

PHARMACOGNOSY AND PHYTOCHEMISTRY

Dr.Galvina Pereira

Department Of Pharmaceutical Science and Technology

Institute Of Chemical Technology Mumbai

Week 1

Lecture2

Week 1: Lecture 2: Introduction to Drugs of Natural Origin

Thank you. Hello everyone, and welcome to the second session of the NPTEL course in pharmacognosy and phytochemistry. In the previous session, we learned what pharmacognosy and phytochemistry are and the scope of the subject. Today, we will start discussing drugs obtained from nature,

which are often referred to as drugs of natural origin. So, let's understand the different drugs of natural origin. Drugs of natural origin can be obtained from various natural sources. They can be obtained from plants. In fact, the majority of the drugs that make their way into natural pharmacy

are mostly plant-based. A minor part of it consists of animal-based products. Then you have microbial-based products and mineral-based products. Now, whenever you have drugs of natural origin, they can either be in the form of organized drugs or unorganized drugs.

So let's understand the difference between the two. So whenever you say organized drugs, it means that they can generally be sourced from plants, animals, and microbes. When you say organized, that means they have a proper cellular structure. That means the cellular organization in them is very much intact. So take, for example, plants.

In plants, you know that there are tissues such as xylem and phloem. There's a proper cell wall that is covered by cellulose. You have your cytoplasmic membrane and so on. So

your cellular arrangement, the tissue arrangement, is very clear. Now, not only that, even when you powder these drugs, even in their most powdered form,

you will find the cell or the cell organelles intact in them. Such types of drugs are called organized drugs. Now, one good thing about this is, Whenever you have such organized drugs in your medicine, their identification becomes very easy. Say, for example, in this case, I have just put a section.

Now we call this a transverse section and this is a transverse section of a stem and it is a plant called an ephedra which gives the molecule ephedrine. Now you can clearly see that there is a nice cellular epidermis to it. And this epidermis has papillose cells, which you can see as little yellow dots at the pointer. And you can see here your xylem, phloem elements and this band like thing are your pericyclic fibers.

So not only the cells, the arrangement of the cells . The nature of that drug entirely can tell us what drug it is. Now, even if it occurs in the powder form, certain unique features such as your stone cells, such as your phloem fibers or typical arrangement of your xylem and phloem in organized drugs help us identify them. So a good example of organized drugs would definitely be your ephedra stem, senna leaflet, ashwagandha root, clove birds, a lot of things that you see in your kitchen, your cumin, caraway, they are all cellular in nature. Even if you cut them, you section them or if you directly take your garam masala and put it under a microscope, you will see a lot of cellular arrangement. You will see a lot of tissues, xylem, phloem. You will see what are called oil ducts and all of them will help us identify what it is. So such types of drugs are called organized drugs.

Now, when you come to unorganized drugs, they do not have cells. So they can be obtained from either plants, animals, microorganisms, or even minerals. Now, with minerals, there is no question of cellular arrangement at all. But when it comes from plants, animals, or microbes, they are chiefly the metabolites which have been pulled out or extracted from them. This extraction can be a solvent extraction.

It can be a distillation. Sometimes even making a cut on a plant can cause it to exudate some fluids. We often refer to them as gums or resins. This may be, you know, some of

them, some of these exudates may solidify. Some of them may remain semi-solid, or some of them may even remain liquid.

So all of them have one common feature. If you take these liquids, or if you take these oils, or if you take these extracts and put them under a microscope, there are no cells to be seen. So they lack cellular arrangement, and as a result, they are called unorganized drugs. Unorganized drugs are relatively difficult to identify but may be identified by their chemical properties, that is, the chemicals they contain, and they can be identified organoleptically.

So depending upon what structure they take. What chemical properties they possess, you can identify this type of drug. A good example is your aloe vera gel. You can see it, you know, when you open the aloe vera leaves, you will see a slimy, you know, tissue inside it. Now this is still cellular.

