constituent per hectare.

Hormone	Key application in medicinal-plant cultivation	The logic
Auxins (IBA, NAA)	Rooting of stem cuttings	Auxins trigger adventitious root formation — cuttings of elite high-yielding plants root fast and uniformly
Gibberellins	Breaking seed dormancy; promoting stem elongation and flowering	Dormant seeds of medicinal species germinate on schedule instead of rotting in soil
Cytokinins	Shoot multiplication in tissue culture; delaying leaf ageing (senescence)	One explant → dozens of shoots; harvested leaves stay fresh longer
Absciscic acid	Stress tolerance, dormancy control	Helps transplants survive drought and hardening
Ethylene	Fruit ripening; stimulating latex flow in some species	Timed ripening; more latex = more drug in latex-yielding plants

Polyploidy, mutation and hybridization — breeding for more drug per plant

All three are plant-breeding tools with one target: raise the secondary-metabolite content (because the secondary metabolite is the drug).

- Polyploidy — doubling the chromosome set, usually with colchicine, which blocks spindle formation during cell division so chromosomes double without the cell dividing. Polyploid plants have bigger cells, bigger organs, and — often — richer secondary metabolism. Classic examples: tetraploid *Datura* strains with higher alkaloid content, and polyploid *Artemisia* lines with more artemisinin.

- Mutation breeding — inducing random changes with radiation or chemicals (e.g., EMS), then screening thousands of mutants for the rare one with higher constituent yield. Example: high-morphine mutants of the opium poppy.
- Hybridization — crossing two varieties or species to combine strengths: the high biomass of one parent with the high constituent content of the other. Example: Cinchona hybrids bred for higher quinine.

Memory logic: secondary metabolites are the product; breeding aims to make the plant a better factory for them.

GPAT angle: "What does colchicine do in polyploidy breeding?" — it inhibits spindle fibre formation (arrests mitosis at metaphase), so the chromosome number doubles. The same antimitotic property is why colchicine itself is a gout drug. One mechanism, two exam topics.

Conservation: ex-situ, in-situ, value addition, eco-pharmacognosy

- In-situ conservation — protecting plants in their natural habitat: national parks, wildlife sanctuaries, biosphere reserves, sacred groves. The plant keeps evolving with its ecosystem.
- Ex-situ conservation — protecting plants outside their habitat: botanical gardens, seed banks, gene banks, cryopreservation, tissue-culture repositories. A backup drive for biodiversity.
- Value addition — instead of selling raw dried herbs cheap, growers process them into standardized extracts, powders, capsules or essential oils. More income for the farmer, better-defined quality for the buyer, and less pressure to over-harvest wild stock.
- Eco-pharmacognosy — using ecological knowledge to harvest medicinal plants sustainably: take enough for today's need without destroying the population that must supply tomorrow. Harvesting with the ecosystem's limits, not against them.

The syllabus's endangered examples — Kutki and Chirata:

- *Kutki (Picrorhiza kurroa)* — Himalayan herb, prized hepatoprotective (you will meet it again in Unit V). Over-collected from the wild for the herbal industry; wild populations are threatened. The answer is cultivation plus regulated collection.
- *Chirata (Swertia chirata)* — Himalayan bitter tonic. Heavy demand for its bitterness value has pushed wild populations down.

Trap alert: Students write "Kutki is endangered because it is poisonous" or invent reasons. The reason is over-collection driven by commercial demand. Endangerment in medicinal plants is almost always an economics story, not a toxicity story.

Processing of crude drugs — from harvest to packing

Collection is only halfway. Between the field and the factory gate, a crude drug passes through processing steps — and every one of them exists to protect a Unit III parameter:

- Garbling — hand-sorting out dirt, foreign plant parts and damaged pieces. This is the original, manual version of the foreign organic matter test.
- Washing / cleaning — roots and rhizomes are washed free of adhering soil. Skip this and the acid-insoluble ash will expose you — silica does not wash off in the lab.
- Cutting / comminution — barks cut into quills, roots sliced or chipped. More surface area means faster, more uniform drying.
- Drying — natural (sun for tough barks and roots, shade for delicate leaves and flowers) or artificial (hot-air ovens, and freeze-drying for heat-sensitive constituents). The target is moisture low enough to stop mould and enzyme action — the moisture content limit in the monograph.
- Grading — sorting by size, colour and quality grade. Higher grades fetch higher prices; grading is value addition at its simplest.
- Packing and storage — gunny bags for sturdy drugs, airtight containers for hygroscopic or volatile-oil drugs; approved fumigation against storage pests, with residues kept within limits.

Notice the pattern: processing is quality control in work clothes. Each step prevents a failure that Unit III's tests would otherwise detect.

Very short questions (2 marks)

- 1 Expand GACP and state which WHO document it comes from. How does it differ from GCP?
- 2 Why are volatile-oil-containing plants collected in the morning?
- 3 Name two plant hormones used in medicinal-plant cultivation and give one application of each.
- 4 Distinguish between in-situ and ex-situ conservation with one example of each.
- 5 What is the role of colchicine in polyploidy breeding?

Short questions (5 marks)

- 1 Describe the WHO GACP requirements for site selection, collection and post-harvest handling of medicinal plants.
- 2 Explain the factors influencing the cultivation, collection and storage of crude drugs, grouped as environmental, biological, collection-stage and post-harvest.
- 3 Write a short note on eco-pharmacognosy with reference to the conservation of Kutki and Chirata.

Long questions (10 marks)

- 1 Discuss the applications of plant hormones, polyploidy, mutation and hybridization in improving the yield of secondary metabolites in medicinal plants, with examples.
- 2 Describe the methods of cultivation of medicinal plants. Compare sexual, asexual and micropropagation methods with reference to uniformity of active constituents.

How to approach these answers

- Very-short Q1: expand both abbreviations in one line each; the difference is one phrase (plants vs clinical trials).
- Very-short Q2: one reason — oil evaporates in day heat; morning collection catches the peak.
- Very-short Q3: two hormone-application pairs; pick auxins and cytokinins for the cleanest answers.
- Very-short Q4: two one-line definitions plus one example each; do not write a paragraph.
- Very-short Q5: one mechanism line (spindle inhibition → chromosome doubling) plus why breeders want it.
- Short Q1: take the GACP table's three stages; 2–3 points under each, close with the "quality starts in the field" line.
- Short Q2: use the four-bucket structure; two solid points per bucket with one example each.
- Short Q3: define eco-pharmacognosy, then Kutki and Chirata as the two case studies, ending on cultivation as the solution.
- Long Q1: structure — intro linking all four tools to secondary-metabolite yield; one subhead per tool with mechanism + example; conclude with the "better factory" line.
- Long Q2: structure — intro on why cultivate; three methods compared in a table (cost, uniformity, speed); close with the wild-vs-cultivated stress trade-off.

