Animal Physiology
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Module No. #01
Lecture No. #25

Let us resume the lectures in animal physiology from the NPTEL series. Now, we will be starting with that thyroid endocrine gland. Thyroid, in general, is one of the very active glands and thyroid hormone has significant physiological implications in our body. At the national level, there is a huge problem related to thyroid gland disorder, across Indian female and male population. This is a very challenging problem. Because, it has to be cured by administering in a control way, that specific hormone, thyroxin which is secreted by the thyroid gland.

Let us start with the thyroid. If you recollect back, basically, it is hypothalamus, from where the story starts. Hypothalamus secrete thyroid releasing hormone. Then, from the pituitary, it receives the signal; in the anterial pituitary. Anterial pituitary sends the signal of thyroid stimulating hormones. This thyroid stimulating hormone goes to the thyroid gland. After reaching the thyroid gland, it stimulates the secretion of thyroxin. So, overall it is like this.

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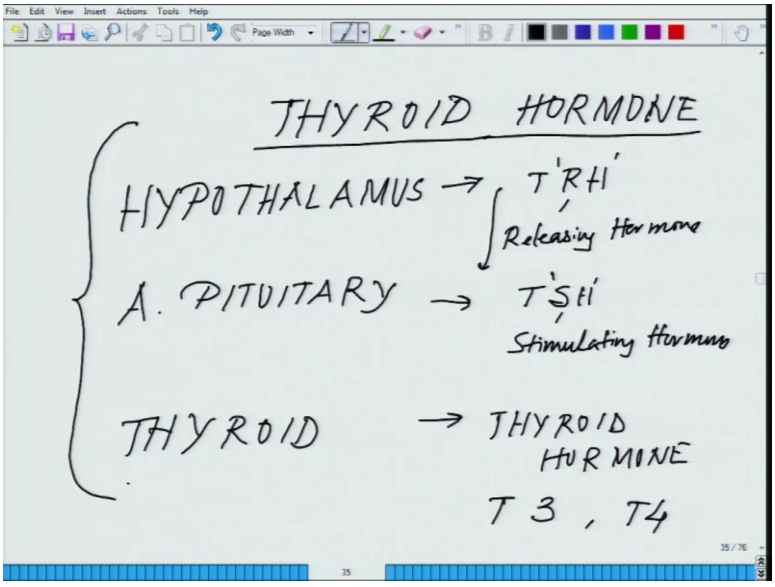

We will start with the thyroid hormone, so, basically, at the level of hypothalamus. Three level of control; hypothalamus; anterior pituitary and thyroid. In the hypothalamus, that is the TRH, which secreted thyroid releasing hormone, and this stimulates thyroid stimulating hormone and thyroid stimulating hormone, eventually, get to the secretion of thyroid hormone, which is basically, in two form it comes. We will discuss about that. T3 and T4, interestingly, this thyroid hormone secretion is regulated by several environmental factors.

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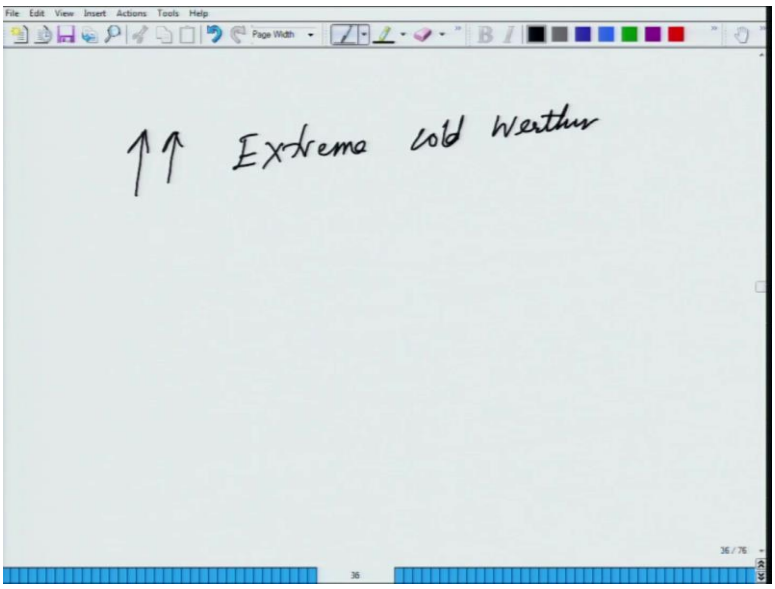

One such example of environmental factor is that, when you are exposed to extreme cold weather, if you think of this situation whenever, there is exposure to extreme cold weather, there are cold receptors, which send that fluctuation in temperature, and this through the spinal cord, send signal to the higher part of the brain. From there, the signal is transmitted to the hypothalamus, and the hypothalamus releases TRH. TRH, then along with the portal blood vessels reaches pituitary.

From pituitary again, through the blood vessels, the signal reaches the thyroid and thyroid secrete a thyroxin. So, this is how this whole cascade goes. Any kind of temperature fluctuation effects most of these hormonal (( )), but this thyroid is the one which is very pronouncedly affected by the change in the weather condition, specially, when you are in a very cold, or you move to a very cold weather; there is always a

change in the concentration of the particular hormone. And it takes certain time to get back to original state.

That leads to a whole lot of physiological changes in the body. Now, what we will do, straight away, we will talk about; what are the functions of the thyroid? That will help us to appreciate that; where it is all involved? What all the different functions it is taking care of?

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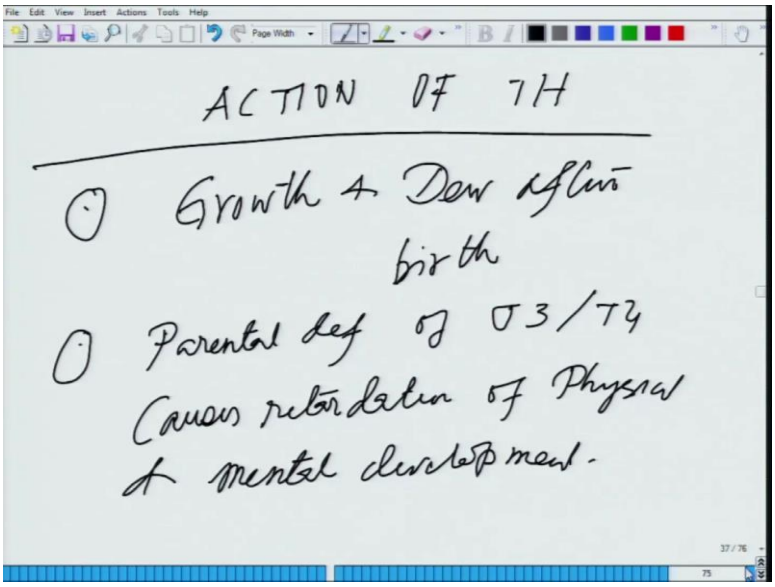

Basically, the action of thyroid hormone, I enumerate them; action of TH. First of all, it is involved in growth and development after birth. This is one of the major things. Thyroid deficiency leads to a lot of developmental abnormalities; parental deficiency of T3 or T4 causes retardation in growth; retardation of physical and mental development.

