

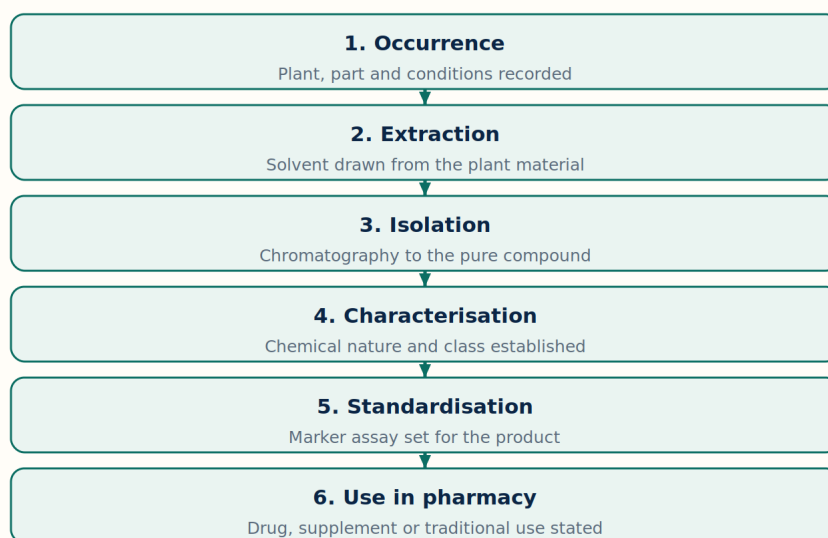
Unit 4: Phytopharmaceuticals

Free notes at pharmacolearn.fyi

4.1 Phytopharmaceuticals: the pattern for every compound in this unit

A phytopharmaceutical, for the purpose of this unit, is a defined plant derived compound or compound group studied as a pharmaceutical substance in its own right: its occurrence, its isolation, and its characteristic features, meaning its chemical nature, its uses in pharmacy, and its medicinal and health benefits. The syllabus lists the compounds group by group, and each section below follows the same four part pattern, so that any compound can be revised and answered in the same shape. Occurrence: where in nature, and in which plant and part, the compound is found. Isolation: the general route by which it is obtained, in outline. Chemical nature: the class it belongs to and the structural feature that defines it. Uses and benefits: its established and marketed uses, stated with the discipline of this course, distinguishing a licensed drug use from a supplement use and from a traditional use. The development path figure below shows how a plant constituent travels from occurrence in the plant to a characterised phytopharmaceutical, which is the journey every section of this unit repeats.

The phytopharmaceutical path



Every compound in Unit 4 is answered in this order

© 2026 PharmacoLearn, pharmacolearn.fyi

Figure: The phytopharmaceutical path: occurrence, extraction and isolation, characterisation of chemical nature, standardisation, and use in pharmacy.

4.2 Carotenoids: alpha and beta carotene, and xanthophyll (lutein)

Carotenoids are the yellow, orange and red pigments of plants, tetraterpenoid compounds built from eight isoprene units, forty carbons in the main chain, with a long system of conjugated double bonds that gives them their colour and their antioxidant behaviour. They divide into the carotenes, which are pure hydrocarbons, and the xanthophylls, which are their oxygen containing relatives.

Alpha and beta carotene. Beta carotene is the most widespread carotene of green leaves and the pigment of carrots, pumpkins, sweet potatoes and other orange vegetables and fruits; alpha carotene occurs

alongside it in many of the same sources, in smaller amounts. Isolation is by extraction of the plant material with organic solvents and chromatographic separation, handled throughout with protection from light, heat and oxygen, since the conjugated system degrades readily. Chemically, both are hydrocarbon carotenes, and both are provitamins A: the body can cleave beta carotene centrally to give vitamin A (retinal and then retinol), which is the basis of their pharmacy use. Beta carotene is used as a vitamin A source in supplements, as a natural colouring agent for foods and pharmaceuticals, and as an antioxidant nutrient; it is also the standard teaching caution that high dose beta carotene supplements increased lung cancer risk in smokers in major trials, the classic proof that a food nutrient and a high dose supplement are not the same exposure.

Lutein. Lutein is a xanthophyll, the oxygenated carotenoid of green leafy vegetables and of marigold flowers, the commercial source. Chemically it carries hydroxyl groups on its end rings, which beta carotene lacks, and that difference decides its fate: lutein is not a vitamin A precursor. Instead it accumulates in the macula of the human eye, where it is, with its relative zeaxanthin, the macular pigment. Its pharmacy and health use follows from that occurrence in the eye: lutein is a standard ingredient of eye health supplements positioned for macular support, and a natural colour as well.