Now put it, blend it in a mixer and extract it in water. you will get the exude eight, which is liquid. And because you're filtered, all the cellular debris is gone. And what you're left with is just the carbohydrates coming out of it. So aloe vera, mucilage, which is coming out, agar agar, which is obtained from your sea kelps, your gelatin, which is obtained from your animal bones and eucalyptus oil obtained from your eucalyptus leaves are good examples of your unorganized drugs. Here you can see that Resin is a drug. So it's an oleogum resin drug called Myrrh. So Mir is one good example of an unorganized drug.

Now moving to drugs of plant origin, there are numerous, as I said; the majority of nature's pharmacy comes from plant-based drugs. So, it is difficult to list all the examples here, but I'm just providing some representative ones. For example, some of these plants have medicinal leaves. To name a few: Vasaka, which is Adulsa; senna, tulsi, mint, and aloe vera. The leaves of these plants are highly medicinal.

In some cases, the medicinal part may be the bark. Examples include cinnamon, also known as dalchini. Cinchona, used for fevers and malaria; and arjuna. Then, for seeds, you may have consumed linseed for cough relief. Or mustard, which is used in culinary preparations as well as for mustard oil.

In some cases, the stems may be medicinal. During the COVID season, or even now, you find many teas containing Giloy. That's Tinospora. It's a stem. Ephedra, as we just saw, is an example that provides ephedrine.

That's also a stem-based drug. Now, some flowers are medicinal. So in this case, if it is an unopened bud, you can have your clove. Clove is actually a flower. You can just take one from your kitchen and try opening the dome of it.

You will see the corolla, that is, you will see the petal part of it, and inside you will see the anther. So if you have it in your kitchen, just give it a try. Your kesar or saffron, calendula, and hibiscus are some examples of flowers which have medicinal values. Now, when it comes to fruits, there are fruits which are medicinal. So take, for example, your graviola or soursop, which is nowadays used in cancers.

Pomegranate—we've seen that pomegranate contains a good amount of pigments called anthocyanins, which are antioxidants. Not only that, the peel of pomegranate is rich in tannins and often used in making face masks and anti-aging creams. You have your amla, which is a rich antioxidant. Myrobalans, which are used in your triphala churna, are some examples of medicinal fruits. Now, coming to roots, these are the underground parts.

You will see your liquorice roots, raulfia, ashwagandha, and ginseng are some of the famous medicinal roots used in pharmaceuticals. When it comes to unorganized drugs from plants, you have your dink or acacia. You have your papaya latex, which is used as a proteolytic enzyme mixture. Then you have your eucalyptus oil or some enzymes from pineapple, which we call bromelain. They also have proteolytic activities. There are a few examples, but like I said, there are lots and

lots of drugs taken from plants. Now, moving to animals. Now, one humble animal that gives you many drugs of natural origin or substances of natural origin is the bee. From the bee, you will get beeswax, which is used in cosmetics and as an emollient. Honey is considered a demulcent and is given for cough. There is also research showing that it has excellent wound-healing and antibacterial properties.

Not only that, but when a bee stings, that bee sting is due to some peptides present in it. So, a bee sting is actually a mixture of peptides, and the major component of that peptide is a protein called melittin. Melittin in large doses is very painful and is responsible for the stinging effect of the bee, but in small doses, it has proven to be anti-inflammatory and

A lot of research has gone to show that this molecule may also be a potent anti-cancer agent. Not only that, sometimes bees produce a substance called bee propolis. It is a mixture of saliva, wax, honey, and it is a rich anti-inflammatory compound. So bee propolis grains are also available in the market nowadays to provide a good defensive effect on the body. Apart from that, you have wool fat, which comes from sheep, gelatin, which comes from most bovine animals, cattle, and their bones, as well as enzymes produced from pigs or cows. Basically, intestinal enzymes or stomach enzymes were initially taken from them when recombinant technology was not as advanced. Then you have cod liver oil, which is a rich source of omega-3 fatty acids, vitamin A, and vitamin D. Not only that, sometimes, you know, the vomit of an organism such as a whale is also highly prized. You know, a substance called ambergris or whale vomit is very prized.

