Introduction to Developmental Biology
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Lecture No – 21
Plant Development (Part 1 of 3)

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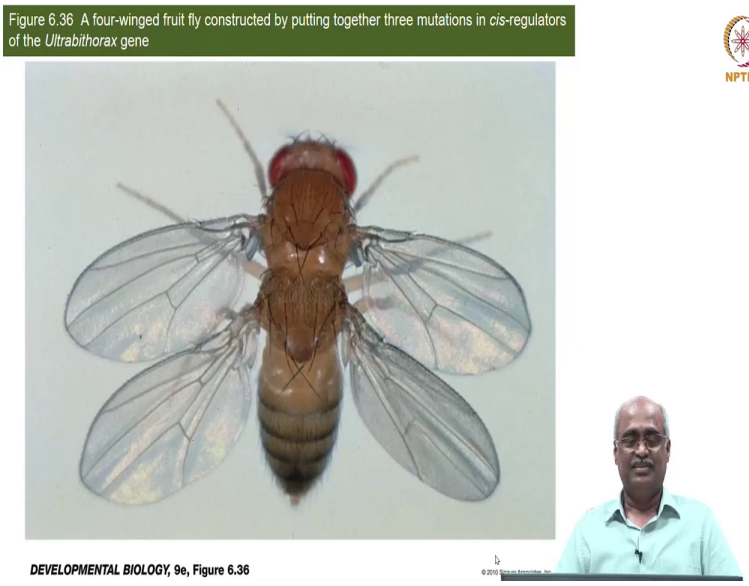

Students welcome back to the developmental biology class. In the last class, we were discussing homeotic genes in *Drosophila*. I was telling you about how their role is and how their expression is controlled by the gap genes and pair-rule genes. So, today we continue the discussion. So to recap again homeotic genes specify the for example in the thoracic region the three segments each 1 form 1 pair of legs so you have three pairs of legs and then the second thoracic segment forms in addition a pair of wings and that is specified by a specific in a combination of homeotic gene expression there. And in the next one does not form a pair of wings instead the homeotic genes expressed there, specify a structure called halteres they again exist in pairs and they help in balancing the flight. So suppose if a homeotic gene that is expressed there that specified haltere is mutated then the second the third segment behaves more like the second segment and ends up making a pair of wings as shown here.

So the third thoracic segment behaves more like the second thoracic segment and ends up making a pair of wings as shown in this particular picture here.

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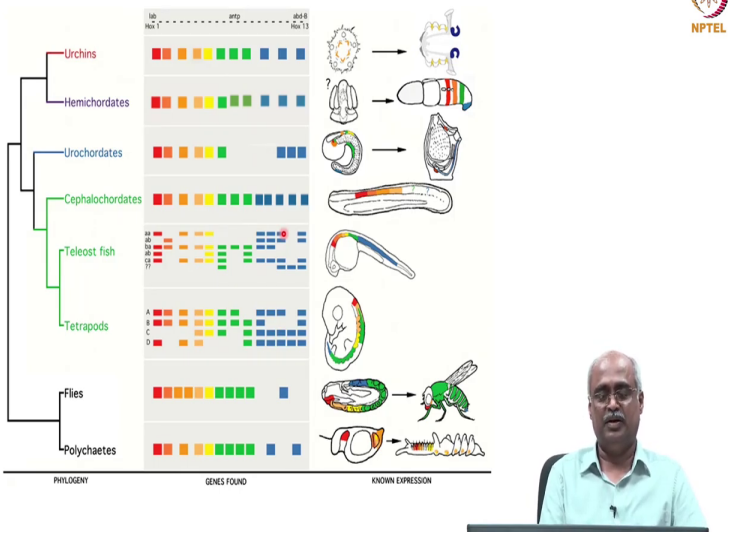

The other important thing about homeotic genes that I want to emphasize today is their conservation among a diverse group of organisms starting all the way from polychaetes to mammals, you have these genes conserved. And it is not that their sequence and functions are conserved; what is really intriguing is a collinear arrangement of the order in which they are present on the chromosomes and the body structures they specify in the anterior to the posterior axis. For example, if you look at here, you have genes on a particular chromosome or hox 1 to hox 13 arranged in this particular order they are color-coded so you have them in a particular arrangement.

The genes in this towards the 5 prime end of the chromosome or in this diagram towards the left end is the one that specifies the more anterior structures and progressively as you go towards the right end of the chromosome so you have the structure specified more posteriorly. So there is collinearity in the arrangement of hox genes on the chromosome and the body structures that they specify in the anterior to posterior. The intriguing thing is in this arrangement the collinearity itself is conserved across, you know, very diverse organisms.

So for example the anterior genes in the fly specify the anterior segments and the posterior to the posterior and exactly the same way it happens in mammals as well. So even the collinearity is conserved. So we do not fully understand why this order and the body axis the structures along the body axis are important but this is the level of conservation you see among the hox genes.

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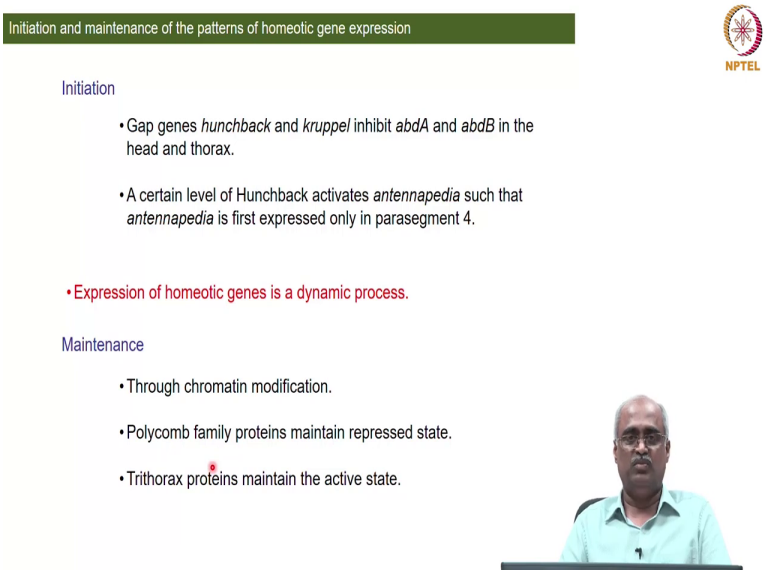

So, now how are the hox gene expressions initiated? So they are initiated by the role of gap genes and pair-rule genes and they are responsible for activating [hox genes]. For example, gap genes hunchback and kruppel, are in the anterior region and they inhibit the expression of the posterior group of hox genes for example abdominal b and abdominal a are inhibited in the head and thorax segments by hunchback and kruppel. And for this, you need a high level of hunchback.