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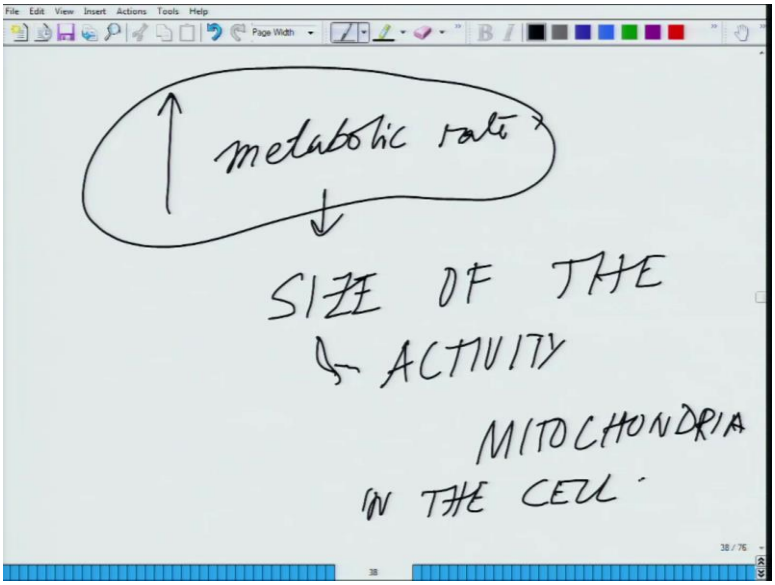

Another key point, what thyroid does; it increases the metabolic rate. Many people who suffers from thyroid, suffers from weight gain; it is specially, what it does in terms of the metabolic rates. It influences the size of the mitochondria with inner cell; size and activity of mitochondria with inner cells. This is one of the major things it does. The abnormalities of thyroid, one second, sorry for the inconvenience.

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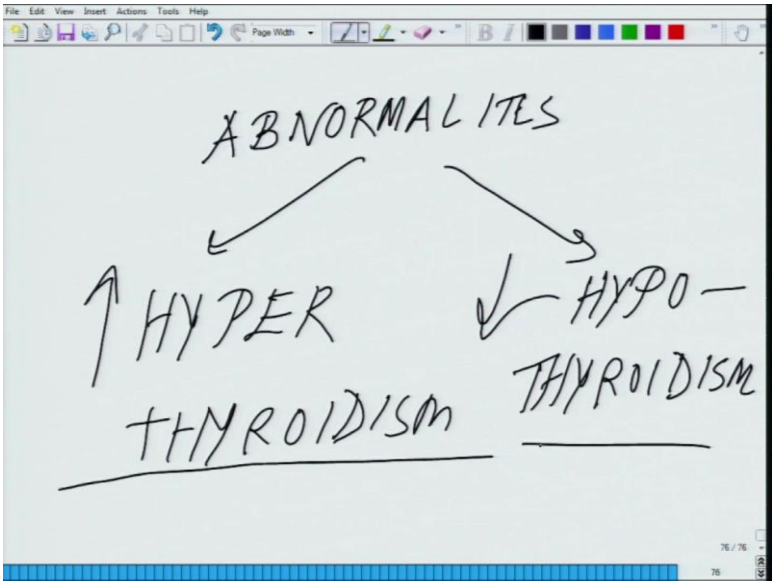

Abnormalities, these two are; when there is an excess of thyroid, it is called hyper thyroidism, or if there is a lesser quantity within the blood of thyroid hormone, it is called hypo thyroidism. If you recollect, how the, one second; again there is a small.

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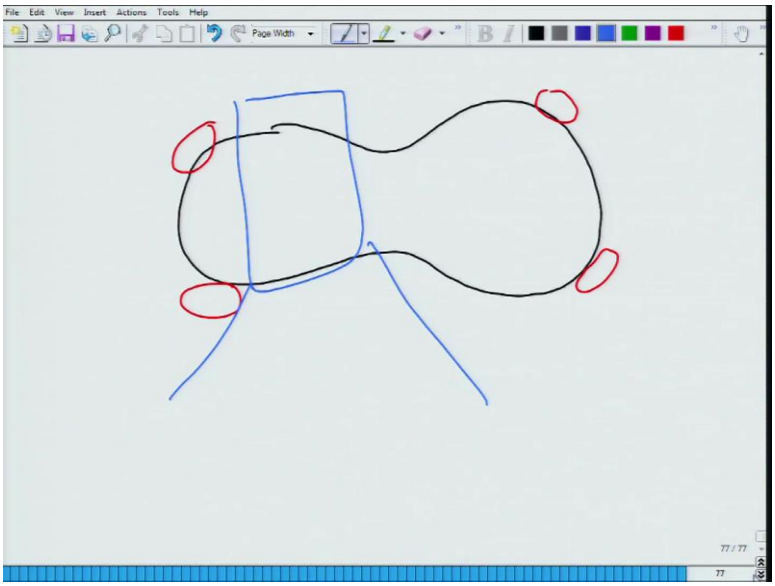

If you recollect back, how the thyroid gland looks like, well I drew the thyroid gland. It is more like this. Along, just behind the (()), you can see four parathyroid glands flanking the x. If you take a cross section of this, it looks something like this.

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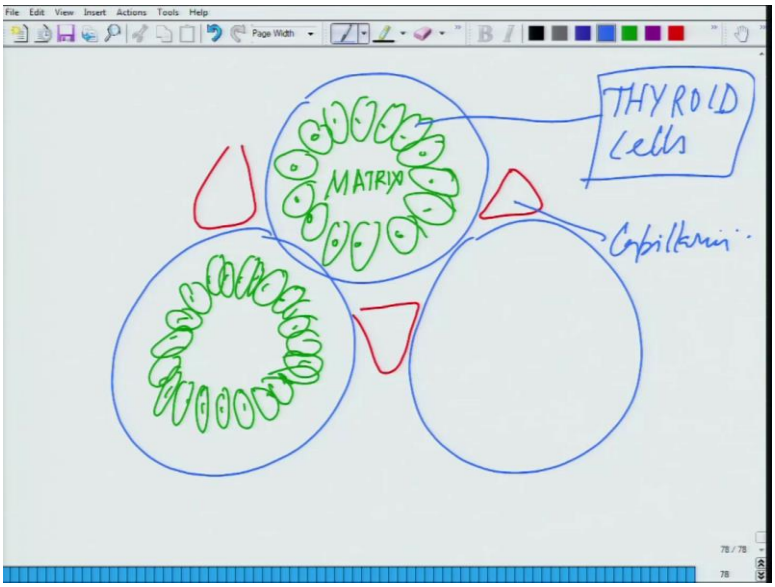

This is how the thyroid gland looks like. You have the blood vessels in between, are the blood vessels in red, and this is how the matrix looks like, it is a kind of secretary structure, something like this. These are the individual cells and they form a secretary channel, and this part is called the matrix. Similarly, here also like that, slightly coupled

like this, something like this. These cells are called the thyroid cells. These are ones which are responsible for secretion of thyroid hormone. And these are the capillaries. Now, this is the basic structure. From here, we will come on to the chemical nature of the thyroid hormone.