A kilogram of it can fetch you crores. And that is something used in the perfumery industry. So these are a few animal-based substances. Moving on to microbe-based substances. Microbes very economically produce substances called antibiotics, and we use them.

I mean the use shouldn't be abundant, but we often use them to curb infections. Now, microbes also provide us with a rich source of enzymes. Now, these microorganisms, when they thrive, in order to thrive, they need to digest the organisms or they digest the plants in order to get food from such sources. So they secrete enzymes such as amylase, glycosidase, and pectinase to hydrolyze the substrate and to get the sugars out of it.

So these microorganisms are cultivated for it in fermenters, and the enzymes are collected. Once collected, they can be of your utility. Then we have carbohydrates such as your xanthan gum. We have your insulin. Now, initially, this was an animal-based peptide, which we were using.

But now, with recombinant DNA technology, many of these enzymes are prepared by microorganisms. So nowadays you have biosimilars. Now, many of them are actually genetically engineered so that your microorganisms can either help or aid in producing it. Not clearly, but sometimes directly, sometimes indirectly. So if it is a two-subunit microorganism, A will produce one microorganism, B will produce one.

And it is used in the case of insulin. Now you have algae-based products. One good example is spirulina, which is considered to be a space food. It is so nutritious that NASA has taken it to space for their astronauts. Now, apart from that, microorganisms are also a rich source of carotenes.

Nowadays, a rich antioxidant, a lipophilic antioxidant in the market, is astaxanthin, which is again produced by microorganisms. And, you know, fungi such as ergot, which grows on rye, is a good source of ergot alkaloids, which provide oxytocin-like activity. So, these are a few examples of microbe-based drugs.

Now, moving on to minerals, you have numerous minerals that have been used. You will see the easiest example is talcum powder or talc. This is commonly used for dusting. Then you have kaolin, which is used as a filter aid, asbestos, glass, bentonite, and calamine.

Calamine is used as a soothing agent, especially for blisters and burns, and as a mineral pigment. These pigments are used for their hue or color and are utilized in the cosmetic industry. Not only are they used, but minerals such as titanium dioxide are also employed in the pharmaceutical industry as an opacifier and an aid. Now, moving to unorganized drugs, there are numerous categories of unorganized drugs. To name a few, they include gums, mucilages, latex, resins, oils, juices, and extracts.

So, what is the slight difference between all of these? Let's try to understand. Now, when I'm talking about this category of unorganized drugs, I'm chiefly referring to unorganized drugs of plant origin. So, let's examine and understand them one by one. When we say gums, gums are basically polysaccharide derivatives that a plant produces when injured.

When a plant is injured or under stress, it changes its carbohydrate metabolism into a process called gummosis. This process of gummosis creates gum, and from that wound or cut you inflict on the plant, you will see a liquid oozing out. This liquid is chiefly carbohydrate in nature but contains complex polysaccharides. These include sugars as well as uronic acid derivatives.

The purpose is to seal the wound so that it doesn't get infected without any other things. So these gums are a good source for us when it comes to a lot of pharmaceutical aids. These gums are capable of absorbing water because they are polysaccharides in nature. Sugars in nature have a tendency to absorb water. Water and swell.

So they swell. Now when you consume them, unlike starches or simple polysaccharides, gums are not easily digested. They are digested with difficulty because they are a little complex in nature, depending upon their linkages. Their digestion rate varies and they are considered only partly digested by humans. So they can be used variably because they absorb water.

They are excellent binding agents. So if you've seen your acacia or dink, it is used for making laddus because it has a good ability to act as a binder. Now you have them as disintegrants, emulsifying agents, and suspending agents. So an emulsifying agent is something which helps you, you know, When there is a biphasic oil and water mixture, when you triturate it, it forms little droplets.

We call it emulsion. So, emulsifying agent if they are not there what will happen is over a period of time again the water phase and oil phase will separate but because there are emulsifying agents it forms coating on each droplet they will no longer fuse and form a biphasic mixture so they will no longer fuse and separate as phases so emulsifying agents then you have suspending agents because they have or impart a good viscosity make your solution very viscous, what happens is your powder doesn't settle down. So because the powder doesn't settle down, your powder remains there for a longer duration of time. In case of certain drugs which are insoluble, we want such kind of action. So they act as a good suspending agent.