So if you go posteriorly when the hunchback level goes down to a certain level and that concentration of hunchback activates the expression of antennapedia 1 of the anterior group hox gene and such that antennapedia is expressed only in parasegment 4. So this is how their initiation is in a set basically the genes gap genes and the parallel genes determine the expression of hox genes and their expression is not you know fixed like antennapedia is expressed in parasegment 4 all through embryogenesis.

So it does not work that way instead it is dynamic. Expression begins in one segment, one parasegment and it might extend posteriorly, and then it retracts back and so it dynamically changes during embryogenesis. The other important aspect is the more anteriorly expressed hox genes are usually inhibited by the posterior genes expressed posterior to a given hox gene. So that when you mutate a posterior hox gene the anterior gene expression domain extends posteriorly.

Initiation happens in this manner and it is dynamic. So do I need the gap genes and pair-rule genes all the time for the hox genes to continue to be expressed? So that is not going to happen because gap gene expression and parallel gene expression are also going to change as the embryonic development progresses and they indeed would not be expressed later. So, therefore, the hox genes need their expression status to be maintained so that the specific downstream

genes responsible for the formation of a given organ are activated. Therefore the hox gene expression needs to be maintained.

That maintenance is usually done through chromatin modifications. So the chromatin or region in which a given hox gene is present is modified such that it either remains repressed so that you do not need any factor to control inhibit its expression. It is permanently set in an inactive state of chromatin, and polycomb proteins do that. If a given hox gene needs to be kept active permanently and that is done by trithorax proteins. So these 2 gene groups of proteins are involved in chromatin modification to maintain the hox gene expression pattern.

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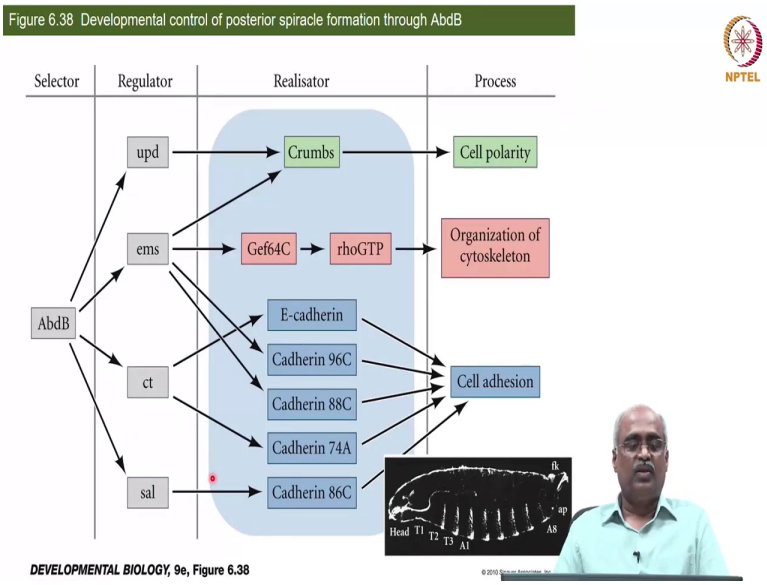

So now how do the hox genes specify the specific organs whose formation they are ultimately responsible for? That is not directly done by them, they act more like the executives sitting in the decision-making or policy-making room and then give instructions to the downstream players. So it is like the CEO giving commands to managers and directors and vice presidents and then they go to the floor - factory floor level managers and give instructions to them and then the managers give instructions to the people who work on the floor who actually make a machine, for example, in the workshops. That is the kind of hierarchy that works in making an organ - not just in fly in all organisms. Hox genes are these executive suite genes, so they are the master regulators, therefore we call them homeotic selector genes. For example, in this particular case where we are talking about the structure called fritz ropher, it is a tube that connects the trachea to the outside through this particular posterior segment.

In this organ formation, we have a better understanding of this genetic hierarchy starting from the decision-making hox homeotic selector genes all the way to the genes that actually alter the cell structure and function such that a specific organ is made. So to go into the details of this, this abdominal b, one of the hox genes of the posterior group gene, is a transcription factor that activates the transcription of 4 other genes which are again transcription factors except for this one which is a paracrine factor the other three are transcription factors.

So these are called the regulator genes and these regulator group genes then activate the transcription of the workers who are going to actually assemble the machine. These are called the realisator genes because they realize that particular organs. So they may bring it to reality and that is why they are called realisator genes and for example, crumbs activated by ems and unpaired is going to create the polarity of the cells.

So that they know that but like, for example, in epithelial cells you have the apical-basal polarity. That sort of cell polarity is directly brought about by crumbs. Similarly, these rho GTPases (that we have learnt earlier in class) are important for morphogenesis. To recall a drosophila example, this is required for ventral furrow formation. So this is involved in the organization of the cytoskeleton so therefore the cell shape can change and as a result, cell function will eventually change too.

And then you have a series of cell adhesion molecules categories they are again induced by these transcription factors and then you have the cell adhesion property to be brought about. So this is finally these properties of cell structure function have to be brought about by proteins that are directly involved in them and those proteins have to be expressed at the right place at the right proportions and that is determined by these regulator genes which are in turn activated by the homeotic genes.

So this is how homeotic genes, also called hox genes in short, control the formation of organ identity in drosophila embryogenesis.

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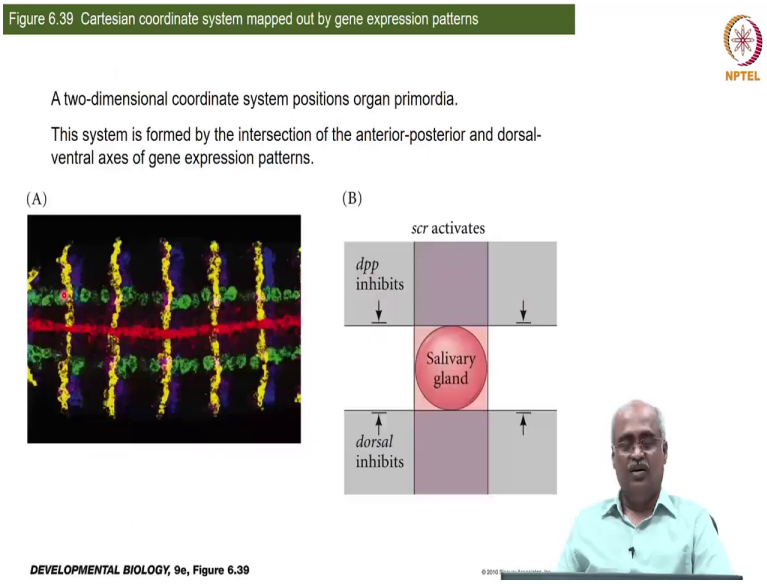

So now we are coming to the end of this discussion on how the anterior-posterior pattern is formed in the embryo. Remember we started with a symmetrical oocyte and then we saw in the oocyte itself we have the dorsal-ventral polarity establishment that starts in drosophila. Then later, we started focusing on the maternal effect genes, how they are set apart to make the embryo asymmetrical, for example, bicoid is expressed only in the anterior and nanos only at the posterior.