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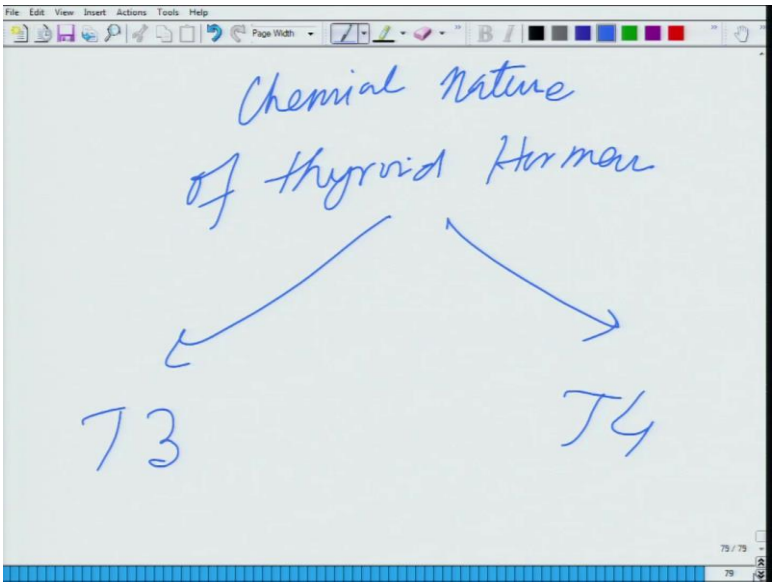

Chemical nature of the thyroid hormone has a direct link with an amina acid called, as I told you that, it comes in two forms; T3; T4.

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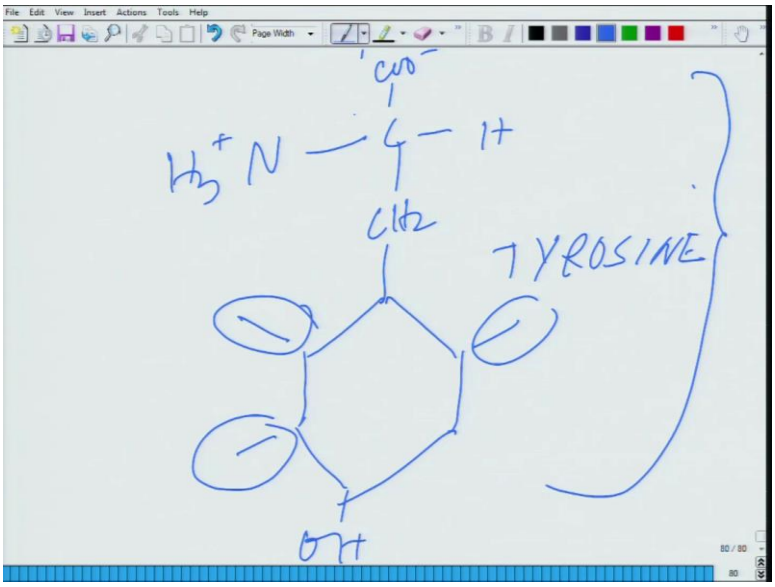

The amina acid which is a precursor for this, is tyrosine, which is something, residues this. I just request you people, kindly look to the structure of the amina acid, one minute, which will be helpful for you people to understand this structure.

So, there is an hydroxyl group here and then, you have the coo group, and if you revise through the initial lecture, you will realize that how this structure is transformed. Basically, what happens is that this tyrosine is modified with iodine. So, there are irenes which are attached in different zones. If there are three irenes which are attached, it forms tri hydro styrene. If there are four, then the four, essentially, what happens is, this is a part of a big protein.

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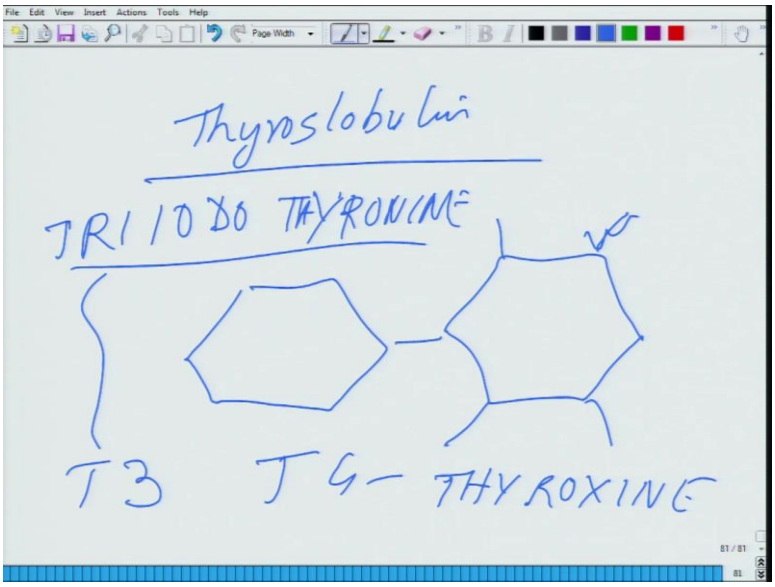

Basically, that is called thyro globin, and within thro globin, you have this thyroslobulin residue. So, structure is something like this. Look at it. You may have four sides which are modified by iodine, or you may have three sides which is modified by iodine. Based on number of iodine molecules, it decides whether it is tri hydro thyroxine, tri iodo thyronine or tyrosine, which is T4. So, this is basically, how the thyroid hormone looks like.