Not only that, because they are polymeric in nature, they encase your drugs into a matrix and then they release it very slowly. So if you want a slow release or what is called a sustained release profile, even in that case, your gums are used. A good example of gums are your Acacia, Tragacanth and Sterculia gum. Now moving on to mucilages. Mucilages as compared to gums are physiologically present.

That means you need not injure the plant. It is already there. It's not there in every plant, but some classes or some families of plants do produce it. So They act as a slimy adhesive material.

I'll give you a good example. So if you know your bhindi (okra), or if you know your isabgol, or if you eat flaxseed, that is your linseed. When you chew it, you know there's a slimy thing coming out, or even in your aloe vera, you will see that jelly-like thing. They are clear, they are slimy, they are rich in sugars and they contain sugars, uronic acid, plus there are sulfated groups present in them.

So sulfates are also present. Now they are there in different plant parts, but mostly you will find many of them are there in the epidermal layer or outer layer of seeds, barks, and leaves which make them extensively slimy and difficult to handle. So

Isabgol, I'll just show you a quick video out here. Now, this isabgol we've kept in water, and you can see it has taken up water and formed a very slimy, viscous, gelatinous, mucilaginous what you call it as a viscous mixture. Now, this thing, when I put it under a microscope, you will see that this is the seed part of it. Now, this seed, in the presence of water, in the seed coat, there is a mucilage in its layer. Normally, the seed would appear as such, but because I put it in water, this mucilage has swollen.

Now, this mucilage can be stained with a staining agent such as ruthenium red, which reacts with the sulfate groups present in mucilage to impart a reddish coloration. So, you can detect it. So, even when you take your nimbupani containing chia seeds or faluda containing chia seeds, you will see that they have a nice outer coating, a halo-like thing next to them, which occurs when they are immersed in water.

That is your mucilage, and it can be stained by ruthenium red. Now, going on to the next category: latexes. Latexes are something you observe in some plants when you break the leaf or when you break the stem part of it or the flowers, you will see some milky white liquid coming out. Now, these plants possess something called lactiferous ducts, and in that is located an emulsion called latex.

So latex is basically an emulsion which has been stabilized by carbohydrates, proteins, and enzymes. Now, because it's an emulsion, it has a water phase as well as an oil phase. The water phase has mostly water-soluble compounds such as carbohydrates, proteins, enzymes, certain glycosides, or flavonoid derivatives. And the oil-soluble fraction has lipophilic compounds. So some sterols or other compounds may be present.

Now, this depends upon the plant. You must have seen a good example of that, such as *Calotropis* or rue. So you must have seen that whenever you tend to break the leaf of this plant, you will see that milky white liquid coming out, or this is the second example. It's a little inaccessible to us, but if you have heard of something called opium, opium actually comes from poppy capsules. So when you make tiny incisions in these poppy capsules with a blade, what happens is the latex comes out.

Another example of latex is when you take a raw papaya and cut the green peel off of it. Again, you will see the milky white fluid exuding out. Now, what happens is on exposure to air, this latex dries and in certain cases even turns brown due to oxidation. Now, examples like we said are even your *Ficus*. Species such as *Ficus bengalensis* or your *Ficus* trees are known to produce latex.

Now, these are used in the tenderization of milk. Your papaya is used in the tenderization of milk. Analgesic—your opium latex contains morphine, which is used as an analgesic, and to a certain extent, *Calotropis* is used as an anti-inflammatory agent. Now, not all latexes are safe. You must have encountered that certain times, if you see a raw mango, you cut it, and if this raw mango latex touches you, you get blisters. Now, certain times, especially in the *Anacardiaceae* family, to which your mango belongs, you will see that they possess compounds called urushiols. And urushiols are toxic phenolic compounds that cause blistering or allergies. So, these compounds are very allergenic in nature.