Unit III — Quality Control of Drugs of Natural Origin (WHO Guidelines)

Adulteration of drugs of natural origin

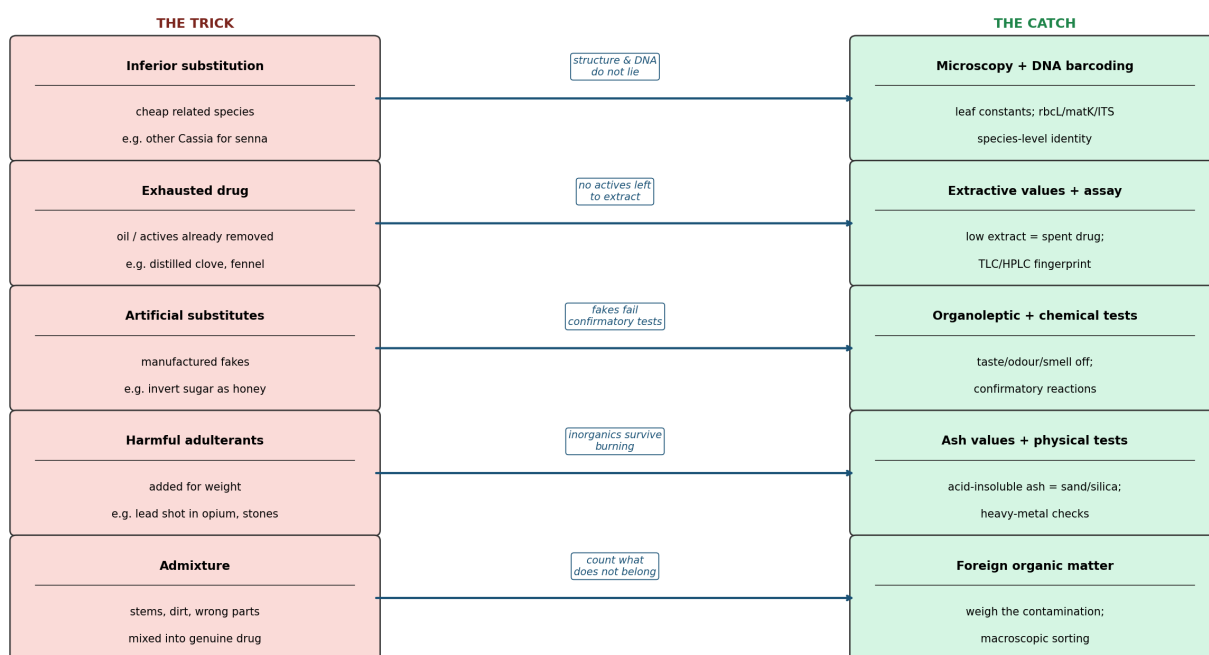
Adulteration is the partial or complete substitution of a genuine drug with a spurious, inferior or otherwise foreign material — or the mixing of such material into the genuine drug. Motive is almost always money: the genuine drug is expensive or scarce, and the substitute is cheap.

Type	What happens	Example
Substitution with inferior varieties	A cheaper, related species replaces the genuine drug	Other Cassia species sold as Senna alexandrina

Type	What happens	Example
Substitution with exhausted drugs	Material already used for extraction — no actives left — is mixed back in	Clove or fennel after the volatile oil has been distilled out
Artificially manufactured substitutes	A fake manufactured to look genuine	Artificial invert sugar passed off as honey; paraffin wax in beeswax
Harmful adulterants	Toxic material added, usually to increase weight	Lead shot in opium; stones mixed into liquorice root
Adulteration by admixture	Genuine drug mixed with inferior material	Stems mixed into a leaf drug; excess dirt and foreign parts

Why this matters beyond exams: adulteration does not just weaken the medicine — harmful adulterants can poison the patient. Quality control exists to catch every row of that table.

Adulteration: which evaluation method catches which trick?



Adulteration: which evaluation method catches which trick?

Trap alert: Students think adulteration is only about substitution. Exhausted drugs are the sneakiest category: the material is the correct species — it looks, smells and feels right — but its actives were already extracted. Organoleptic examination passes it; only extractive values and chemical assay catch it. That is why the flowchart pairs exhausted drugs with extractive values. Learn the pairing, not just the list.

Evaluation of drugs — the five methods

Evaluation means testing a crude drug to confirm its identity, purity and quality. The syllabus lists five approaches. Think of them as five sieves with different mesh sizes — a fraud that slips through one gets caught by another.

1. Organoleptic evaluation — the senses

Colour, odour, taste, size, shape, texture, fracture — judged with the sense organs. Liquorice tastes sweet; clove smells strongly aromatic; asafoetida smells unmistakably of garlic-onion. It is fast, cheap and needs no instrument — and it is the first screen everywhere from mandi to factory gate.

Its weakness is subjectivity and fakability: artificial substitutes are designed to fool the senses (invert sugar looks and tastes like honey). So organoleptic evaluation screens, but never confirms.

2. Microscopic evaluation — qualitative and quantitative

Qualitative microscopy studies tissue structure to confirm identity: the type of stomata (paracytic in Senna, anisocytic, diacytic, anomocytic), trichomes (unicellular covering trichomes of Senna; glandular trichomes of mint), calcium oxalate crystals (prisms, rosette/cluster aggregates, needle-like raphides), fibres, cork cells, and xylem vessels. Lignified tissues turn pink-red with phloroglucinol + HCl — because the reagent reacts with cinnamaldehyde end-groups in lignin — which is how you spot fibres and vessels in a powder.

Quantitative microscopy — the leaf constants. These are numbers that are genetically fixed for a species and do not change with environment, which makes them perfect fraud detectors in powdered leaf drugs:

Leaf constant	What it is	Why it is useful
Stomatal number	Number of stomata per sq. mm of leaf surface	Fixed per species; differs between genuine drug and substitute
Stomatal index	$S / (E + S) \times 100$, where S = stomata count, E = epidermal cells in the same area	More reliable than stomatal number because it is a ratio — leaf age and size cancel out
Vein-islet number	Number of vein islets per sq. mm (between midrib and margin)	Independent of leaf size; characteristic of the species
Veinlet termination number	Number of veinlet endings per sq. mm	Same logic — a structural fingerprint
Palisade ratio	Average number of palisade cells beneath one epidermal cell	Catches substitution even in fine powders

GPAT angle: The stomatal index formula $SI = S/(E+S) \times 100$ is asked directly, sometimes as a numerical. Remember what S and E stand for. And remember why the index beats the raw number: it is a ratio, so it stays constant while the leaf grows.

3. Physical evaluation

Measurement of physical constants — moisture content, melting point, viscosity, optical rotation, refractive index, ash values. These are numbers a pure drug must match; deviation means impurity. (The individual parameters are detailed in the next section.)

4. Chemical evaluation

Chemical tests and assays for the active constituents — and here is where you must know not just the names but why the colour appears, because "give the principle" questions separate memorisers from understanders:

Test	For	Reagent	What you see	Why it happens
Mayer's	Alkaloids	Potassium mercuric iodide	Cream/white precipitate	Heavy-metal complex with the alkaloid's nitrogen
Dragendorff's	Alkaloids	Potassium iodobismuthate	Orange-red precipitate	Bismuth-alkaloid complex
Wagner's	Alkaloids	Iodine in potassium iodide	Reddish-brown precipitate	Polyiodide complex
Hager's	Alkaloids	Picric acid	Yellow precipitate	Picrate salt of the alkaloid
Bornträger's	Anthraquinone glycosides	Boil with acid, extract, add ammonia	Pink-red in the ammoniacal layer	Free anthraquinones form a coloured phenolate anion in alkali
Keller-Kiliani	Cardiac glycosides	Glacial acetic acid + Fe^{3+} , layered with conc. H_2SO_4	Blue/green ring at the junction	Reaction of the deoxy-sugar (digitoxose) with ferric ions in acid
Shinoda	Flavonoids	Magnesium + conc. HCl	Pink to red colour	Reduction of the flavonoid to a coloured anthocyanidin
Ferric chloride	Tannins	Ferric chloride solution	Blue-black or green-black colour	Ferric-tannate complex
Gelatin test	Tannins	Gelatin solution	White precipitate	Tannins precipitate proteins — this is the astringency mechanism
Molisch's	Carbohydrates	α -naphthol + conc. H_2SO_4	Violet ring at the junction	Acid dehydrates sugars to furfural, which condenses with naphthol

Test	For	Reagent	What you see	Why it happens
Biuret	Proteins	CuSO ₄ in alkaline solution	Violet colour	Copper complexes with peptide bonds

Why do four different reagents all "test for alkaloids"? Because they attack the same feature from different sides: the alkaloid's nitrogen lone pair, which forms salts and complexes with heavy metals and acids. That shared logic is also why alkaloids are extracted with acids and precipitated with bases — one principle, many applications.