So these are molecular asymmetries. The uniform cytoplasm has now become asymmetric in terms of its components and that finally gets elaborated via the activities of downstream genes like gap genes, pair-rule genes, and segment polarity genes, and finally the hox genes. As a result of the sequential action of these genes, the embryo is patterned as shown in this. This is only an example, a set of proteins shown here, but you have more molecules that are asymmetrically localized in a manner shown in this particular image here.

So here what you are actually seeing in the left is the anterior and the right is the posterior of the embryo, dorsal and ventral. Here, you have the distribution of different proteins color-coded. So the green and then you have the red meaning this red protein, we do not need to worry about what exactly is this protein. The focus here is the pattern and asymmetric localization. So only in this narrow band of cells, you have this expressed and similarly, you have vertical polarity as well. The anterior-posterior is shown in the vertical lines and then the dorsal-ventral polarity is shown in these horizontal lines, this green red and then green again.

So this actually forms based on the asymmetric expression of these proteins that we can actually pinpoint. Like in a map, if you give the longitude and the latitude for a particular point on earth only that point will have that particular longitude and latitude. So like the longitude and latitude in 2 axes, they specify the point position of a given location in a geographical map. We call that a

Cartesian coordinate diagram. That sort of a Cartesian Cartesian coordinate diagram forms through this dorsal-ventral and anterior-posterior distribution of these molecules.

That is what gives a set of unique combinations of factors in every one of the cells in these 2 axes. What the consequence of that is exemplified by how the salivary gland is specified as you see in this diagram B. So this scr gene activates when you look anterior to posterior in this narrow band dorsal to ventral is the region where the scr activates the formation of salivary glands. But salivary glands do not form all through this dorsal-ventral axis in this anterior-posterior position.

But it is only in this particular place because here you have high dpp which inhibits the activity of scr in specifying salivary gland. Similarly, in the pore in the ventral region dorsal remember dorsal specifies the ventral fate. So dorsal inhibits a salivary gland formation here and therefore salivary gland forms only in this specific place. So this is how the specific location of each organ formation is determined in this Cartesian coordinate system by the unique set of molecules that are expressed in every group of cells. So this is how anterior-posterior axis formation helps in organ specification in drosophila.

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So now we sort of take a break in our discussion on animal development. So we got an idea of starting, we learnt about differential gene expression initially as the major, you know, underpinning for bringing about asymmetry and how a zygote becomes asymmetrically or developing embryo forming organs at specific places. And then we took the drosophila example where we saw how the dorsal-ventral asymmetry and anterior-posterior asymmetry forms.

So this has already given us a good grounding on how animal body plan is set so now what we are going to do is we are going to go from this background, in this context, and we are going to look at another group of multicellular organisms that became multicellular completely independently from the animals and we will see how there the body pattern is established then after that we will come back to continuing on early embryonic development in other animals as well.

The main thing that we are going to focus on when we learn about plant development is what are things that are unique about plants. I want to remind you that organisms, you know, evolved the ability of what we normally associate with the plants at the unicellular stage so the photosynthetic organism was not a multicellular thing. So the branching happened before multicellularity. So, in that sense multicellularity evolved twice independently once in the animal kingdom and another one in the plant kingdom.

So, therefore there could be a completely independent set of rules that could have, you know, played a part. You know like, there need not be only 1 way of setting up a multicellular status. So here, what we are going to look at is whether there are any unique rules in this multicellularity. So did plants evolve a different set of rules that governed the formation of a multicellular structure? That is what really interests us to go forward in considering how plant development happens and what is fascinating about plants first.

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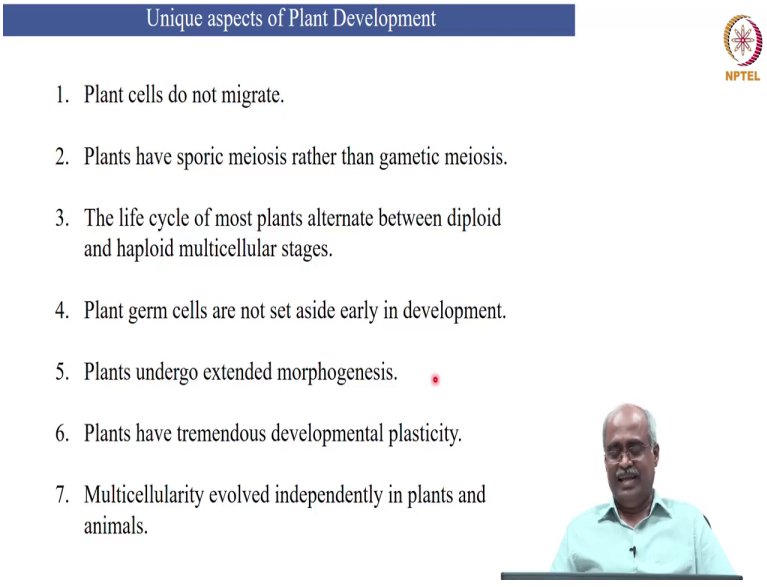

So unlike the animal cells, you know, we talked extensively about gastrulation early on while we were talking in the very first lecture about the amphibian life cycle. Plants do not have the luxury of gastrulation so there are no cell migrations. So there is only 1 exception that I will point out when we get to that particular one. So without cells migrating you have to form all the organs. So that is a challenge that the plants have to handle while forming a multicellular body.

And the second unique thing about plants is that in animals you have germ cells that undergo meiosis and they form applied gametes. So directly meiosis, like reduction division end product is gamete, but plants do not do that at the end of meiosis. They form a set of haploid cells; they are not right away gametes. They could mitotically proliferate in the haploid state and then later form egg and sperm. So that is unique about them and that is 1 of the main differences between plants and animals.

As a result of that, the meiosis does not result in gametes and instead it generates a set of cells that can mitotically proliferate. Plants actually exist in 2 different stages in their life cycle. So in 1 stage they are diploid and then when they undergo meiosis they produce a set of cells that are haploid. So the diploid stage is called the sporophytic stage or sporophytes. A diploid plant body is sporophyte because it is capable of generating spores.