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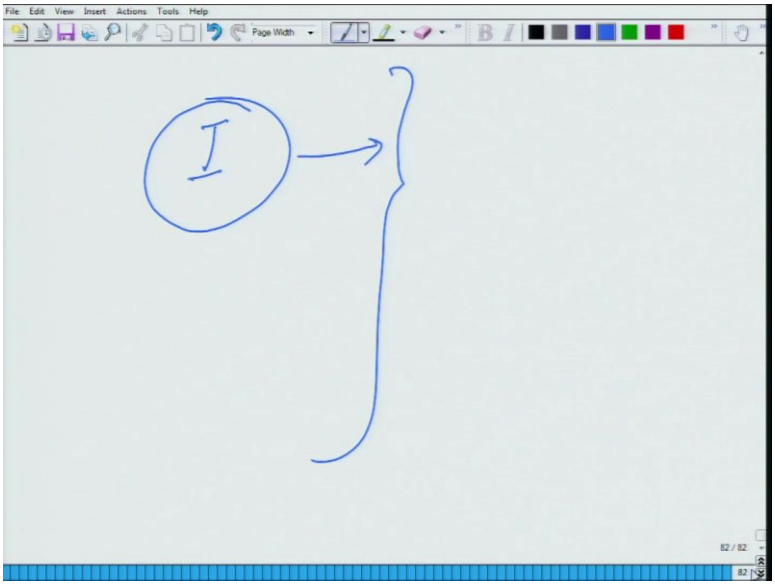

While seeing this structure, it must have strike you, there is a role of iodine. Essentially, one of the problems, people who suffer from thyroid, has something to do at times; something to do with lack of iodine in the diet. It is recommended in India, that you should take iodinated salt because, that helps in the synthesis of thyroid hormone. Whenever, there is a deficiency in the diet of iodine salt, that thyroid hormones synthesis gets hampered on all, likely. There is a possibility, that there may be a person suffering from hypo thyroidism, like disorders, where thyroid hormones synthesis is below normal. Coming back where, we were. This is mostly about the chemical nature of thyroid hormone, and the glands which are secreting it. Then, there is another, while I was drawing the structure I told you.

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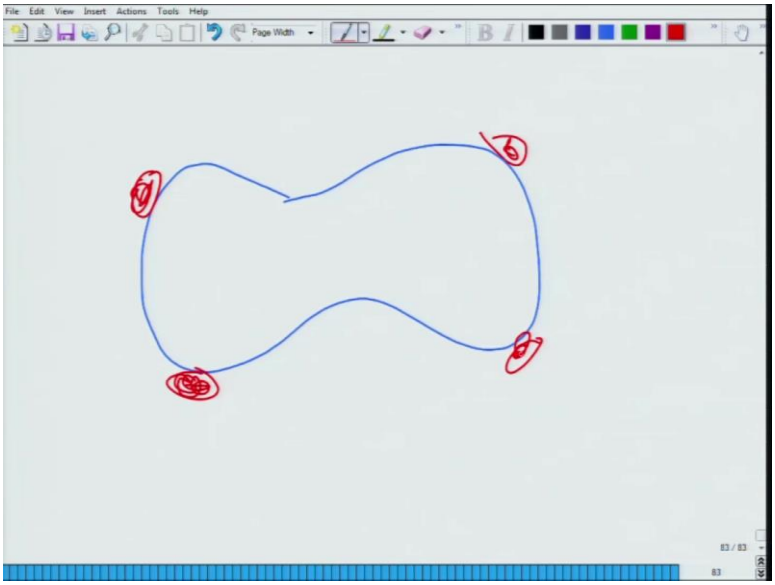

Along the thyroid, there are four other structures which are there, which is called parathyroid. They are all pretty much linked with their functions. So, this parathyroid and thyroid have certain roles, in terms of calcium regulation. This particular parathyroid has, now, what we will do, we will talk about, how calcium level is being regulated to this parathyroid gland.

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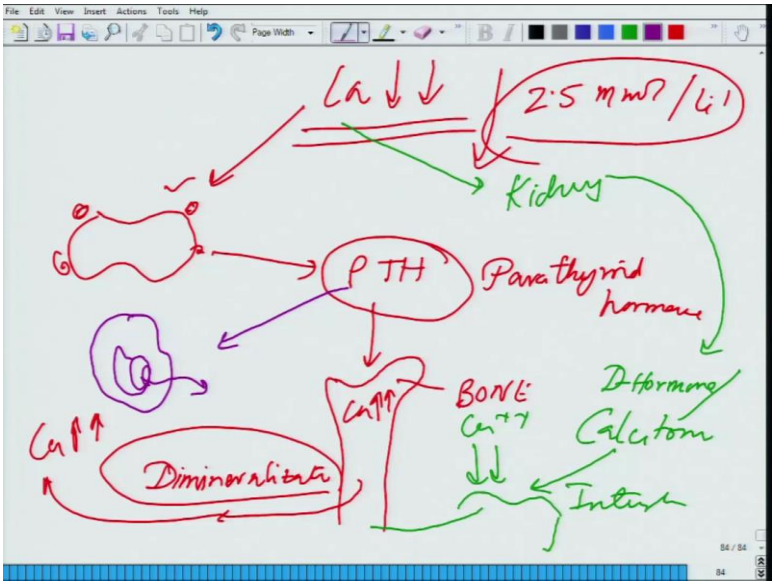

The way it happens is this. Whenever, the body suffers from or calcium goes down in the body; in the blood serum there is a fall below the normal level of calcium, which is basically, the normal level of calcium within the blood is 2.5 mille molar per liter. This is the level of calcium; normal level of calcium. But, when it goes down this normal level

of calcium, it immediately, those four glands what you see; they gets activated. Now, if they get activated, they secrete something called parathyroid hormone; PTH. This parathyroid hormone, what it does?

It triggers the senses signals to the bones. Because, bone is a large deposit of calcium which has rich source of calcium. From the bone, there is a process called demineralization taking place, because of the action of the parathyroid hormones. That demineralization leads to raising the level of calcium within the blood. This is the one root, by which parathyroid functions by enhancing the demineralization, within the bones. There is another root, how it works. The second root is that whenever, if there is like, calcium level goes down a signal is sent to the kidney.

In the kidney, this leads to the secretion of something called de hormone or calcitonion. There are two terms in literature; de hormone and calcitroll or calcitonion, whichever you want to put. Then, this de hormone sends a signal to the intestine, to absorb as much calcium as possible. This is the second way by which the calcium pool is being maintained. There is a third root, which is the root followed by parathyroid hormone. This time it again, sends signal to the kidney, but it sends to the tubules of the kidney, and ask it not to lose calcium.

To summarize, how the calcium is being regulated in our body; there are three mechanisms which have being followed. The first is whenever, there is, I told you, 2.5 mille molar per liter is the average calcium concentration in our blood. Whenever, it goes down the signal is being sent to the brain and from there, it is received by the parathyroid. Once parathyroid receives the signal, parathyroid leads to the secretion of parathyroid hormone.