5. Biological evaluation

Testing the drug's effect on living organisms, tissues or microbes — used when chemical tests cannot measure potency. The classic cases:

- Digitalis on cardiac muscle (historical pigeon/cat assays) — because the leaf contains a mixture of related cardiac glycosides, and chemistry could count them without telling you how strongly the mixture acts on the heart.
- Microbiological assay of antibiotics — the zone of inhibition on a bacterial plate measures real killing power, which is what the patient needs.
- Vaccines, toxins, antitoxins — potency is a biological property by definition.

The principle to quote: chemistry measures how much is there; biology measures how well it works. When the two do not track each other — mixtures of active and inactive relatives — biology is the referee.

Trap alert: Students write "biological evaluation is outdated". It is not — it is irreplaceable wherever potency $\neq$ chemical content. The exam trap is asking "why is digitalis evaluated biologically?" The answer is the mixture argument above, not "because it is traditional".

Physicochemical parameters — what each one detects

This list is asked as "define and give the significance of..." — four parameters make a standard short note. Learn each as what it measures → what a bad value means.

Parameter	What it measures	A bad value tells you...
Extractive values (water-soluble, alcohol-soluble)	Amount of constituents a solvent pulls out	Low value → exhausted or adulterated drug
Moisture content (loss on drying)	Water in the drug	High moisture → mould growth, enzyme activity (glycosides get hydrolysed), spoilage
Foreign organic matter	Plant parts or materials not part of the drug	How careless the collection and cleaning were
Ash values (total, acid-insoluble, water-soluble)	Inorganic residue left after burning the drug away	See the deep dive below — the single most-asked parameter

Parameter	What it measures	A bad value tells you...
Bitterness value	Bitterness compared with quinine hydrochloride	Quality check for bitter drugs (Gentian, Chirata) — weak bitterness = weak drug
Foaming index	Frothing power of a shaken water decoction	Presence (and rough amount) of saponins
Haemolytic potential	Ability to burst red blood cells	Another saponin check — saponins lyse RBC membranes
Swelling index	Volume (ml) taken up by 1 g of drug in water	Mucilage/gum content (Isabgol, Agar) — low swelling = poor mucilage
Viscosity	Thickness/resistance to flow	Quality and consistency of gums and mucilages
Optical rotation	Rotation of plane-polarized light	Identity and purity of optically active drugs (sugars, volatile oils)
Refractive index	Bending of light passing through	Purity of fixed and volatile oils — adulterated oils refract differently
Acid value	mg of KOH needed to neutralize free fatty acids in 1 g of oil	High value → rancidity (fats breaking down into free acids)
Saponification value	mg of KOH needed to saponify 1 g of oil	Inversely related to the average molecular weight of fatty acids; detects adulteration of oils

Ash values — the deep dive (high exam yield)

Burn the drug completely: the organic part vanishes as CO_2 and water, and what remains is ash — the inorganic part. Total ash has two components:

- Physiological ash — minerals the plant itself absorbed (calcium, potassium salts). Normal and expected.
- Non-physiological ash — dirt that hitched a ride: sand, soil, silica stuck to the drug.

Three measurements separate them:

- 1 Total ash — everything left after ignition. High total ash suggests contamination but does not prove it.
- 2 Acid-insoluble ash — boil the total ash with dilute HCl. Everything dissolves except silica and sand. So high acid-insoluble ash proves earthy contamination. This is the money parameter — if the examiner asks "which ash value detects sand?", this is the answer.
- 3 Water-soluble ash — the part of total ash that dissolves in water (mostly the plant's own soluble salts).

Trap alert: Students write "high total ash = adulteration". Not quite — some genuine drugs are naturally mineral-rich. The diagnostic value is in the acid-insoluble fraction: silica does not belong inside a leaf drug, so its presence means dirt. Quote it that way.

WHO quality-control parameter wheel



WHO quality-control parameter wheel

DNA barcoding — the modern identity test

The idea: just as a supermarket barcode identifies a product, a short standard DNA sequence identifies a species. For plants, the CBOL Plant Working Group recommends *rbcl* + *matK* as the core barcode, with *ITS2* (and sometimes *psbA-trnH*) as backup.

How it actually works, step by step:

- 1 Extract DNA from the sample — even a spoonful of powder works.
- 2 PCR-amplify the barcode region using universal primers (short DNA starters that latch onto the barcode locus in almost any plant).
- 3 Sequence the amplified fragment.
- 4 Match the sequence against a reference library (BOLD, GenBank). A ≥ 98 –99% match to a reference *Senna alexandrina* sequence confirms identity.

Why pharmacognosy needs it: microscopy fails when the plant's structure is destroyed — powders, extracts, tablets, multi-herb formulations. DNA survives processing far better than cell structure does, and it catches substitution with closely related species that look identical even to a botanist.

Honest limitations (examiners ask for these): needs a lab, reference database and trained staff — not a field test; DNA degrades in heavily processed extracts; hybrids and very closely related species can share barcodes; and a barcode confirms species, not quality — genuine species, badly stored, still fails every other parameter.

GPAT angle: "Which loci are used as plant DNA barcodes?" — answer *rbcl* and *matK* (core), *ITS2* (supplementary). And the one-line principle: a short standardized DNA sequence used for species identification. Pair this with the leaf-constants question — both are "identity when morphology is hard" tools, one classical, one modern.

Qualitative microscopy — the structural fingerprints

Quantitative microscopy gives you numbers; qualitative microscopy gives you pictures — tissue features so characteristic that a trained eye can name the drug from a slide. Learn these as a table:

Feature	What to look for	Example
Stomata types	Paracytic (subsidiary cells parallel to the pore), anisocytic (three unequal subsidiaries), diacytic (two subsidiaries at right angles), anomocytic (no distinct subsidiaries)	Senna: paracytic stomata
Trichomes	Covering (non-glandular) vs glandular; unicellular vs multicellular; warty vs smooth walls	Senna: unicellular, warty, conical covering trichomes
Calcium oxalate crystals	Prisms, rosette/cluster aggregates, needle-like raphides, microspenoidal sand	Senna: cluster crystals; Cinchona: microspenoidal
Fibres and vessels	Lignified → pink-red with phloroglucinol + HCl	Cinchona bark: phloem fibres
Cork	Polygonal, suberized (waterproof) cells in rows	Bark drugs — confirms you have bark, not wood

Why this works against adulteration: each feature is genetically fixed. A substitute species may look identical to the naked eye, but its stomata type or crystal form will differ — and the microscope does not negotiate.

WHO guidelines — beyond identity: contaminants

The WHO quality-control guidelines for herbal materials insist on three layers, and students usually remember only the first:

- 1 Identity and purity — the evaluation methods and physicochemical parameters above.
- 2 Contaminant limits — heavy metals (lead, cadmium, mercury, arsenic — absorbed from polluted soil and water), pesticide residues (from cultivation), and microbial contamination (total aerobic count, *E. coli*, *Salmonella*). Aflatoxins — toxins from moulds growing on badly dried/stored drugs — are the nightmare case: invisible, heat-stable, carcinogenic.
- 3 Documentation and traceability — the GACP paper trail from Unit II.

This closes the loop across units: GACP in the field keeps contaminants out; contaminant testing in the lab proves they stayed out. The WHO has also published monographs on selected medicinal plants (four volumes) giving specifications for widely used species — the international cousin of the IP herbal monographs from Unit I.

GPAT angle: "Name three contaminant tests prescribed for herbal drugs" — heavy metals, pesticide residues, microbial load (plus aflatoxins for the extra mark). And the one-line principle: WHO guidelines cover identity, purity and contaminants — not just the active constituent.