The immediate product of meiosis are the spores. So meiosis produces spores not gametes and the spores are capable of undergoing mitotic divisions extensively or only limited numbers or may not even do that; it varies from species to species and they generate gametes. Because they have the ability to generate gametes, they are called gametophytes. So to summarize sporophytes are diploid plant stage it is a multicellular organism capable of independent existence and meiosis generates what are called spores so they are sporophytes.

Then those haploid cells, thus formed, can undergo mitosis and make a multicellular structure that may be having an independent existence or it may in some cases be completely inside - attached to a sporophytic plant. These are the gametophytes because they produce gametes. So now, let us go ahead and look at these structures. Before we go ahead, there are some more differences that we need to look at.

I think what particularly fascinates me because I study germ cells, is that plant cells do not right away set apart the germ line when it undergoes cleavage and gastrulation and so on. So they make a lot of cells and then they make a lot of different kinds of cells and germ cells are 1 of those kinds. So they do not set up our germ cells during the early stage of development. So in that sense any plant cell will actually can become a germ cell if the situation warrants so.

So that is an interesting aspect of plants; they do not make germ cells in their early development. Then plants undergo extended morphogenesis. You know, if you cut off your finger it is not

going to come back your rest of your hand is not going to develop a finger. But that is not the case with plants. You pluck a leaf, the leaf grows, you cut a branch another branch grows up. So they can undergo morphogenesis throughout their existence; it is not that morphogenesis happens only during embryonic development.

If you consider as a contrasting example if you take a human development by the time you are born your development in the sense of morphogenesis is complete. All the body structures are already formed and they only grow up later. New structures are not possible then. I mean regeneration of lost structures is in very limited capacity but that is not the case with plants. They undergo morphogenesis throughout their existence. Not only that, they are capable of undergoing morphogenesis throughout, they have tremendous flexibility in development - what we call as developmental plasticity.

We will learn about developmental plasticity in another context, you know, several lectures from now. But here what I am talking about is, for a given genotype plants are not like identical twins. So you can have identical genomes and you can plant the identical seeds in 2 different locations or maybe even next to each other but they are not going to form identical fully developed plants. You know, the branch pattern, leaf arrangement, where how many flowers etc are not going to be identical.

So depending on the environment they can change. For example, a plant seedling that grows adjacent to a wall might make branches away from the wall and another seed you know it is identical cousin planted in an open ground will you know make branches all over all around. So you see different body structures, different arrangements of other parts depending on the environmental influences. So that is what we call developmental plasticity.So they have tremendous developmental plasticity.

This point I highlighted even before starting this lecture. Multicellularity evolved independently, so therefore, plants or studying plant development helps us to understand whether there are a completely different set of rules that govern plant development. How cells interact among themselves in plants differ from animals. So these are all the reasons that really excites us to learn about plant development.

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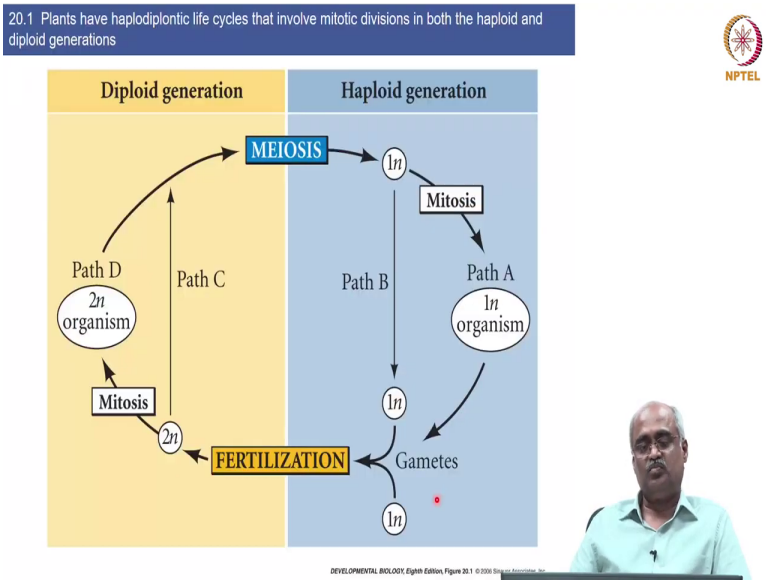

So I sort of introduced you (for some of you since you do not actively think about it all the time, a confusing thing) that meiosis that does not generate gametes. What do you mean by sporophyte and gametophyte? Gametophytes being separate entities? It is not inside the gonad like egg and sperm are; so therefore we will get into that right away and get all the confusions clarified to start with. So let us go step by step in this cartoon.

So, if you look at the left you have a 2n organism like any adult so there is no confusion here. We have a diploid organism. The diploid organism has some cells that undergo meiosis, no big deal in my body also germ cells undergo meiosis. So you will think so and you would not find this hard, so it is easy. So this meiosis results in half the number of chromosomes. So from 2n we came to 1n. Now this 1n need not necessarily fuse with another 1n and in fertilization and give rise to the 2n organism. This is what happens in most of the animals and this is what you are familiar with.

This is just one of the paths and this need not be the one life path. So you can have this 1n cell dividing why not? The rules of mitosis do not stop, you know, it does not count to how many pairs of chromosomes there are, it only worries about what is the total number of chromosomes. So the duplicated sister chromatids can come to the metaphase and divide into 2 cells. So 1n can make a lot of 1n cells through mitosis and that can create an 1n organism like the 2n organism so that is the haploid generation.

So this organism can be in a haploid generation and this could be extended or it could be short like path B. This 1n organism, when the conditions are favorable can generate the gametes that can fuse with another 1n in fertilization and give rise to 2n. This 2n you always think it will

undergo mitosis to form 2n organism and then when it reaches sexual maturity we learn to produce, you know, gamete through meiosis.

It can directly, like skipping the way you are thinking, [skip] this here. The 2n can skip this generating the 2n organism and directly undergo meiosis and make 1n. So what I am trying to highlight here is that just like how we are used to seeing this phase of existence at this stage or the diploid generation being the main generation, this is the more dominating thing like that you can have the 1n stage also haploid generation. To extend this argument further, in some organisms this may be the dominant one and this may be shorter.

So these variations all exist in plants. I am sure you will not need me to show an example for this being dominant. I will show you an example for an organism where this is some independent individually self-sufficient existing generation.