Parathyroid hormone immediately, triggers a series of signal which reaches the bones. Once it reaches the bone, there it triggers another set of signals, which leads to the demineralization of calcium, present in the bones. This is root number 1. Simultaneously, parathyroid sends signal to the kidney, and ask the kidney that do not loose calcium during the process of filtration. Restore as much calcium as possible. This is the second route. There is a third route; the lowering of the calcium level triggers the kidney to secrete another hormone called de hormone or you can call it calcitonion or calcitrol. What it does is that, this sends a signal to the intestine, and requires the intestine absorb

as much as calcium as possible; the same way parathyroid hormone does in the kidney. It requires the kidney reabsorb as much as calcium as possible. If you look at this whole thing, while I am explaining all these three systems, you always have to, whenever, you study endocrinology, and you have to look it from a very holistic. As a matter of fact, the whole physiology is very holistic. It is not a standalone system. It is very integrated function, and each one of the system is a backup for another system.

If one fails, someone will have more stress because, someone has to back it up for the failure of one system. So, body does not depend on one root or one circuit; it always has multiple circuits to ensure, that we make the best use of all the resources, available around us. This is extremely important for you people to appreciate, that it is not a standalone system. This goes back, fine, this is how it is going to work. So, there are multiple channels, multiple roots, multiple level of clearance and multiple level of a rectifying the system. Now, we will talk about the reverse situation, when the calcium level goes up in the body; it goes more than 2.5 mille molar per liter.

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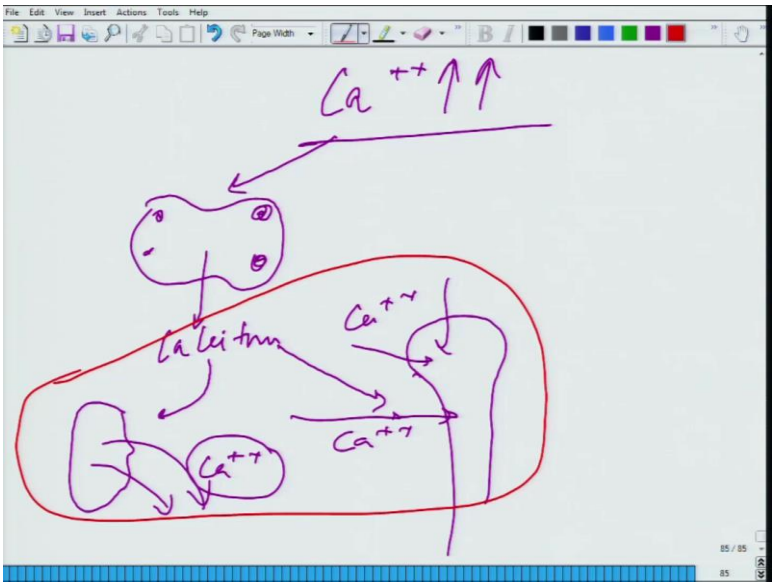

Then, what happens? Calcium level is up in to the system. When the calcium level goes up in the system, again the parathyroid gets activated. Parathyroid secrets calcitonion. This calcitonion goes to the kidney. This time, it is following a different route, goes to the kidney and promotes more secretion of calcium, because; we have to get rid of the calcium.

Second thing, calcitonion of course, does is that, it promotes, it goes to the bone and requests the bone to accept more calcium. Because, bones could really store a lot of calcium. So, there is a mobilization of calcium towards the bone. And in this process, par thyroid hormone does not play any roles. It is these two routes, which significantly rule the whole thing. To summarize it, whenever the calcium level goes up, parathyroid again gets activated.

Then, parathyroid creates a calcitonion. Calcitonion goes to the kidney and tell the kidney that body has excess calcium. We need to get rid of the calcium because, if there is an excess calcium, there will be, if you remember, while we were talking about nervous system and the cardiac system; calcium plays a very vital role in excitability of the nervous transmission and cardiac transmission. Under hyper calcium condition, those transmissions get affected. Kidney has to throw away that excess calcium which is present and simultaneously, the same calcitonion sends some message to the bone, telling it; you pull out as much calcium as possible from the blood stream, and store it in the bone or transform it in the bone, so that, the bone has significantly higher reserve of calcium deposition. So, summarizing, what happens in just before this when calcium was low, you could see parathyroid hormone.

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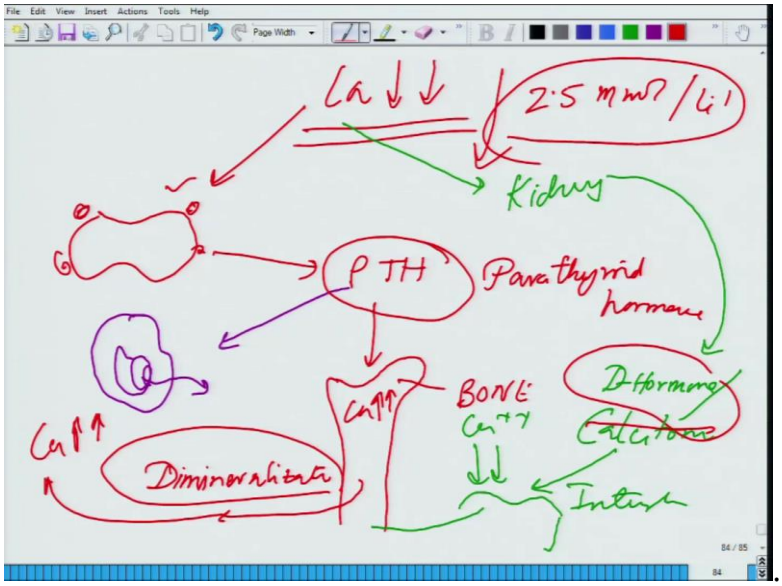

Calcium level goes down. So, kidney gets activated, it secretes de hormone or calcitrol. The de hormone tells the intestine to absorb as much calcium as possible.

Simultaneously, parathyroid secretes parathyroid hormone. With parathyroid hormone goes to the bone and ask it to demoralize as much calcium as possible, which is needed by the body and simultaneously, tells the kidney that to reabsorb calcium, and thereby, increase the extra cellular fluid concentration of calcium. This is one route.