Very short questions (2 marks)

- 1 Define adulteration of crude drugs. Give one example of adulteration with an exhausted drug.
- 2 Write the formula for stomatal index and explain what S and E denote.
- 3 Which ash value detects contamination with sand/silica, and why?
- 4 Name the core DNA barcode loci recommended for plants.
- 5 Why is *digitalis* evaluated by biological methods rather than chemical assay alone?

Short questions (5 marks)

- 1 Describe the five types of adulterants with one example of each.
- 2 Explain quantitative microscopy (leaf constants) and its role in detecting adulteration of powdered leaf drugs.
- 3 Write short notes on any two: (a) acid value and saponification value, (b) swelling index and foaming index, (c) bitterness value and haemolytic potential.

Long questions (10 marks)

- 1 Describe the five methods of evaluation of crude drugs (organoleptic, microscopic, physical, chemical, biological) with the principle and one example of each. Explain how the methods complement each other in detecting adulteration.

- 2 Explain DNA barcoding: its principle, the loci used, the step-by-step procedure, its applications in herbal drug quality control, and its limitations.

How to approach these answers

- Very-short Q1: one-line definition plus the exhausted-clove/fennel example; name the type too.
- Very-short Q2: write the formula first, then expand S and E in one line each.
- Very-short Q3: name acid-insoluble ash; the "why" is one line — silica survives dilute HCl.
- Very-short Q4: rbcL + matK (core), ITS2 as backup — three names, no paragraph needed.
- Very-short Q5: one line on the mixture of related glycosides; chemistry counts, biology measures action.
- Short Q1: five mini-rows — type, what happens, example; keep each to two lines.
- Short Q2: list the five leaf constants with one-line definitions, then two lines on why they catch substitution in powders.
- Short Q3: for each parameter — what it measures, then what a bad value means; that pairing is the whole answer.
- Long Q1: structure — intro on identity/purity/quality; five subheads with principle + example; close with the exhausted-drug case showing why one method alone fails.
- Long Q2: structure — principle (barcode analogy), loci, four procedure steps, two applications, three limitations; conclude with "identity, not quality".

Unit IV — Introduction to Metabolites of Plant Origin; Traditional Systems of Medicine

What plant metabolites are

Plant metabolites are the chemical compounds produced by plant metabolism. They fall into two great groups — and the whole of pharmacognosy pivots on this split:

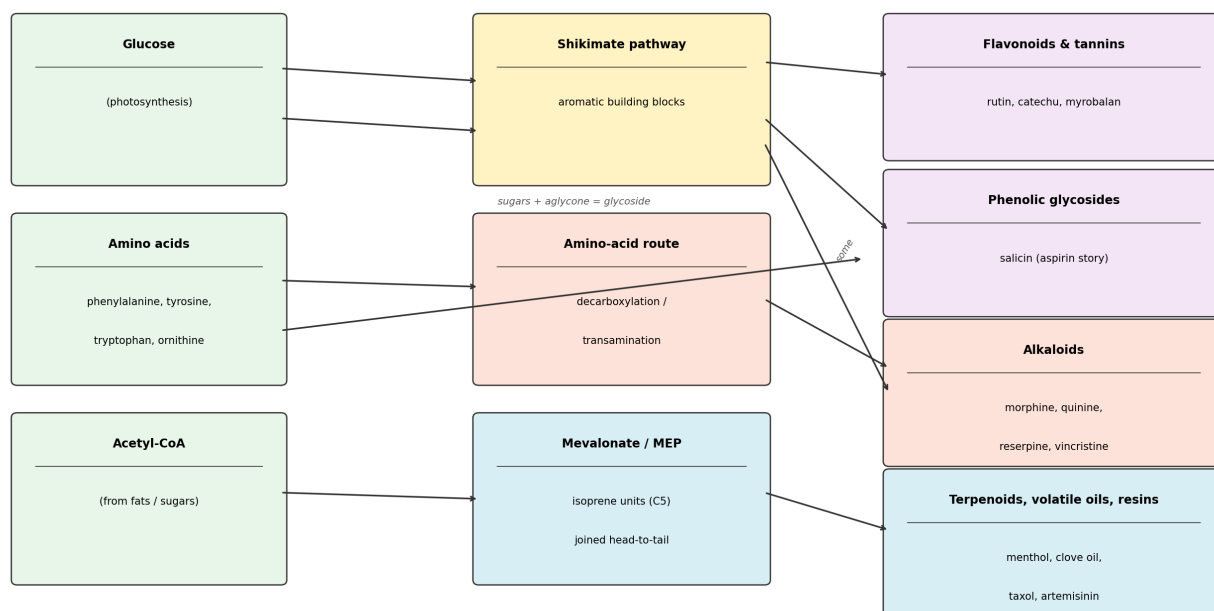
Feature	Primary metabolites	Secondary metabolites
Role	Run the core life processes: growth, development, reproduction	Handle the plant's interactions with the world — defence, signalling, pollinator attraction, UV protection
Distribution	In all plants	Restricted to certain families, genera or species

Feature	Primary metabolites	Secondary metabolites
Quantity	Large amounts	Small amounts, and the amount swings with environment and stress
Drug value	Mostly nutritional or excipient value (with exceptions)	Most plant drugs come from here
Examples	Carbohydrates, proteins, lipids	Alkaloids, glycosides, flavonoids, tannins, terpenoids, volatile oils, resins

Why do plants make secondary metabolites at all? Because a plant cannot run from a caterpillar or hide from the sun. Its chemistry is its immune system, its armoury and its advertising agency: alkaloids poison herbivores, volatile oils summon pollinators, tannins make leaves unpalatable, flavonoids screen UV. Humans simply borrow these defence chemicals as drugs — which is why so many plant drugs are bitter, toxic in overdose, or strongly bioactive. The bitterness of Chirata and the toxicity of strychnine are not accidents; they are the plant's weapons, repurposed.

This also explains a Unit II fact you already met: stressed, wild plants often make more secondary metabolites. No stress → no need for weapons → lazier chemistry.

From primary metabolism to plant drugs: biosynthetic logic



From primary metabolism to plant drugs: biosynthetic logic

The biosynthetic logic — how the classes connect

You do not need full pathways for this paper, but the logic connecting the classes is exactly the kind of "bridge slightly beyond the syllabus" understanding that makes GPAT questions easy:

- Sugars (photosynthesis) feed the shikimate pathway, which builds aromatic rings → flavonoids, tannins, phenolic glycosides (the aspirin story starts here — salicin is a phenolic glycoside).
- Amino acids are decarboxylated and modified → alkaloids (the nitrogen comes from the amino acid; that is why alkaloids contain nitrogen).
- Acetyl-CoA feeds the mevalonate/MEP route, which joins C5 isoprene units head-to-tail → terpenoids, volatile oils, resins — and also steroids and steroidal saponins.
- Sugars + any aglycone → glycosides. Glycosides are not one chemical family; they are a marriage of a sugar (glycone) with a non-sugar partner (aglycone/genin). The aglycone decides the class: steroidal aglycone → cardiac glycoside; anthraquinone aglycone → laxative glycoside.

GPAT angle: "Why do alkaloids contain nitrogen?" — because they are built from amino acids by decarboxylation. "Why are terpenoids built from C5 units?" — the isoprene rule. One-line origins like these turn ten scattered facts into one story.

The metabolite classes — definition, test (with why), drug example

For each class, learn this triple: what it is → how you detect it (and why the test works) → one drug example. The "why the test works" column is what makes this mastery tier.

Carbohydrates

Polyhydroxy aldehydes or ketones; the plant's energy currency and structural material. Drugs: starch (tablet diluent/disintegrant), acacia and tragacanth (suspending agents, emulsifiers), agar (laxative, microbiology cultures). Test: Molisch's — conc. H_2SO_4 dehydrates sugars to furfural, which condenses with α -naphthol to give the violet ring.