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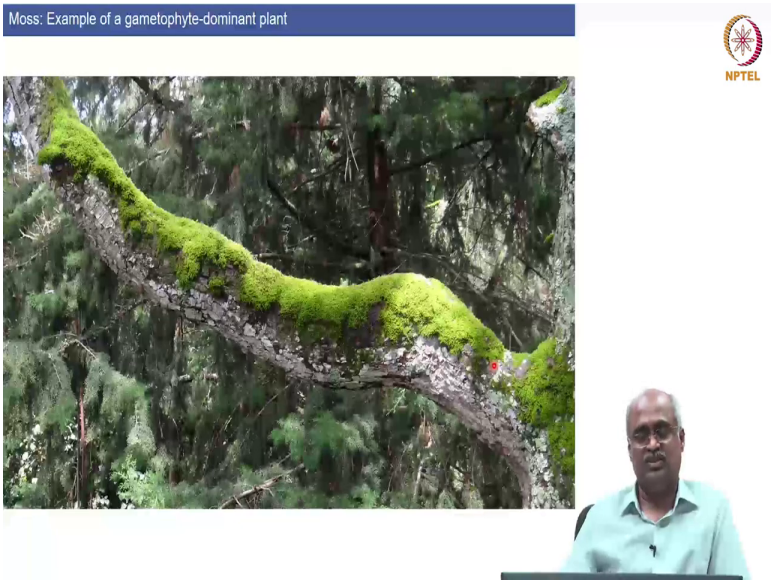

So that is in the next picture so you have here a tree branch on which you have this lot of moss plants growing and these are believe me these are haploid cells and this is a haploid generation. So you know, cells underwent meiosis produced haploid cells which divided and formed this plant body. So this is an example of a gametophyte dominant plant.

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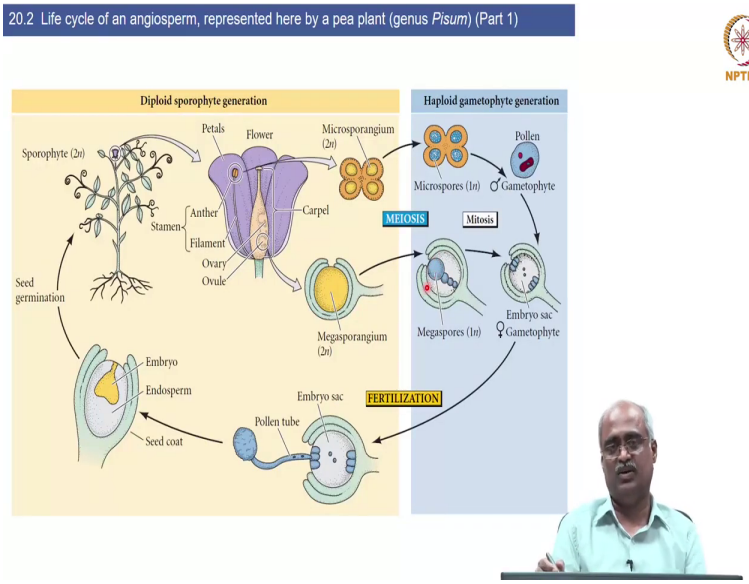

So now before we go any further into plant development, let us start with how to make the gametes. Then we will go about gamete fusing and making then embryo and then we will talk about how the body plan is set apart, and how the body plan of the embryo is formed. So we start with gamete formation or gametogenesis and for that we need to understand the plant structures. That is the main focus in our plant development discussion in this lecture. In the subsequent lectures on plant development our focus will be on flowering plants, also known as angiosperm, so this is what we are going to focus on.

So the angiosperm gamete formation happens in a specialized organ, a beautiful organ, called flower. So let us learn about the structure of flowers because this is the one that is going to make the eggs and the sperm to generate the next generation. So if you look at the flowers, we'll talk about the different kinds of sexuality in flowers later, but before we go there we take one cartoon that has all the structures the male female structures everything in one flower.

So that is the kind of structure we are going to look at. So in the flowers, all of you know what is a petal and then inside the petal you have something called a filament, at the end of the filament there is a structure called anther. So this is the male reproductive organ. Then you have another structure called and this both together like the filament and anther both together you call it as a stamina. So stamina is like the testis. Then you have another structure called a carpel which is like our ovary okay in mammalian ovary.

So this has a stigma on the top I will show you in a specific plant therefore you will appreciate these distinct structures very well. Style and then you have the ovary in which you have the ovules - individual eggs. Now, let us see how they form gametes. So now, if you take this anther and make a cross section then you will have like this 4. So this is a cross section when it is cut

and each 1 of these chamber-like structures we call them microsporangium, because it makes cells called microspores.

The cells inside them, multiples of them, they are called the microspores. So we are going to ignore other structures because the class is not focused on plant anatomy. Our goal is to understand what gives rise to gametes. So that is our main focus, so that we are going to only focus on the cells that we would normally like to call germ cells. So the microspores are present in this microsporangium and these microspores are formed by, as I have already elaborated, meiosis and therefore they are 1n cells.

These will undergo mitotic divisions, and we are not going to get into all the details of how a microspore through mitosis gets here, but the final structure that they form - the gamete - is called pollen. Okay, so we are going to learn in detail in the next slide about what is the structure of a pollen cell. So this is the male gametophyte. In the microsporangium, you have microspores formed by meiosis and each of those microscopes is capable of undergoing mitosis and generating what is called pollen, and this pollen is the gametophyte - male gametophyte.

And if you look at the female structure, this has a structure called megasporangium, and the megasporangium unlike the microsporangium which have multiple microspores. Microspores themselves come from what are called microspore mother cells. Microspore mother cells undergo meiosis to make microspores and they in turn undergo mitosis and finally form pollen grain. So, here you do not have multiples of them you will have 1 megaspore mother cell that will give rise to the gamete eventually.

So this megaspore mother cell is formed by meiosis, so actually, you end up making 4 cells as a result of meiosis, but these are not formed by equal cytokinesis. Unequal cytokinesis and meiosis ends up generating a large megaspore and three small megaspore. These are not going to do anything, they are going to degenerate and this 1 large megaspore is the 1 that will undergo three successive rounds of mitosis in the making 8 nuclei.

These 8 nuclei will be present in seven cells so we will learn that also in the next couple of slides later how this female gametophyte forms. So the megaspore mother cell, I mean megasporangium undergoes meiosis to generate 4 cells but due to unequal cytokinesis will make 1 large megaspore and that megaspore after three rounds of mitotic division forms the female gametophyte. Now, the male gametophyte female gametophyte fusion generates the embryo.

So this is the outline. Let us get into the details of male gametophyte formation and female gametophyte formation.