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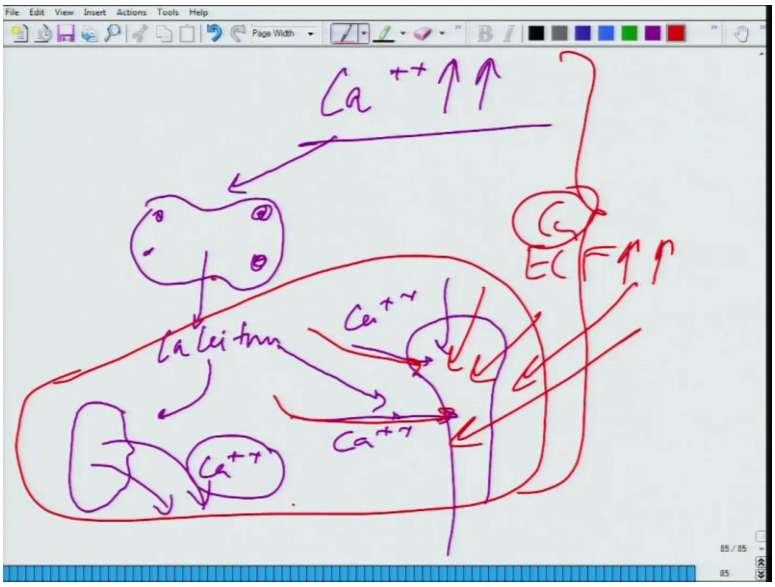

And the second route is, what we talked about, when calcium level goes up, parathyroid gets activated again, but this time, it secretes calcitonion. Calcitonion goes to the bone and tell the bone to absorb as much calcium as possible. So, from the extra cellular fluid, excess calcium goes down. And whereas, calcitonion also regulates the kidney and tells the kidney, that throws away more calcium because, extra cellular fluid has more calcium.

With this, we covered pretty much, all the major hormones. The one which is secreted by the pancreas, we will be dealing with that in the digestive system, but what I will do now, there is one tailpiece, which is left. We will be talking about the hormone secreted by the pituitary, which directly affects our gonads. Here, we will be talking about the gonarotrofens. So, if you remember, I told you that there are two hormones which are secreted. The first hormone which is secreted is GNRH; gonarotrofen realizing hormone by the hypothalamus, and which leads to secretion of follicle stimulating hormone and liternizing hormone; FSH and LH.

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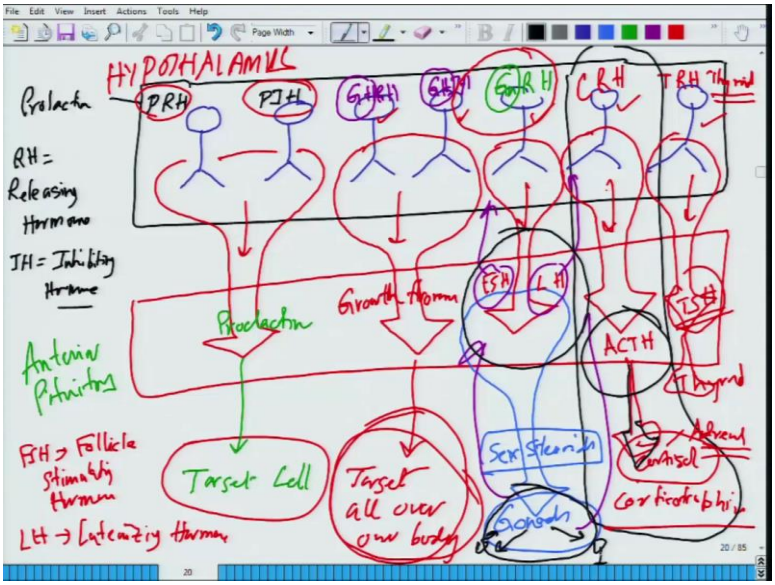

If I take you back to the, from initial chart, while I was trying to explain. Let us go back. So, that it will help you to; coming back to this chart. If you look at the GNRH secreted by the hypothalamus, and then, anterior pituitary secreting FSH and LH, and this leads to the secretion of the gonads; secretion of the hormones by the gonads. Here, there will be a classification, one, we will be talking about the male; other one will be the female. Let us talk about what happens in the males. In the males, there is a continuous, once we attained puberty or adolescent or sexual maturity, our testis could produce the sperm continuously.

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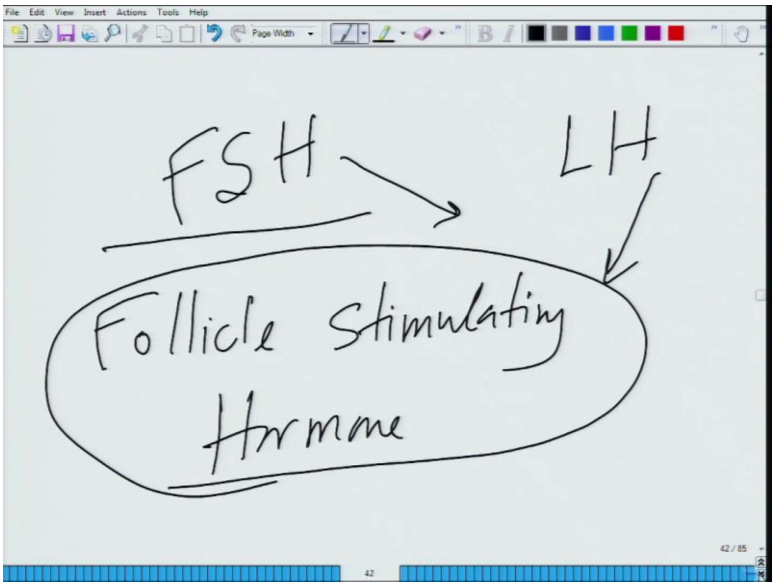

How it does so? The hormone which is involved in it is FSH. The full form of FSH is follicle stimulating hormone. Here, let me remind you, we talked about the androgen; we talked about that androgen is responsible not in really, that development of the sexual part, but it is mostly involved in the sexual behavior. Follicle stimulating hormone is involved in the production of the sperm and there is another hormone, which we talked about with the LH; luteinizing hormone.

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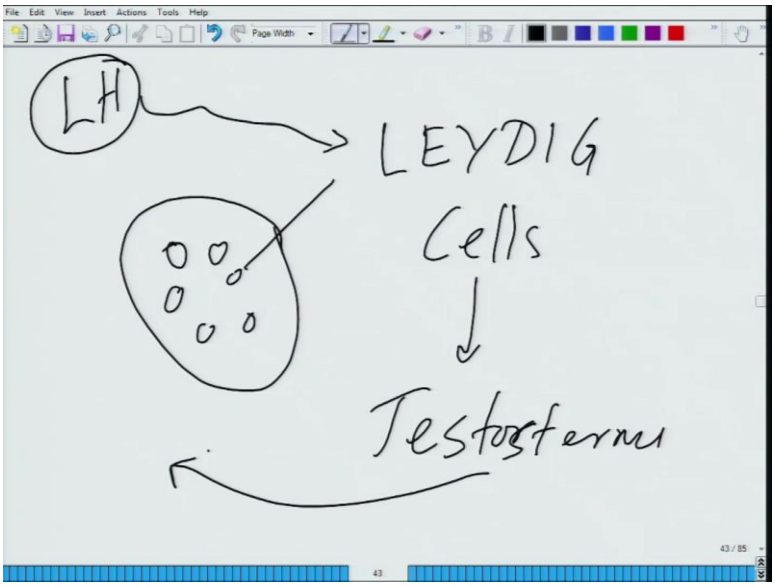

Luteinizing hormone, what it does, within the testis there are specific cells. The testis are something like this. Within the testis, you have specific cells called leydig cells. Whenever, there is luteinizing hormone goes there, it tells the leydig cells to secrete one of the sex hormone, called testosteron. This testosteron involved in proper maturity and growth of the sperm. Here, since I have gone directly into it, I will tell you couple of other things about the reproduction, which is very essential for you to appreciate reproduction. This part I have not touched really. So, I will give you just a brief introduction.