Proteins

Polymers of amino acids; enzymes are proteins. Drugs: gelatin (capsule shells — denatured collagen), papain (protein-digesting enzyme from papaya latex; digestant, anthelmintic). Test: Biuret — Cu^{2+} in alkaline solution complexes with peptide bonds → violet.

Lipids (fixed oils, fats, waxes)

Esters of fatty acids with glycerol. Drugs: castor oil (stimulant laxative — ricinoleic acid), cod-liver oil (vitamins A & D), beeswax (ointment stiffener). Tests: saponification value, acid value, and the spot test — a fixed oil leaves a translucent grease stain on paper (a volatile oil's stain disappears as it evaporates).

Trap alert: Fixed oils vs volatile oils — students confuse them because both are called "oils". Fixed oils are non-volatile glycerides (leave a permanent grease spot, saponifiable, obtained by expression). Volatile oils are steam-distillable aromatic terpenoids (evaporate completely, characteristic odour, obtained by distillation). Castor oil vs clove oil — different chemistry, different tests, different uses.

Alkaloids

Nitrogen-containing compounds of plant origin with marked physiological action — usually alkaline in reaction (the name says it: alkali-like). The nitrogen's lone pair is the whole story: it forms salts with acids (so alkaloids are extracted with dilute acid and precipitated with base) and complexes with heavy-metal reagents (so Mayer's, Dragendorff's, Wagner's and Hager's reagents all give precipitates). Drugs: morphine (analgesic), quinine (antimalarial), reserpine (antihypertensive), vincristine (anticancer).

Glycosides

Compounds that yield a sugar (glycone) and a non-sugar part (aglycone or genin) on hydrolysis. Classified by the aglycone: cardiac glycosides (digitalis — digoxin, cardiotonic), anthraquinone glycosides (senna — sennosides, laxative), saponin glycosides (liquorice, dioscorea), cyanogenetic glycosides (bitter almond — release HCN on hydrolysis). Tests: Bornträger's for anthraquinones (pink-red phenolate in ammonia), Keller-Kiliani for cardiac glycosides (blue ring from the deoxy-sugar).

Flavonoids

Polyphenolic C₆-C₃-C₆ compounds, often the yellow pigments of flowers; antioxidant, anti-inflammatory, capillary-protective. Drugs: rutin (capillary protectant, from buckwheat), quercetin. Test: Shinoda — Mg + HCl reduces the flavonoid to a pink/red anthocyanidin.

Tannins

Polyphenolic compounds that precipitate proteins — and that single property explains their astringent action (they tighten tissues by cross-linking surface proteins), their use in tanning leather, and the gelatin test. Two types: hydrolysable (gallotannins — myrobalan) and condensed (catechu). Tests: ferric chloride (blue-black/green-black ferric-tannate complex), gelatin (white precipitate).

Terpenoids

Built from isoprene (C₅) units joined head-to-tail: monoterpenes (C₁₀ — menthol, camphor), sesquiterpenes (C₁₅ — artemisinin), diterpenes (C₂₀ — taxol, andrographolide), triterpenes (C₃₀ — steroidal saponins, boswellic acids). The carbon count is the classification.

Volatile oils

Aromatic, steam-distillable oils — mostly mono- and sesquiterpenes. They evaporate at room temperature and carry the plant's characteristic odour. Drugs: clove oil (dental analgesic — eugenol), eucalyptus oil (expectorant — cineole), peppermint oil (carminative — menthol). Stored in glandular trichomes or oil ducts — which is why crushing the leaf releases the smell.

Resins

Solid or semi-solid plant exudates — complex hydrophobic mixtures, insoluble in water, soluble in alcohol. They are the plant's wound sealant (think of pine resin sealing a cut trunk). Drugs: benzoin (expectorant; antiseptic inhalation), asafoetida (carminative oleo-gum-resin).

Traditional systems of medicine — core principles

AYUSH = India's officially recognized traditional systems: Ayurveda, Yoga & Naturopathy, Unani, Siddha, Homoeopathy (Sowa-Rigpa is also recognized). TCM = Traditional Chinese Medicine. The syllabus asks for the core principles of treatment in each — learn one or two lines per system:

System	Core principle of treatment
Ayurveda	Health = balance of the three doshas (Vata, Pitta, Kapha) built from five elements (panchamahabhuta). Treatment: herbal drugs, diet, lifestyle, and Panchakarma detoxification. Diagnosis through nadi (pulse), etc.
Unani	Greco-Arab system: health = balance of the four humours (blood, phlegm, yellow bile, black bile) and temperament (mizaj). Treatment: regimental therapy (Ilaj-bil-tadbir), diet (Ilaj-bil-ghiza), herbal drugs (Ilaj-bil-dawa).
Siddha	South Indian system: balances three humours (Vata, Pitta, Kapha) like Ayurveda but leans heavily on herbo-mineral preparations (parpam, chenduram) alongside herbs.
Homoeopathy	"Like cures like" — law of similars: a substance causing symptoms in a healthy person cures similar symptoms in disease, given as a single remedy in minimum (potentized) dose.
TCM	Health = balanced Yin-Yang and smooth flow of Qi through meridians; five-element theory. Treatment: herbal formulas, acupuncture, cupping, diet. Diagnosis by syndrome differentiation.

Dosage forms in AYUSH medicines

Classical AYUSH pharmacy has its own dosage-form vocabulary — learn the Sanskrit term with its modern equivalent:

AYUSH form	What it is
Kwatha	Decoction — herbs boiled in water
Churna	Fine powder of dried herbs

AYUSH form	What it is
Vati / Gutika	Pills/tablets rolled from powders with binders
Asava & Arishta	Self-generated alcoholic fermented liquids (asava: unboiled; arishta: from decoction)
Taila	Medicated oils (oil boiled with herbal decoction/paste)
Ghrita	Medicated ghee
Bhasma	Calcined herbo-mineral preparations — incinerated metals/minerals made "bioavailable" by classical processing
Lehya / Avaleha	Confections — semi-solid linctus-like preparations (e.g., Chyawanprash)
Arka	Distillates (aromatic waters)

GPAT angle: Asava vs Arishta is a standard 2-marker: both are fermented (sandhana kalpana), but arishta is prepared from a kwatha (decoction) while asava is prepared directly from the unboiled drug. Alcohol content is self-generated in both — no distilled spirit is added.

Role of pharmacognosy in allopathy and traditional systems

- In allopathy: pharmacognosy is the supplier and the policeman. Supplier — lead compounds and drugs (morphine, taxol, artemisinin, vincristine all entered modern medicine through pharmacognosy). Policeman — pharmacopoeial standards, identity testing and adulteration control for every herbal raw material the industry buys.
- In AYUSH and TCM: pharmacognosy gives traditional medicine its scientific backbone — correct botanical identification of classical drugs (so "Brahmi" in a formula is actually the right plant), quality standards for pharmacopoeial monographs (API, UPI), safety testing, and validation of traditional claims through phytochemistry and pharmacology.

The two roles meet in the middle: a modern Ayurvedic manufacturer and a multinational pharma company both need the same thing — the right species, at the right quality, batch after batch. That is pharmacognosy's job description in one line.

Two classifications examiners love: alkaloids and glycosides, by structure

Unit IV's classes are big tents. Two of them are routinely sub-classified, and the sub-classification is asked:

Alkaloids — by ring structure (the ring is what the amino-acid building block becomes):

Type	Example drug → alkaloid
Tropane	Belladonna → atropine
Isoquinoline	Opium → morphine; Berberis → berberine
Indole	Rauwolfia → reserpine; Vinca → vincristine
Quinoline	Cinchona → quinine
Purine (xanthine)	Tea/coffee → caffeine
Quinazoline	Vasaka → vasicine

Glycosides — by aglycone (the sugar is usually glucose and tells you nothing; the aglycone decides the action):

Type	Example drug → glycoside → action
Cardiac (steroidal)	Digitalis → digoxin → cardiotonic
Anthraquinone	Senna → sennosides; Aloe latex → aloin → laxative
Saponin	Liquorice → glycyrrhizin; Shatavari → shatavarins
Cyanogenetic	Bitter almond → amygdalin → releases HCN on hydrolysis
Isothiocyanate	Black mustard → sinigrin → pungent, rubefacient
Phenolic	Willow → salicin → the aspirin story

Very short questions (2 marks)

- 1 Distinguish between primary and secondary metabolites with one example of each.
- 2 Why do plants produce secondary metabolites? Give two ecological reasons.
- 3 What is the structural basis for classifying terpenoids? Give one example each of a monoterpene and a sesquiterpene drug constituent.
- 4 Expand AYUSH. Name the dosage form prepared by fermentation of a decoction.
- 5 State the law of similars and name the system of medicine based on it.