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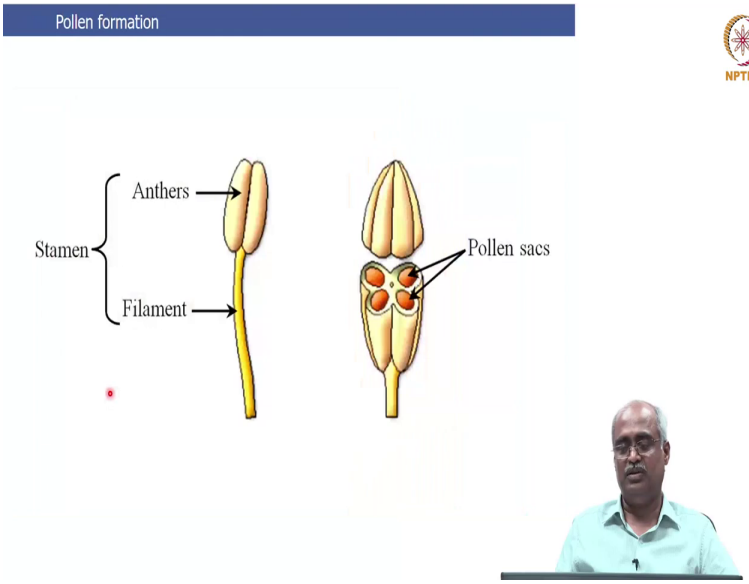

So this is the cross section I talked about. If you take anther of a typical angiosperm cell angiosperm flower and if you take a cross section, you will see these 4 chambers and you can call them microsporangium or pollen sacs.

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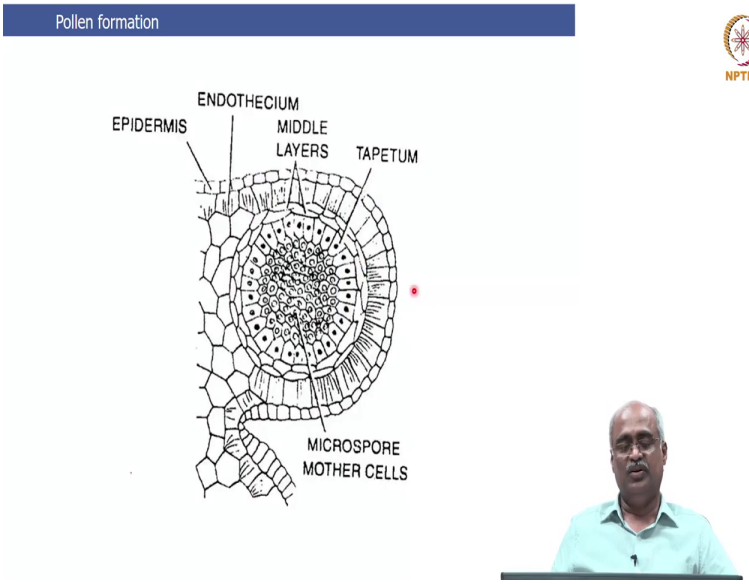

And there you are going to, if you look enlarge and look at that, see these somatic structures that if you are very much interested you can read and remember the labels. But all I want to highlight is that there are a lot of diploid cells, you know, the sporophyte cells are around there and this is the 1 that is going to form the gametophyte. So these are our germ cell equivalents and these are the microspore mother cells.

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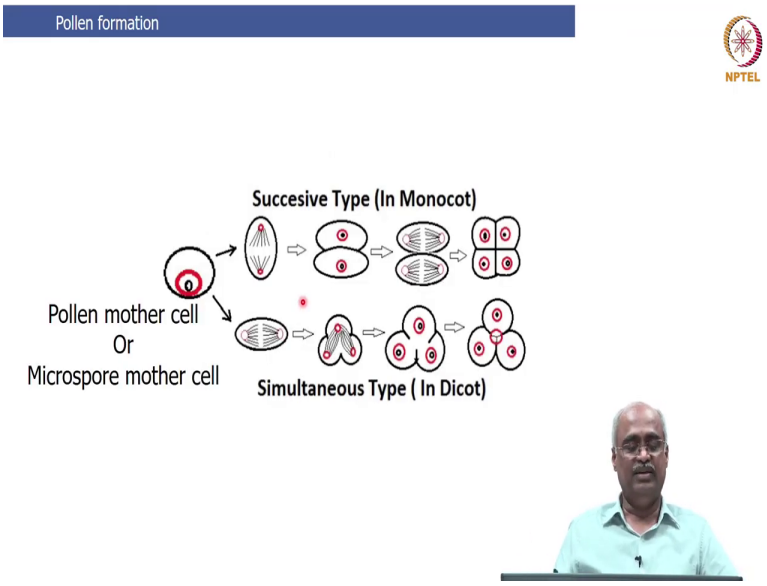

These microspore mother cells undergo a division and when they do that they could undergo 2 successive meiosis. Meiosis 1 generates 2 cells and then each cell individually undergoes cell division as shown here and forms 4. So this is how it happens in monocot successive type. Then here, you have a simultaneous type where 1 after the first division you have simultaneous spindle formation which results in simultaneous division without any cytokinesis into 4 cells.

So this is what happens in the dicot. So these are the 2 different ways by which the pollen mother cell or the microspore mother cell undergoes meiosis and generates microspores.

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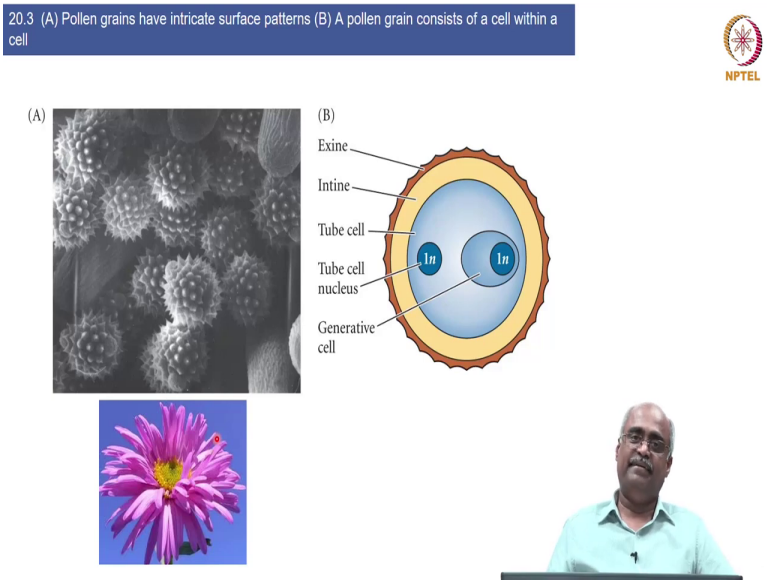

The microspores after mitotic divisions, they end up forming a structure called the pollen grain, so pollen. So this is how the pollens look under scanning electron microscopes. So here, you see the on the top portion so this colored one. So that is where these are the structures, you know, anther where you are going to have the pollen grains. And if you take individual ones and enlarge it and take a cross section this is what you find. So let us focus on the business end of the structure, that is this blue colored one.