4.3 Limonoids: d-limonene and alpha terpineol

The syllabus places two monoterpene compounds under the limonoid heading: d-limonene and alpha terpineol. (In strict chemical classification, limonoids are the bitter tetranortriterpenoids of citrus seeds and neem; limonene and alpha terpineol are monoterpenes of citrus peel oil. The syllabus groups them with the citrus compounds, and this section teaches them as listed, with the classification stated honestly, as an examiner rewards.) **d-Limonene** is the major constituent of citrus peel oils, orange oil above all, a monocyclic monoterpene hydrocarbon with the characteristic orange odour. It is obtained as a by product of the citrus juice industry, by cold expression or distillation of the peel. In pharmacy it is used as a flavouring and fragrance material, as a solvent and penetration assisting ingredient in formulations, and it is sold as a supplement, chiefly positioned for digestive comfort. **Alpha terpineol** is a monoterpene alcohol, occurring in pine oil, petitgrain and other essential oils and formed from other terpenes; it carries a lilac like odour and is used in pharmacy and cosmetics as a fragrance ingredient and for the mild antiseptic character of the terpene alcohols, and it appears in cleaning and disinfectant type preparations. Both compounds teach the same point: volatile oil constituents are phytopharmaceuticals too, standardised by assay of the named terpene in the oil.

4.4 Saponins: shatavarins

Saponins are glycosides whose aglycone (sapogenin) is either a steroid or a triterpenoid, and whose combined sugar and aglycone structure makes them surface active: their aqueous solutions foam, the property that names them from soap. **Shatavarins** are the steroidal saponins of shatavari, the roots of *Asparagus racemosus*, a major Ayurvedic drug; shatavarin I is the most studied of the group. Occurrence is in the root, the official drug part. Isolation is by extraction of the roots, commonly with alcohol or aqueous alcohol, followed by fractionation and chromatographic purification of the saponin fraction. Chemically, shatavarins are sarsasapogenin type steroidal saponin glycosides. Shatavari's traditional and marketed uses are as a galactagogue (supporting milk production), a general female health tonic in Ayurvedic practice, and a soothing demulcent type drug for the gut. Shatavari is the bridge example of this unit: an Ayurvedic drug whose marker saponins let a traditional product be standardised by modern assay.

4.5 Flavonoids: resveratrol, rutin, hesperidin, naringin and quercetin

Flavonoids are the great polyphenol family of plants, built on a fifteen carbon C6-C3-C6 skeleton of two aromatic rings joined by a three carbon bridge, usually closed into an oxygen containing ring. They colour flowers and fruits, protect plants against ultraviolet light and oxidation, and dominate the antioxidant chemistry of the diet. The syllabus names five, and the family figure below sets them side by side before each is taken in turn.

The Unit 4 flavonoid family		
Resveratrol	Stilbenoid	Grape, knotweed
Rutin	Flavonol glycoside	Buckwheat, Sophora
Hesperidin	Flavanone glycoside	Citrus peel
Naringin	Flavanone glycoside	Grapefruit
Quercetin	Flavonol aglycone	Onion, apple, tea

One C6-C3-C6 family, five named members: class and source are the exam facts
 © 2026 PharmacoLearn, pharmacolearn.fyi

Figure: The five named flavonoid group compounds of Unit 4. Resveratrol is strictly a stilbenoid, grouped with the flavonoids in the syllabus list and taught here as listed, with its true class stated.

Resveratrol. A stilbenoid polyphenol (the syllabus groups it with the flavonoids; its true class is the stilbenes), produced by plants such as grape vine and Japanese knotweed, the commercial source, in response to fungal attack and stress: it is a phytoalexin, a defensive compound. It occurs in grape skins and therefore in red wine in small amounts. Isolated by extraction and chromatography from knotweed or grape sources, it is sold as a supplement positioned for antioxidant and healthy ageing support, and it is one of the most researched polyphenols in the literature, which an examination answer may say, without converting research interest into proven drug claims.

Rutin. A flavonol glycoside: the aglycone quercetin carrying the disaccharide rutinose. It occurs widely, in buckwheat, in citrus, and classically in rue and in Sophora flower buds, a commercial source. Rutin has a long pharmacy history under the vitamin P name given to the flavonoids once thought to govern capillary permeability, and it is used in preparations positioned for capillary and venous support, often with its semisynthetic relatives.