Short questions (5 marks)

- 1 Explain the chemical tests for alkaloids. Why do four different reagents (Mayer's, Dragendorff's, Wagner's, Hager's) all detect alkaloids?
- 2 Compare fixed oils and volatile oils under the heads: chemistry, method of preparation, spot test and one drug example each.
- 3 Describe the core principles of treatment in Ayurveda, Unani and TCM (two lines each), and list four AYUSH dosage forms with their meanings.

Long questions (10 marks)

- 1 Classify secondary metabolites of plant origin. For alkaloids, glycosides, flavonoids and tannins, give the definition, the chemical test with its principle, and one drug example with its use.
- 2 Discuss the role of pharmacognosy in allopathy and in traditional systems of medicine (AYUSH and TCM), with suitable examples of drugs that travelled from traditional use to modern medicine.

How to approach these answers

- Very-short Q1: two one-line definitions plus one example each; the table's first two rows are enough.
- Very-short Q2: defence against herbivores + pollinator attraction/UV protection — ecological framing earns marks.
- Very-short Q3: state the isoprene/C5 rule first, then menthol (C10) and artemisinin (C15).
- Very-short Q4: expand the five letters; the dosage form is arishta — add the asava-vs-arishta distinction in a phrase.
- Very-short Q5: one line for the law, one word for the system.
- Short Q1: list the four reagents with their precipitates, then the unifying line — the nitrogen lone pair — as the explanation.
- Short Q2: a four-row comparison table is the whole answer; keep each cell to a phrase.
- Short Q3: three two-line principles, then four dosage forms as term = meaning pairs.
- Long Q1: structure — intro with the primary/secondary split; four subheads each carrying definition → test principle → drug example; conclude with the biosynthetic-link line.
- Long Q2: structure — two halves (allopathy: supplier + policeman; traditional: scientific backbone); name taxol/artemisinin as the bridge examples; close with the one-line job description.

Unit V — Phyto-therapeutic Agents

This unit carries the most marks per hour of any unit in the paper. The exam pattern is brutally predictable: biological source (botanical name + family + part used) → major chemical constituents → uses. Learn every drug in that order, and then add the why — the mechanism nugget given under each table. That extra line is what converts a 5-mark answer into a 10-mark one, and it is where GPAT questions live.

One general caution before the tables: several families below have been reshuffled by modern APG classification. Older textbooks (and most exam keys) still use the classical family. Both are noted; in the exam, quote the classical one unless the question asks otherwise.

Adaptogens and immunomodulators

Adaptogens help the body resist stress; immunomodulators tune immune response up or down.

Drug	Biological source	Major constituents	Uses
Ashwagandha	Dried roots of <i>Withania somnifera</i> , Solanaceae	Withanolides (withaferin A, withanolide D), alkaloids (withanine)	Adaptogen, anti-stress, immunomodulator; strength, stamina, sleep quality
Tulsi (Holy basil)	Leaves of <i>Ocimum sanctum</i> (= <i>O. tenuiflorum</i>), Lamiaceae	Eugenol, ursolic acid, rosmarinic acid	Immunomodulator, adaptogen; cold, cough, respiratory disorders
Amla (Indian gooseberry)	Dried fruits of <i>Phyllanthus emblica</i> (= <i>Emblica officinalis</i>), Euphorbiaceae (modern: Phyllanthaceae)	Vitamin C, tannins (emblicanin A & B), gallic acid	Immunomodulator, antioxidant, Rasayana (rejuvenative); Triphala and Chyawanprash ingredient

Deeper lines:

- Ashwagandha: withanolides are steroidal lactones that modulate the HPA axis — they blunt the cortisol spike of chronic stress — with mild GABA-mimetic (calming) action. That dual stress-plus-calm profile is the pharmacological meaning of "adaptogen".
- Tulsi: eugenol is the same phenolic compound that makes clove oil a dental analgesic — anti-inflammatory and antimicrobial. One constituent, two syllabus drugs (Tulsi, clove): examiners notice such links.
- Amla: the vitamin C here is unusually stable because the emblicanin tannins protect it from oxidation — which is why amla powder retains vitamin C far better than citrus juice does. A ready-made "why" for a reasoning question.

Hepatoprotectives

Drug	Biological source	Major constituents	Uses
Milk thistle	Dried seeds/fruits of <i>Silybum marianum</i> , Asteraceae	Silymarin — a mixture of flavonolignans (silybin/silibinin, silychristin, silydianin)	Hepatoprotective: hepatitis, cirrhosis support, Amanita mushroom poisoning (injectable silibinin)
Kutki	Dried rhizomes/roots of <i>Picrorhiza kurroa</i> , Scrophulariaceae (modern: Plantaginaceae)	Picroside I & II, kutkoside (iridoid glycosides)	Hepatoprotective, bitter tonic; jaundice and liver disorders

Deeper lines:

- Milk thistle: silymarin works three ways — antioxidant (scavenges free radicals in hepatocytes), membrane stabilizer (blocks toxin entry), and stimulant of ribosomal protein synthesis (helps liver cells regenerate). "Flavonolignan" = flavonoid + lignan fused — a word examiners love to ask.

- Kutki: the iridoid glycosides stimulate bile secretion (choleretic) while protecting liver cells — and remember from Unit II, this is the endangered Himalayan herb. Conservation status and therapeutic use in one drug: a perfect long-question ingredient.

Cardiovascular drugs

Drug	Biological source	Major constituents	Uses
Garlic	Bulbs of <i>Allium sativum</i> , Liliaceae (modern: Amaryllidaceae)	Alliin → allicin (formed by allinase on crushing), ajoene	Hypolipidemic, antihypertensive, antiplatelet; atherosclerosis
Arjuna	Dried stem bark of <i>Terminalia arjuna</i> , Combretaceae	Arjunolic acid, arjunic acid, tannins, flavonoids	Cardiotonic; angina, heart-failure support, hyperlipidemia

Deeper lines:

- Garlic: the intact clove contains odourless alliin; crushing brings the enzyme allinase into contact with it, generating pungent allicin — which is unstable and breaks down to ajoene and other sulphur compounds. So how you prepare garlic decides what chemistry you get: raw crushed garlic ≠ cooked garlic ≠ aged extract. Antiplatelet action (ajoene inhibits platelet aggregation) plus lipid-lowering is the cardiovascular logic.

Trap alert: "Name the active constituent of garlic." The safe answer: alliin (precursor) and allicin (formed on crushing by allinase). Writing only "allicin" misses the enzyme story; writing only "alliin" misses the active form. Give both, in that order.

- Arjuna: triterpenoid arjunolic acid plus a heavy tannin load — the tannins explain its astringent bark, the triterpenoids its cardiotonic claim. Classical Ayurvedic texts recommend it for hritshoola (cardiac pain), one of the oldest documented cardio-herb uses.