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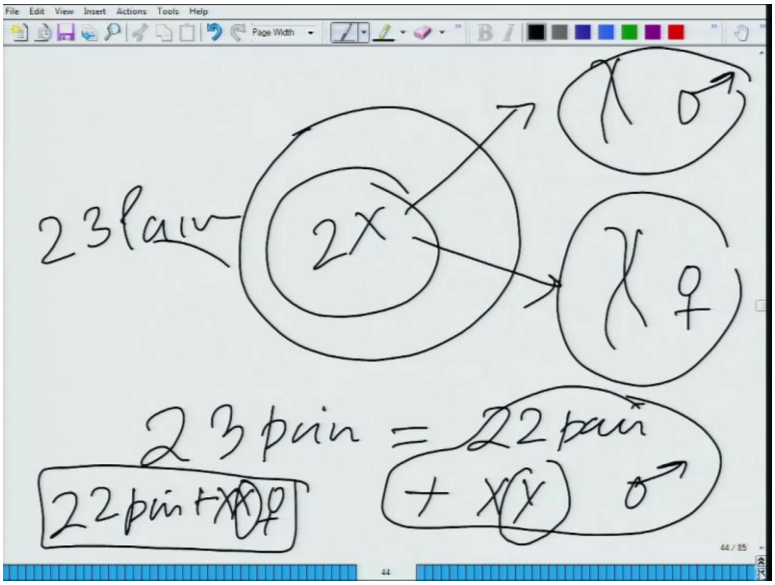

All our cells of the body contains two pairs of chromosome; call it as 2X, something like this. One pair of chromosomes received from our father; the other pair will be received from mother. So, all our cells have 2X or like, pairs of chromosomes, of course, we have 23 pairs of chromosomes in human. So, it is like 23 pairs. Out of 23 pairs, 22 pairs of normal chromosomes and then, you have XY, which makes us male; this is the 23rd pair of 22 pairs plus xx, which makes someone a female. So, this is the only difference in that; Y and there is an X. Rest is all fairly the same. Now, when we reproduce, the reproductive cells, for example.

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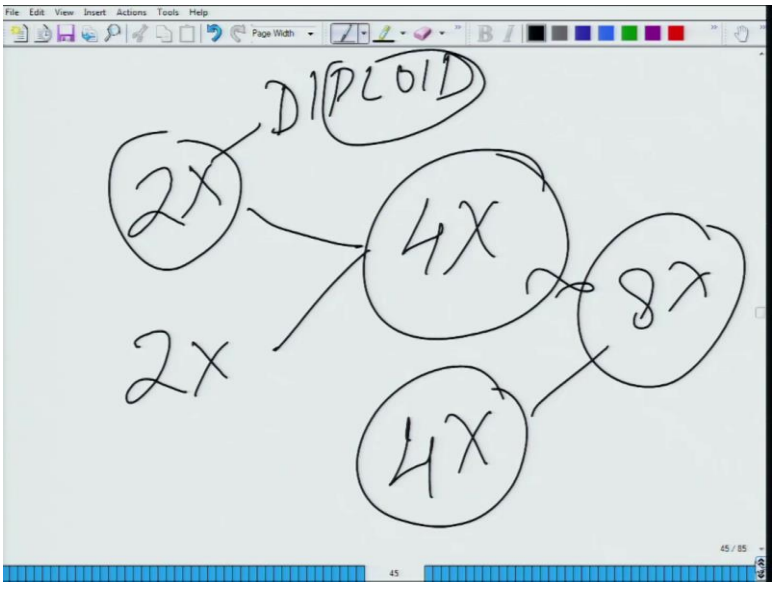

I have 2X and if 2X and 2X, there is next will be a four X. So, if that happens, we will be become continuously bigger and bigger. Because, our size of gnome; size of the nucleus; has to accommodate more and more jeans, and more and more chromosomes, all the time. So, it will keep on doubling. So, if somebody is 4X, then it has to sex with another 4X and then, it will become 8X. Likewise, you move on, but that does not happen in nature. Essentially, what happens is that, with all our cells, this 2X is called a diploid. Ploid means, it is called ploidy; the set of chromosomes called ploidy, and diploid means something like that.

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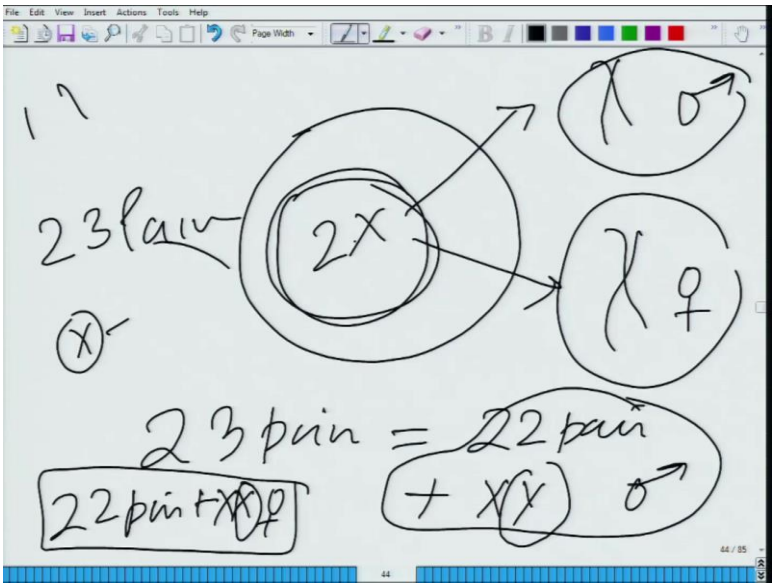

So, one pair, this is diploid or X is a ploid; single ploid. We are having a diploid cell in our body, but the sperms, what we produce are not diploid.