So here a funny thing you see is a cell with its own nucleus and it is you know coming from a cell that underwent meiosis and therefore it is 1n nucleus no big deal. But in its cytoplasm it has another cell so that is the funny thing and that cell has its own nucleus. So you have a cell within that you have another cell and this cell is called the generative cell. So this is the one that is going to divide into 2 and form 2 sperm, the gametes. So this is still not gamete it is a gametophyte.

So this generative cell is present within another cell which we call a tube cell. Why am I calling tube cell will become very obvious when we go further and learn about how fertilization happens. So until then do not worry about why this is called a tube cell. So you have a tube cell within which you have a generative cell and that is what is going to divide into 2 and form 2 sperm. And these are encapsulated in a structure called intine and this intine is produced by this you know, gametophyte stage.

So this is a gametophyte, individually existing male gametophyte, it is the haploid generation of that particular plant species. So this produces this intine whereas the outer surface called exine is produced by the sporophytic cells that were around like, you know, what we saw in the previous structure like these cells. So these are sporophytic cells from the diploid organism. They have the 2n nucleus, so they form this outer structure. So if you are trying to think like our egg or sperm it is not purely germline derived it has components coming from the diploid stage.

So the maternal component is there here so I am highlighting this because it becomes important for our discussion in a later topic. So this is the way male gametophytes form.

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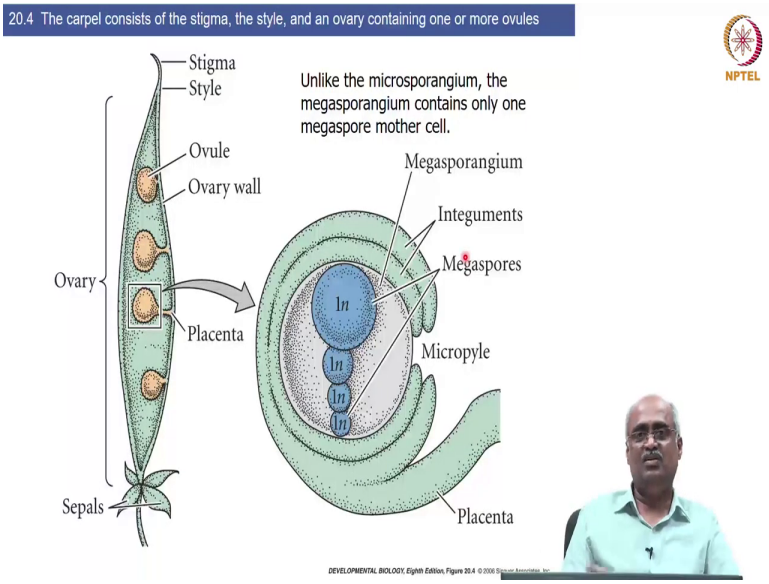

So now let us look at how the female gametophyte forms. So this is, you know, the top is the stigma and then this in this particular cartoon this is shorter but in some organisms style is a long filament like structure and then inside the petals etc, you will find this structure called ovary and inside the ovary you have these ovules. So, these are the ones that are going to make the female gamete and they are attached to this sporophyte wall, via the structures called a placenta.

So then later when this is fertilized and it is going to really grow further, this ovary becomes the fruit or in pea plants this is the pod and inside you have multiple seeds. So, this gives you an orientation of what you normally see if you take a fruit. The fruit is the structure, this structure that transforms into fruit and this structure transforms into the seeds. So now if you take one of them and look closely there you find the unequal cytokinesis for during meiosis has generated this one big megaspore and these are going to degenerate.

So this is the one that is going to undergo three rounds of mitosis three rounds 2 to 4 to 6 to 8, 8 nuclei it will form and these are encapsulated in the sporophytic diploid cell structure which we call as integument. So this you know ends up as a protective layer later when this is fertilized and becomes seed this is going to be the seed cover. So this is going to form the seed cover and this micropyle is the opening that helps in fertilization.

And this whole structure we call, you know, once it has undergone the three mitotic divisions we call as the embryo sac. So that is shown in the next slide.

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So once that one single megaspore the larger of the largest of the 4, that undergoes the you know three meiotic divisions it is going to form 7 cells, 1 2 3 4 5 6 and this whole thing 7 cells and

this big cell is going to have 2 nuclei. So that accounts for, so by this we have accounted for, all the 8 nuclei as well as the cells you know 7 cells and 8 nuclei. So out of the 3 cells that orient themselves near the micropyle, the one cell that is going to fuse with the sperm that is the egg cell is, you know, surrounded by the 2 more cells called synergids.

These synergids help in the pollen coming here and fertilizing this properly and opposite to this as a result it is called antipodal you have 3 more cells. So their function is not clear or later they are going to degenerate. While these 2 nuclei and this whole cell is called endosperm and this is going to produce and store a lot of lipids and proteins and carbohydrates required by the next generation to develop. So this is the nourishment providing structure for this particular cell.

So this is the structure of the female gamete and this whole structure with these 8 nuclei and 7 cells we call the embryo sac. So the female gametophyte is the embryo sac and male gametophyte is the pollen grain.

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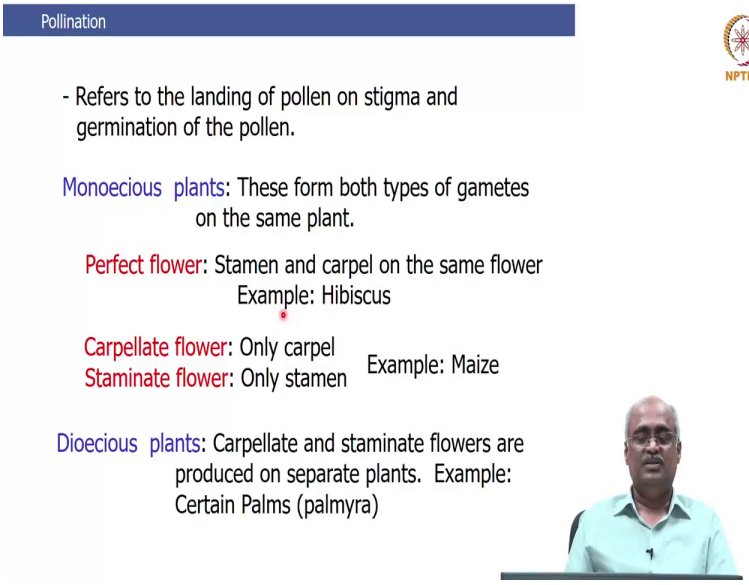

So now we are going to, you know, of course, your next question is how these 2 gametes fuse, right? We are on our way to understand that and how that happens by a process called pollination. So pollination refers to the process of pollen grain from one flower coming and landing on the top of this female structure the top of the female structure, as I told you is the stigma. So the pollen grain lands on the stigma and then it has to find its way to reach this micropyle. It has to come here and that process of landing and then germination is the process of the pollen grain being able to reach the egg cell. This is the germination.