Antidiabetics

Drug	Biological source	Major constituents	Uses
Gymnema (Gurmar)	Leaves of <i>Gymnema sylvestre</i> , Asclepiadaceae (modern: Apocynaceae)	Gymnemic acids (triterpene saponins)	Antidiabetic; reduces intestinal glucose absorption
Fenugreek (Methi)	Seeds of <i>Trigonella foenum-graecum</i> , Fabaceae (Leguminosae)	Trigonelline, diosgenin, 4-hydroxyisoleucine, galactomannan mucilage	Antidiabetic, hypolipidemic; galactagogue (lactation support)

Deeper lines:

- **Gymnema:** "Gurmar" literally means sugar destroyer — chewing the leaves temporarily blocks sweet-taste receptors on the tongue, so sugar tastes like sand. The same gymnemic acids reduce glucose absorption in the intestine. Taste experiment + pharmacology in one leaf: that is why examiners adore this drug.
- **Fenugreek:** two GPAT-worthy constituents — 4-hydroxyisoleucine, an amino acid that stimulates insulin release, and diosgenin, a steroidal sapogenin that became the industrial starting material for steroid drugs via the Marker degradation (the contraceptive-pill story). The mucilage slows carbohydrate absorption, flattening post-meal glucose spikes.

Anti-inflammatory and analgesic drugs

Drug	Biological source	Major constituents	Uses
Turmeric (Haldi)	Dried rhizomes of <i>Curcuma longa</i> , Zingiberaceae	Curcumin (plus demethoxy- and bisdemethoxy-curcumin = curcuminoids), volatile oil (turmerone)	Anti-inflammatory, analgesic, antioxidant; arthritis, wound healing
Boswellia (Salai guggul)	Oleo-gum-resin of <i>Boswellia serrata</i> , Burseraceae	Boswellic acids, especially AKBA (3-O-acetyl-11-keto- β -boswellic acid)	Anti-inflammatory; osteoarthritis, rheumatoid arthritis, asthma, inflammatory bowel disease

Deeper lines:

- **Turmeric:** curcumin blocks the NF- κ B pathway — the master switch for inflammatory genes — and inhibits both COX and LOX enzymes. Its Achilles heel is poor oral bioavailability (rapid metabolism, poor absorption); piperine from black pepper inhibits its glucuronidation and multiplies absorption several-fold — which is why traditional turmeric milk and modern formulations both pair it with pepper. Tradition knew the pharmacokinetics before the word existed.
- **Boswellia:** AKBA selectively inhibits 5-lipoxygenase, choking off leukotriene production. Note the contrast: NSAIDs block COX (prostaglandins); boswellic acids block LOX (leukotrienes). Different enzyme, different inflammatory mediators — a favourite "compare" angle.

CNS drugs

Drug	Biological source	Major constituents	Uses
Brahmi	Whole plant of <i>Bacopa monnieri</i> , Scrophulariaceae (modern: Plantaginaceae)	Bacosides A & B (saponins), brahmine (alkaloid)	Nootropic (memory enhancer), anxiolytic; epilepsy support; Medhya Rasayana

Deeper lines:

- Brahmi: bacosides enhance memory by supporting cholinergic transmission and providing antioxidant protection to neurons; clinical interest centres on age-related memory decline and student-type cognitive load. Medhya Rasayana = the Ayurvedic category of intellect-promoting rejuvenatives — quote the term; it signals you know the classical frame.

Trap alert — the Brahmi naming trap (the most famous one in this subject): In pharmacognosy textbooks and the IP, *Brahmi = *Bacopa monnieri* (bacosides). But in several regional traditions, "Brahmi" also means Gotu kola = *Centella asiatica*** (asiaticoside). Both are Medhya Rasayana, both are memory herbs — which is exactly why the confusion survives. In the exam, write "*Bacopa monnieri* (note: *Centella asiatica** is also regionally called Brahmi/Mandukaparni)" and you are bulletproof.

Antimicrobials and antivirals

Drug	Biological source	Major constituents	Uses
Giloy (Guduchi)	Stems of <i>Tinospora cordifolia</i> , Menispermaceae	Tinosporin, cordifolioside A, tinosporaside, berberine	Immunomodulator, antipyretic; recurrent infections; supportive care in dengue/chikungunya
Neem	Leaves/bark/seeds of <i>Azadirachta indica</i> , Meliaceae	Azadirachtin, nimbin, nimbidin, salannin	Antimicrobial, insecticidal; skin diseases, dental care
Andrographis (Kalmegh)	Whole plant of <i>Andrographis paniculata</i> , Acanthaceae	Andrographolide (diterpene lactone)	"King of bitters"; antimicrobial, hepatoprotective, immunostimulant; cold, flu, liver disorders

Deeper lines:

- Giloy: a climbing shrub whose stems (not leaves) are official — the starch from its stems (Guduchi satva) is itself a classical preparation. Immunomodulation plus antipyresis explains its frontline role in fevers of unknown origin in AYUSH practice.
- Neem: azadirachtin is an antifeedant — it does not poison insects outright so much as stop them eating and moulting, which is why neem is a pesticide that spares beneficial

insects relatively. Same molecule, two industries: pharma (antimicrobial) and agriculture (biopesticide).

- Andrographis: andrographolide is a diterpene lactone — link it back to Unit IV's terpenoid classification (C20). Intensely bitter (hence "king of bitters" — compare with Chirata's bitterness value in Unit III). The bitterness is not incidental: bitter diterpenes are the plant's anti-herbivore defence, borrowed as medicine.

Gastrointestinal drugs

Drug	Biological source	Major constituents	Uses
Psyllium (Isabgol)	Dried seeds/husk of <i>Plantago ovata</i> , Plantaginaceae	Mucilage (arabinoxylan) — very high swelling index	Bulk-forming laxative (constipation); also used in diarrhoea and hyperlipidemia

Deeper lines:

- Psyllium: the husk's mucilage swells enormously in water (recall the swelling index from Unit III — psyllium is the textbook example of why that parameter exists). As a bulk laxative it works mechanically: the swollen gel increases stool volume, which stretches the gut wall and triggers peristalsis — no chemical stimulation of the bowel, which is why it is safe for long-term use. In diarrhoea the same mucilage absorbs excess water; in hyperlipidemia it binds bile acids. One property (water-holding gel), three uses — learn it as that.

Dermatological agents

Drug	Biological source	Major constituents	Uses
Aloe (Ghrithkumari)	Dried juice of the leaves of <i>Aloe barbadensis</i> (= <i>Aloe vera</i>), Liliaceae (modern: Asphodelaceae)	Aloin (barbaloin), aloe-emodin (anthraquinone glycosides); mucilage (acemannan) in the gel	Gel: burns, wounds, moisturizer. Latex: stimulant laxative

Deeper lines:

- Aloe: the leaf holds two different drugs in two compartments — the clear inner gel (mucilage: soothing, wound-healing, cosmetic) and the bitter yellow latex just under the rind (anthraquinone glycosides: stimulant laxative, like senna — same Bornträger chemistry as Unit III). Confusing the two is the standard exam trap: gel for skin, latex for laxation.

Trap alert: "Aloe is a laxative" — half true. The latex is the laxative; the gel you put on sunburn has negligible anthraquinones. Always specify which part. Examiners phrase it as "distinguish between aloe gel and aloe latex" precisely to test this.

Drugs used in women's health

Drug	Biological source	Major constituents	Uses
Chasteberry	Dried ripe fruits of <i>Vitex agnus-castus</i> , Verbenaceae (modern: Lamiaceae)	Agnuside, aucubin (iridoid glycosides); casticin (flavonoid); essential oil	PMS, menstrual irregularities; regulates prolactin
Shatavari	Dried roots of <i>Asparagus racemosus</i> , Liliaceae (modern: Asparagaceae)	Shatavarins I-IV (steroidal saponins)	Galactagogue (promotes lactation), menopausal support, Rasayana for women's health

Deeper lines:

- Chasteberry: its constituents act on dopamine receptors in the pituitary, lowering prolactin — and excess prolactin is what disturbs the menstrual cycle in PMS and cycle irregularities. Dopamine → less prolactin → regular cycles: a clean three-step mechanism for a 5-mark answer. (The name nods to its old reputation for calming libido — agnus-castus = "chaste lamb".)
- Shatavari: "she who possesses a hundred husbands" — the name itself signals women's-health use. Shatavarins are steroidal saponins (link back to Unit IV: saponin glycosides, foaming index, haemolytic potential — the same chemistry that makes them foam also underlies their bioactivity).