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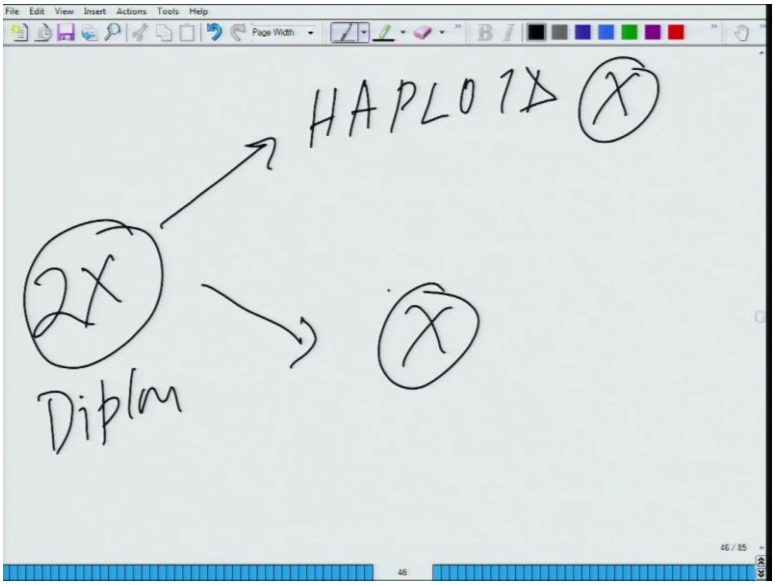

So, this is haploid. Haploid means, if this is 2X which is diploid, haploid is having only X.

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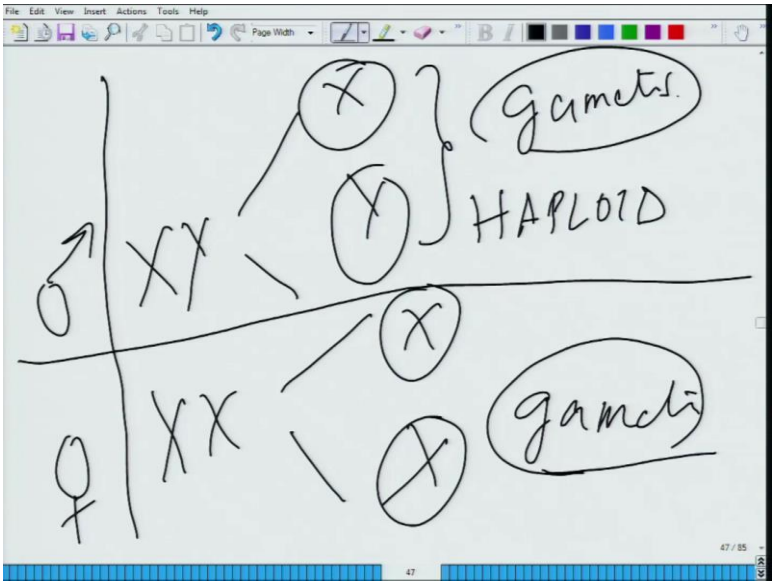

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In case of female, they produce and these haploid cells are called gamets; XY. So, this is in the case of male; this is in the case of female. In females, what these haploid cells, are called gamets. I will not in depth of how cell division takes place; you can pick up any books or any online resources material, give and google search; cell division, it will show you that how that division taking place. When a cell maintains its ploidy; 2X

produces another 2X; and another produces 2X; this is called mitosis. When the 2X makes 2X x or XY making, XY becoming X and Y, it is ploid is fits up. So, diploid become haploid; 2X become 1 X. That process is called meocis.

I request you, please go through any online resources; it is available all over online. There are beautiful, if you go to google images; meocis and mitosis. That will tell you exactly, how this meocis and mitosis takes place, we can go through that. What is essential is that, for you people to understand reproductive process, what regulates this meosis process?

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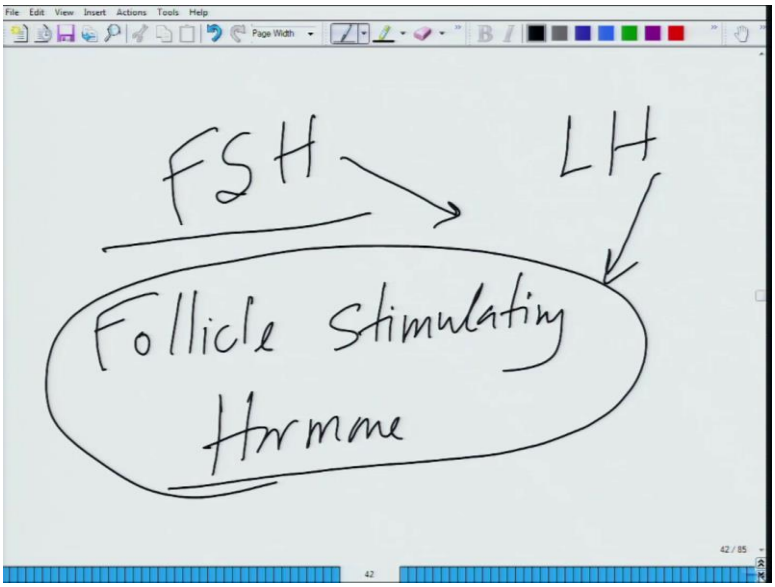

This process formation is called gametogenesis or, one second, the formation of gamets is called gametogenesis. Gametogenesis falls under two levels; one is called spermatogenesis; another one is called oosenegenesis. What does this all word means? We attained reproductive maturity, say at the age of 14, 15 or 16 or 17, when our body in the case of males, we start producing the sperms. In other words, we are in the position to reproduce. If you have a sex with the female, it could lead to a production of a baby. Vice versa, a female attainted her maturity, at the age of 14, 15, when the menstro cycle starts. So, what does this means?

This is the time, when the gonads of the body, start producing the sex cells; this process is very tightly regulated and it is a very time bound process; it is very tightly regulated by the hormonal system. This whole thing is under the neuroendocrine access of the GNRH,

FSH, LH and androgen, which is secondary sexual behavior. In this section, what will be studying is the inter play of these, different hormones, which leads to the formation of the gamets; in the case of males; in the case of females.

What happens when that cyclicity specially, in the case of female, is being disturbed or perturbed by some foreign agents, which you can call them endocrine disruptors or something, and why this process in the case of male, is once it starts puberty, at the age of 15, it goes pretty much lifelong in the case of males. But, in the case of females, this last only up to a certain age like, at the age of 50 or 45, it will ask. After that, the production of gamets by women stops. So, that phase is called menopause.

What is menostro cycle and what is monopoles? And how the hormones regulate this process is exceptionally, important for us to understand. What is reproductive agent and what is the exact time, when a male gamet could fertilize a female gamet, so as to make another diploid cell, which we called Zygore, is under a very tight regulation on endocrine system. What we will be doing after this is that we will talk about those cycles and will finish off this part. So, I will be closing here and in the next class, I will resume from here, talking about the spermetogenesis and oosenegenesis, and how the different level of FSH, LH and other secondary sexual hormones, are regulating this whole process.

Thank you.