Hesperidin. A flavanone glycoside, the characteristic flavonoid of orange and other citrus peel, where it is a major component of the peel's flavonoid fraction. Chemically it is hesperetin (the aglycone) with rutinose attached, and its low water solubility is a known formulation feature. It is used in venous health preparations, in combination with diosmin in the micronised flavonoid fraction used for chronic venous insufficiency and haemorrhoids in many countries, the strongest established pharmacy use in this flavonoid list.

Naringin. The flavanone glycoside of grapefruit and pomelo, responsible with its aglycone naringenin for much of grapefruit's bitterness. It is taught for its occurrence and class, and for one interaction fact that also belongs to Unit 5: grapefruit constituents, the furanocoumarins above all, with naringin long studied alongside them, are associated with the inhibition of intestinal CYP3A4 and the raised blood levels of many medicines taken with grapefruit products, the textbook biodrug-food interaction.

Quercetin. The most widespread flavonol aglycone in the diet, occurring in onions, apples, berries and tea, mostly as glycosides such as rutin. Quercetin is the reference flavonol of the laboratory, used across antioxidant and enzyme studies, and a common supplement ingredient positioned for antioxidant and seasonal immune support. Its glycoside rutin and quercetin itself together teach the aglycone and glycoside relationship that runs through flavonoid chemistry.

Compound	True class	Best known source	Signature point
Resveratrol	Stilbenoid polyphenol	Grape skins; Japanese knotweed	Phytoalexin, made by the plant under attack
Rutin	Flavonol glycoside	Buckwheat; Sophora buds	Quercetin plus rutinose; the old vitamin P
Hesperidin	Flavanone glycoside	Orange and citrus peel	Partner of diosmin in venous preparations
Naringin	Flavanone glycoside	Grapefruit and pomelo	Grapefruit bitterness; interaction teaching
Quercetin	Flavonol aglycone	Onions, apples, tea	The reference dietary flavonol

4.6 Phenolic acids: ellagic acid

Phenolic acids are the simpler plant phenols, aromatic acids of the hydroxybenzoic and hydroxycinnamic families, widespread as free acids and as parts of larger tannins. **Ellagic acid** is the syllabus's named example. It occurs in pomegranate, raspberries, strawberries, walnuts and other fruits and nuts, and it is formed from the ellagitannins, the large hydrolysable tannins of those sources, which break down to release it. Chemically, ellagic acid is a fused, planar polyphenolic dilactone, poorly soluble in water, a property that shapes both its isolation, by extraction and hydrolysis of ellagitannin rich material, and its formulation. It is positioned in supplements and cosmetics for antioxidant content, and in the gut it is further converted by gut bacteria to the urolithins, the metabolites through which much of its biology is now studied.

4.7 Vitamins as phytopharmaceuticals

Vitamins appear in this unit in their listed position, as plant derived pharmaceutical substances, after their supplement treatment in Unit 3. The phytopharmaceutical angle is occurrence and isolation: vitamin C (ascorbic acid) from fruits such as amla, acerola and rose hips in natural source products; the vitamin E family of the next section, from vegetable oils; provitamin beta carotene of Section 4.2; and folates from green leaves. The characteristic feature to state is that a vitamin is the same molecule whether it is synthesised or isolated from a plant, so natural source vitamins are standardised by the same assays as synthetic ones, and the choice between them is one of source, formulation and labelling, not of a different active.

4.8 Tocotrienols and tocopherols

Tocopherols and tocotrienols together form the vitamin E family: eight compounds, alpha, beta, gamma and delta tocopherols and the corresponding four tocotrienols, all built on a chromanol head with a long side chain; the tocopherols carry a saturated chain and the tocotrienols an unsaturated chain with three double bonds, the structural difference that names and separates them. They occur in vegetable oils and seeds: tocopherols widely, in sunflower, wheat germ and many seed oils, and tocotrienols concentrated in palm oil, rice bran oil and annatto. Isolation is from the oils and their deodorisation fractions, by extraction and chromatographic methods. Alpha tocopherol is the form with the highest vitamin E activity and the reference form for requirements. In pharmacy the family is used as vitamin E supplements, as antioxidants protecting oils and formulations themselves from oxidation, and in skin preparations; tocotrienols are separately marketed and researched for their own profile, distinct from the common tocopherols precisely because of

the unsaturated chain and its different distribution in tissues.