Respiratory drugs

Drug	Biological source	Major constituents	Uses
Vasaka (Adulsa)	Leaves of <i>Adhatoda vasica</i> (= <i>Justicia adhatoda</i>), Acanthaceae	Vasicine, vasicinone (quinazoline alkaloids)	Expectorant, bronchodilator; cough, asthma, bronchitis

Deeper lines:

- Vasaka: vasicine is a quinazoline alkaloid with bronchodilator action — and it is the parent molecule of a famous semi-synthetic story: chemists modified vasicine → bromhexine → ambroxol, the mucolytics still sold worldwide for productive cough. Vasaka is therefore the plant answer to "name an alkaloid that became a modern respiratory drug", mirroring the aspirin-from-salicin story in Unit I. The syllabus's milestone table and this drug are the same lesson: traditional use → isolated constituent → modern medicine.

GPAT angle: The vasicine → bromhexine → ambroxol chain is asked as "which plant alkaloid led to bromhexine?" Also remember the family cluster: Acanthaceae gives you three syllabus drugs — Vasaka, Andrographis, and Kalmegh's cousin... actually Vasaka and Andrographis (plus Adhatoda). Family-repetition is a memory hook: when you see Acanthaceae, think respiratory + bitters.

Fast-revision checklist for Unit V — cover the tables and recite each drug as common name → botanical name → family → part → constituents → uses → one mechanism line. Twenty-one drugs, eleven classes:

Adaptogens: Ashwagandha, Tulsi, Amla · Hepatoprotectives: Milk thistle, Kutki · Cardiovascular: Garlic, Arjuna · Antidiabetics: Gymnema, Fenugreek · Anti-inflammatory: Turmeric, Boswellia · CNS: Brahmi · Antimicrobial: Giloy, Neem, Andrographis · GI: Psyllium · Dermatological: Aloe · Women's health: Chasteberry, Shatavari · Respiratory: Vasaka.

Cross-links: three ways to revise the 21 drugs (GPAT favourite)

Memorizing 21 drugs as 21 isolated rows is the slow way. Examiners — especially GPAT — ask across the rows. Here are three cross-cutting views; each one reuses the same facts you already learned.

1. By constituent class (links back to Unit IV — "which syllabus drug is an example of class X?"):

Constituent class	Syllabus drugs
Alkaloids	Vasaka (vasicine, vasicinone)
Saponins (triterpene / steroidal)	Brahmi (bacosides), Shatavari (shatavarins), Gymnema (gymnemic acids), Fenugreek (diosgenin)
Tannins / polyphenols	Amla (emblicanins), Arjuna (tannins), Turmeric (curcumin — a diarylheptanoid polyphenol)
Terpenoids	Boswellia (boswellic acids — triterpenes), Andrographis (andrographolide — diterpene lactone)
Sulphur compounds	Garlic (alliin → allicin)
Anthraquinone glycosides	Aloe latex (aloin)
Iridoid glycosides	Kutki (picrosides), Chasteberry (agnuside)
Flavonolignans	Milk thistle (silymarin)
Withanolides (steroidal lactones)	Ashwagandha
Mucilage	Psyllium, Aloe gel
Volatile-oil phenols	Tulsi (eugenol)
Limonoids (tetranortriterpenoids)	Neem (azadirachtin)

Constituent class	Syllabus drugs
Mixed (alkaloid + glycoside)	Giloy (tinosporin, cordifolioside, berberine)

2. By family clusters (one family, several drugs — a memory hook):

Family	Syllabus drugs
Acanthaceae	Vasaka, Andrographis
Solanaceae	Ashwagandha
Lamiaceae	Tulsi
Zingiberaceae	Turmeric
Combretaceae	Arjuna
Menispermaceae	Giloy
Plantaginaceae	Psyllium

3. By the "story drugs" — traditional use → isolated constituent → modern medicine (the Unit I milestone pattern, repeated):

Story	The chain
Willow → aspirin	Salicin (phenolic glycoside) → salicylic acid → acetylation (Hoffmann, 1897)
Vasaka → bromhexine/ambroxol	Vasicine (quinazoline alkaloid) → semi-synthetic mucolytics
Sweet wormwood → ACT	Artemisinin (sesquiterpene endoperoxide; Tu Youyou, Nobel 2015)
Fenugreek/Dioscorea → steroids	Diosgenin (steroidal sapogenin) → Marker degradation → contraceptive steroids
Pacific yew → taxol	Paclitaxel (diterpene; Wani & Wall, 1971) → semi-synthesis from needles

GPAT angle: "Which of the following is a saponin-containing drug?" — look at the class table: Brahmi, Shatavari, Gymnema, Fenugreek. "Which syllabus drug gives a steroidal starting material?" — Fenugreek (diosgenin). Cross-classification turns 21 separate facts into one searchable map.

Very short questions (2 marks)

- 1 Give the biological source (botanical name, family, part used) of Ashwagandha and name its major constituents.
- 2 Why is Gymnema called "Gurmar"? Name its active constituents.
- 3 Distinguish between aloe gel and aloe latex in terms of constituents and uses.

- 4 Which plant alkaloid is the parent molecule of bromhexine and ambroxol? Give its source.
- 5 Name the two hepatoprotective drugs in the syllabus with one major constituent of each.

Short questions (5 marks)

- 1 Describe the biological source, constituents and uses of Garlic. Explain why crushed garlic differs chemically from an intact clove.
- 2 Write short notes on: (a) Turmeric as an anti-inflammatory (include the bioavailability problem), (b) Boswellia (include its enzyme target and how it differs from NSAIDs).
- 3 Explain the Brahmi naming ambiguity. How would you correctly identify the official drug?

Long questions (10 marks)

- 1 Describe the biological source, major chemical constituents and uses of any five of the following: Ashwagandha, Kutki, Arjuna, Fenugreek, Brahmi, Vasaka, Shatavari. Add one mechanism-based note for each drug chosen.
- 2 Discuss plant-derived drugs that became modern medicines, with reference to (a) vasicine → bromhexine/ambroxol, (b) salicin → aspirin, and (c) artemisinin. What common lesson do these stories teach about pharmacognosy?

How to approach these answers

- Very-short Q1: botanical name + family + part in one line, then the withanolide line; that is the complete answer.
- Very-short Q2: translate "Gurmar" first (sugar destroyer), then the sweet-taste-blocking logic in one line, then gymnemic acids.
- Very-short Q3: two columns — gel (mucilage, skin) vs latex (anthraquinones, laxative); one line each.
- Very-short Q4: name vasicine, then *Adhatoda vasica*/Acanthaceae/leaves; the bromhexine link is the point.
- Very-short Q5: two drug-constituent pairs; milk thistle (silymarin) and kutki (picrosides).
- Short Q1: source → constituents → uses, then the alliin/allinase crushing story as the second half.
- Short Q2: for each — source line, constituent line, mechanism line (NF- κ B/piperine; 5-LOX vs COX); keep the two notes balanced.
- Short Q3: state both plants and their constituents, explain why the confusion exists (shared *Medhya Rasayana* use), close with the IP position.
- Long Q1: structure — five equal mini-sections, each with source/constituent/use plus the mechanism line; do not let one drug eat half the answer.
- Long Q2: structure — intro on the traditional-to-modern path; three case studies in parallel (source → constituent → modification → modern drug); conclude with the one-line lesson about pharmacognosy as the bridge.