So landing and germination is what is pollination. And before we go and understand the process of pollination we need to clarify potential confusions that will arise because different plants

produce different kinds of flowers. So therefore, let us first understand the different kinds of flowers that exist. So the male gamete producing structure and the female gamete producing structure, both can be on the same individual plant. So why I am emphasizing this? For example, if you are a girl you are not producing the male gamete you only produce the female gamete.

And if you are a boy you produce only the male gamete you do not produce the female gamete. So this is what you are more used to. But in plants this need not be the case both the structures can be on the same body, same individual and therefore both being in the same house. That is what this word monoecious in one house both may be there. Even in that you can have 2 different varieties, like you could have as the cartoon that we first saw both stamen that is the filament and you know anther and the carpel so that is the stigma, style, ovary they both can be on the same flower.

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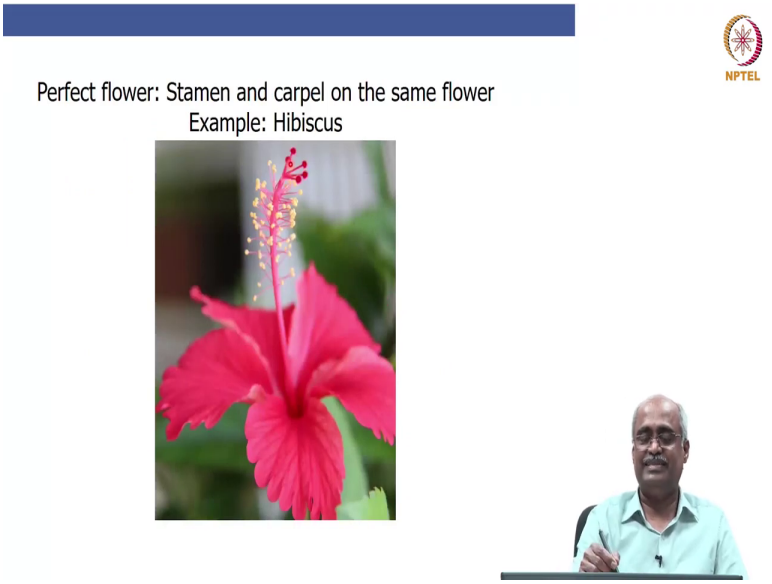

You know the example is hibiscus, you know, shown here, this is the stigma I was talking about, see here, you have the style - really long structure going all the way here. So the ovary and ovule, they are all inside you cannot see in this flower. So this is the stigma, so the pollen grain has to land here and this has the filament and anther on the same flower. So this is a perfect flower having both structures on the same flower on the same plant so that is called a perfect flower. Then you have another thing, that is, one flower produces only the carpel and another one produces only the stamen but both are present on the same plant and that is why it is still monicious. And there are examples like that and one good example is maize.

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So we will see that too. So here you have that, if you have seen maize or if you walk around somewhere outdoors and if you chance upon a corn field have a look at this structure. So since this is the stem so this is the, you know, this is the leaf and you see in that on the axial on the side you have this structure forming - this is the female structure. And on top of the stem as you see in this picture on the right, you have the tassel so this structure is called ear and this is called tassel.

So this is the male part. So the male flower and the female are on the same plant so this says carpellate flower this is the staminate flower as we saw in the definition here staminate and carpellate. So if these are possible then the other one that is one plant being male plant another plant being female plant just like us that also exists they are called the dioecious plants. A good example is the palmyra palm that is ubiquitous, particularly in South India.

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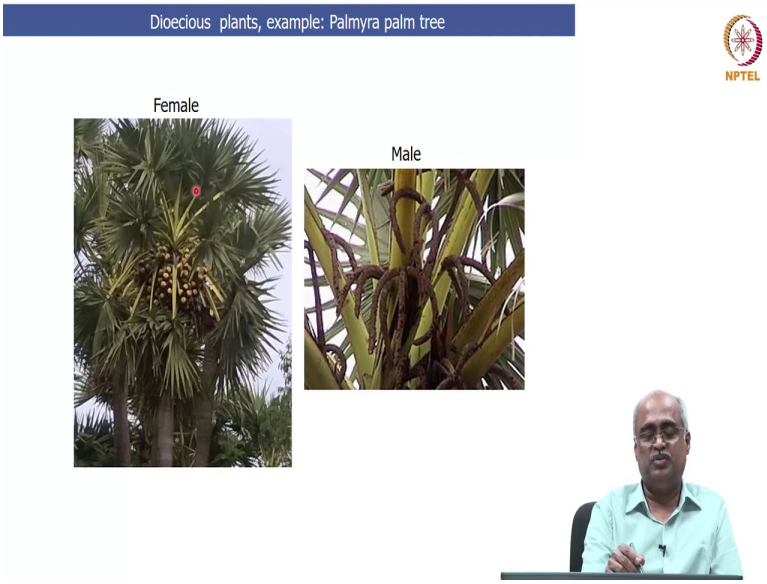

So I will show you that. As well as here, yes so this, you know, a tall palm tree that you see everywhere. You know in many parts of India and southeast Asia and so on. This one has seeds. This produces the palm fruit and this is the male plant - sorry the female plant - producing the female reproductive structures. This is how the male plant reproductive structure looks like, so this has lot of flowers on it and these produce only pollen; they do not have ovaries.

So this is the one the farmer wants, because this is the one that is going to produce the fruits and this is the male. So you need to have both although you are not interested in it without this you are not going to have these fruits forming the female flower. So this is an example of dioecious. Interestingly, this is not common among all palm species. For example coconut trees are monoecious. So they are in the same plant - you have both.

So that is an example for the dioecious plant. So we will stop here and then in the next lecture we will continue on pollination and then how the same pollen fertilizes the eggs in the same plant and therefore how genetic diversity generated is reduced, or limited. How is that avoided and then how, you know, the embryo develops etc so we will continue that in the next slide, see you in the next lecture.