4.9 Andrographolide, glycolipids and guggulipids

Andrographolide is the bitter diterpene lactone of *Andrographis paniculata*, kalmegh, the intensely bitter Ayurvedic and traditional drug known as the king of bitters. It occurs in the leaves and aerial parts, is isolated by alcoholic extraction and crystallisation or chromatography, and is the marker on which andrographis products are standardised. Its traditional and marketed uses centre on the common cold and upper respiratory infections and on liver support in tradition, and it is one of the best studied Indian phytopharmaceuticals.

Glycolipids are lipids carrying one or more sugar units: membrane compounds of every living cell, in plants including the galactolipids of chloroplast membranes. They are taught as a class: occurrence in plant and food materials, isolation with the lipid fractions and separation by chromatography, and their amphiphilic character, part fat and part sugar, which gives them emulsifying and membrane related interest in pharmacy and food science.

Guggulipids are the standardised lipid fraction of guggul, the oleo gum resin of *Commiphora wightii* (syn. *Commiphora mukul*), the Ayurvedic drug guggulu. The active markers of the fraction are the guggulsterones, E and Z guggulsterone, steroid compounds of the resin. Guggulipid preparations were developed in India as a standardised phytopharmaceutical positioned for cholesterol support, and they remain the textbook Indian example of a traditional resin converted into a marker standardised product, with the conservation note that the source tree has been heavily tapped and is under pressure in the wild, linking this section back to Unit 1.

4.10 Withanolides, vascine and taxol

Withanolides are the steroidal lactones of ashwagandha, the roots of *Withania somnifera*, the most prominent adaptogen drug of Ayurveda. Chemically they are ergostane type steroids with a lactone side ring; withaferin A and withanolide A are the most studied members. They occur chiefly in the root, the official part, are isolated by alcoholic extraction and chromatography, and are the markers on which ashwagandha extracts are standardised. Ashwagandha products are positioned for stress, sleep and vitality support, and the plant is also this course's recurring example of a cultivated Indian drug developed through agricultural research.

Vascine (also spelled vasicine) is the quinazoline alkaloid of vasaka, the leaves of *Adhatoda vasica* (*Justicia adhatoda*), the classic Ayurvedic expectorant drug. It is isolated from the leaves by standard alkaloid extraction, acid base partitioning and purification. Vascine's pharmacy importance is doubled by its descendant: the synthetic expectorant and mucolytic drugs bromhexine and its active metabolite ambroxol were designed from the vascine structure, making vascine a clean example of a phytopharmaceutical serving as a drug design lead as well as a traditional drug constituent.

Taxol, the generic name paclitaxel, is the diterpenoid anticancer drug first isolated from the bark of the Pacific yew, *Taxus brevifolia*. Chemically it is a complex taxane diterpene with an unusual ring system and side chain, and its mechanism is distinctive: it stabilises microtubules and prevents their breakdown, freezing cell division, the opposite action to the vinca alkaloids. Its occurrence in bark in very small amounts created the classic supply crisis: bark collection killed a slow growing tree for a small yield. The solutions are now standard teaching and a model for Unit 2's supply problems: semisynthesis from baccatin III and related taxanes obtained from renewable yew needles and cultivated yew, and plant cell culture production. Paclitaxel is an approved anticancer medicine, the strongest proof in this unit that a phytopharmaceutical can become a front line drug.

4.11 Miscellaneous

The syllabus closes Unit 4 with the open head Miscellaneous, naming no further compounds. Taught honestly, it is the instruction to be able to extend the method of this unit to any further named phytopharmaceutical an examiner or a monograph presents: state the occurrence, outline the isolation, give the chemical nature and class, and state the uses and benefits with the same discipline, distinguishing drug, supplement and traditional uses and naming the marker where one exists. No list is invented under this head in these notes.

4.12 Unit 4 in one view

Phytopharmaceuticals are studied in one fixed pattern: occurrence, isolation, chemical nature, uses and benefits. Carotenoids colour and, for the carotenes, feed vitamin A; lutein serves the macula. The citrus terpenes serve pharmacy as flavours, solvents and supplements. Shatavarins standardise shatavari; the five flavonoid group compounds span stilbenoid to flavanone glycoside chemistry; ellagic acid represents the phenolic acids; the vitamin E family divides into tocopherols and tocotrienols by one side chain difference; and andrographolide, the guggulsterones of guggulipid, the withanolides, vascine and taxol close the unit with India's standardised phytopharmaceuticals and one world class anticancer drug.

*More free M.Pharm notes and unit wise PDFs at pharmacolearn.fyi
Free video lectures on the PharmacoLearn YouTube channel*