They cause urticarial rashes. So even your bilwa, or what you call it as your Semecarpus anacardium, contains bilavalol, and bilavalol also produces blistering properties. So, you need to be careful while handling drugs containing latex. They are very potent but may contain medicinal compounds as well.

Now, moving to the next, they are resins. Now, as compared to gums, resins are more complex in terms of their chemical nature—terpenoids. These are also produced when incisions are made. They are produced through resiniferous ducts, which are present, and they contain terpenes. Now, what happens with these terpenes is that as they exude out, they get oxidized,

they get polymerized, and result in a resinous secretion. This resinous secretion is called resin. Good examples are pine resin, myrrh resin, and chili resins, which are located inside. For example, in pepper spray, you could take chili and soak it in oil. Mostly, the resins come out.

Turmeric resin, guggul, and hing powder are all examples of resinous extracts. Now, depending upon... How is it processed? As I mentioned, most terpenoid compounds do oxidize. In some cases, as they remain, during their fossilization, many volatile compounds are lost.

Sometimes they occur as native resins. Sometimes they occur as resin combinations. So when resin combinations happen along with the terpenes, the oil will also come out, giving rise to oleoresin. A good example of oleoresin is chili and ginger. It is a combination of oil plus resin.

In some cases, you get oil plus resin plus carbohydrates. In such cases, they are called oleogum resin. A good example of oleogum resin is hing powder. So it's oil plus resin plus gum. So whenever you triturate it, because there is gum present in it, you will get a milky emulsion with such drugs.

Now, the next category of unorganized drugs is lipids. Lipids are lipophilic substances present in certain plants. These lipophilic substances may be oils. For example, when you press groundnuts or dry fruits, you get oil from them. Such oils are called fixed oils.

Now, fixed oils are Apart from that, our fixed oils are triglycerides in nature. If they are solid at a temperature below 15.5 degrees Celsius, we call those triglycerides fats. Now, in some cases, what happens is these esters may be very long-chain esters. So, esters of monohydric alcohols with long-chain fatty acids come together to become what are called waxes.

So, waxes—for example, beeswax—whereas fixed oil, your example is olive oil. Whereas when you say fats, you can imagine your Dalda Vanaspati ghee, you know, they are solids at room temperature, so hydrogenated vegetable oil mostly. So, apart from that, another case of lipids is essential oil or volatile oil. Your aroma of rose or your lemon oil—the thing that spurts out when you remove an orange peel.

They are also oleaginous or lipophilic in nature, but they are essential. That is, low boiling. So, this class of compounds is called volatile oils. Fixed oils are generally used for cooking, whereas volatile oils are generally used for aroma. Fixed oils are generally fatty acids or fatty derivatives in nature.

Whereas when you see essential oils, they are triterpenoidal or phenylpropanoid derivatives. Now, moving on to the next category of unorganized drugs. They are your simple derivatives, such as plant juices and extracts. Now, plant juices are your juices. So, you squeeze the plant, and whatever you get is called plant juice.

A good example of plant juice, which is medicinal in nature, is your papaya leaf juice. It is often given to patients to treat constipation. Dengue, in which your platelet count goes low. So, papaya leaf juice has the property to increase the platelet count. In a similar manner, tulsi juice is given as an antitussive for cough as a remedial therapy.

Now, extracts, on the other hand, are when a solvent is used. So, if I take my tea powder and boil it in water, my solvent happens to be water. So, when I take or dissolve the compounds in a particular solvent using temperature or even at room temperature, because the solvent is used, which can be water, alcohol, or ether.

Depending upon what I want to remove or what I want to extract, you have your extracts. A good or simple example of extracts are your tea, coffee, or even your catechu. Catechu,

you know, is something which is used in your paan masala, katha. So this is your pale catechu. What is used in your paan masala is black catechu.

Pale catechu is also used medicinally for its antimicrobial properties. So these are a few examples of unorganized drugs. And here are a few references if you wish to do more reading about understanding organized and unorganized drugs with their examples. So thank you, everyone, for your patient listening.

Thank you.