Human Physiology
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Lecture –51
Introduction to Endrocine system

How many birds Were there in this alien subsidy building? About 150. Months ago, about 35. 10000 animals came to my office screen. It was so great! Even today the stories seemis Abe's stepfather. Okay, so what I will do is, I will give you another 15 minutes we will spend on having a broader view of what endocrine are. Okay, let us see what endocrine are.

Okay, okay. I am sure you have, you know all this. You know all this, I will run over it. Okay, so this gives us an idea of the different endocrine.

We have the pineal and pituitary and the thyroid and the parathyroid and the thymus and the atrial cortex and the islets of Langerhans and in the gonads we have the, in the male we have the latic cells which are the source for testosterone and the female we have the source for female hormones. And this is just to give you a very interesting idea. We are talking about the signaling molecules. Okay, and the signaling molecules go in the nervous system. Okay, and we call them as what? Neuro-transmitters.

We call them as signaling molecules. The chemical form of signaling is across, just and they are very short distance. In the endocrine system they travel over a very long, very long distances and then they are over such a long distances that a molecule cannot really effectively diffuse. So they use blood as the medium. So what is the peculiarity of an endocrine system? It will pour its content or secretion which is the hormone into the blood and the blood will flow wherever it goes everywhere.

It goes everywhere, blood goes everywhere. So the hormone goes everywhere. And then the hormone will, so when it goes finally in any organ when it goes through the capillaries, it will diffuse out of the capillaries and it will go everywhere and if it finds its receptor then it will do its kick in its action. If it does not find a receptor that is fine, it will be broken down and it will be thrown out either by the way of liver or by way of kidney, it will be thrown out. Are you with me so far? But what is really amazing about the endocrine system is as compared to the synapses is that they can act at extremely low concentrations.

Just imagine how many picograms or nanograms of hormone a tiny gland will release. It will go into the blood. In blood, 5 liters of blood how much of dilution will be there? And out of that then it will go in every capillary. And in most of the places it will not find its target. So finally how many molecules will ultimately reach a target or its receptor is extremely small.

But therefore the system has to be extremely efficient. It is roughly evaluated that when we talk about the hormones like epinephrine, norepinephrine or so which are travelling through the blood, they can effectively work at the concentration of 10 raised to the power of minus 12 M. Hello? Did I say something meaningful or not? M, capital M, but minus 12, 10 raised to the power of what? Extremely, extremely, okay, okay. So here we have the, so it will go through the and wherever the receptors are it will specifically act. And then this also we have, okay, when I look at this diagram you should immediately think of histamine, okay, it just really goes in there.

This thing it is either and within a sphere of radius of 1 mm either it has its find, it is destroyed, okay, okay, okay. And this is something, the cell can stimulate itself, okay. This is also, this also example, okay, good, good, good, good, good, good. In terms of chemistry if we look at the entire hormone world, okay, broadly you can divide it into three categories. So you are looking at what? Any hormone.

The moment you look at a hormone you must ask yourself a question, what is it to what family in terms of chemistry it belongs to? And the author gives us the three family. One is the peptide family. What is it? Peptide family, you all know, Greilin is there, Cystokinin is there, Secretin is there, Pituitary hormone, Growth hormone is there, ACTA, they are all peptide hormones, one big family. The second family is the steroid family and this molecule is very much familiar with that. This molecule, okay, tell me, answer my question, what must be the precursor for this molecule? Very good.

What is the precursor? Cholesterol. Cholesterol. So there is a second source is a steroid, okay. And the moment you use a steroid hormone, okay, you must immediately think of two sources, namely the adrenal cortex and the gonads, and the gonads, okay. Testis in the case of male which will, the leadic cells will secret test the steroid and in the case of female you will have the estradiol and progesterone, we will talk about it sometime later.

The third category is even more interesting, third category of hormones. These hormones are derived from an amino acid called tyrosine. So we call them as tyrosine derived hormones. What do you call them as? Tyrosine derived hormones. Tyrosine derived hormones and the tyrosine derived hormones are, can somebody label it, identify one for me please? Very good, tell me again.

Thyroid hormone. Thyroid hormone, very good. T3, T4, thyroid hormones are, why T3, T4? I will tell you shortly, T3, T4. And also epinephrine, norepinephrine. And dopamine, they are all what? Tyrosine, say that again, tyrosine derived hormones.

Say that again. Tyrosine derived hormones. And example will be dopamine, epinephrine, norepinephrine as you said, T3, T4 or thyroxine. We will talk about. So, you talk of any hormone immediately ask question as to in what category does it go. Here is a table that I got from Guyton, he talks about the steroid hormones, estradiol, progesterone, cortisol, aldosterone, peptide, hormones, oxytocin, vasopressin we have done at length, angiotensin we have done, somatostatin, somatostatin, somatostatin.

Can you tell me the source for this hormone? Very good, what is a D cell? D cell, where and where? Pancreas and? Very good, pancreas and? Stomach. Stomach, you are right, absolutely correct. And what it does? It inhibits what cells? Parietal cells. Parietal cells. It inhibits what? It inhibits acid secretion, parietal cell.

You also get somatostatin in the brain, I will talk about it a little later. And then we have the, if a protein molecule is small you call it a peptide hormone, it becomes a large, you call it a protein hormone, you call it what a protein hormone. But basically it is all, they are all made up of, they are all made up of amino acids. Ok, let us see. Ok, so chemical nature, again same tyrosine derived, steroid, peptides, I have done this, let us go ahead.

Just a small word on the mechanism of action of the different hormones. The steroid hormones, look at the top. This is a target cell. It can be anywhere. It can be a muscle, it can be a liver, it can be all of the uterus, anywhere, anywhere.

It can be adrenal cortex, whatever. But if a hormone is acting, it will act via the receptor. In the case of a steroid hormone, look at the top, the author is giving an example, what example author has selected for us is progesterone. Now is there a charge on this molecule? No is it a lipid soluble molecule? We have seen it in the previous one. So it can freely go across the target.

It will just diffuse for this molecule, nothing to absorb, it will diffuse to plasma membrane and it will inherently have a receptor either in the cytoplasm or in the nucleus. Ok, there is a receptor here. So this is the hormone, this is the receptor and this bound hormone, hormone bound to the receptor, it will go enter into the nucleus, it will act to its promoter or some part of the gene and trigger its activity. This is how the steroid hormones act. The second category belongs to the peptide hormone, two different categories.

One we are talking about LH, somebody can tell me what is LH? Luteinizing hormone, say that everybody, again you see, what is it? Luteinizing hormone, what is the source? Pituitary gland, what is the source? So LH comes from where? Comes from where? It comes from pituitary gland, anterior pituitary, LH comes from where? Antirepituitary gland, good good. And it acts, again we have done this 100 times, these are protein hormones, they might have a charge, they cannot easily cross the plasma membrane, so the nature has provided the receptor right in the plasma membrane. We have done this. And invariably it is 7 transmembrane protein, outside there will be a site where the ligand which is the hormone can combine and inside it will trigger the, and then one of the, and invariably the second messenger is what? What is the second messenger? Cyclic AMP. Cyclic AMP, very good, cyclic APK and then whatever is.

The third is like, it is again protein hormone, in this particular case IGF, forget IGF, say insulin. Say what? Insulin of growth hormone. It acts via receptor, that receptor has tyrosine, that tyrosine can be phosphorylated and then it can undertake downstream reactions. So this is just a summary of what are the different ways in which the hormones can act. So the hormones are released into the blood, they diffuse to the capillary and they will act under, okay.

Now, so we have to find out how long the, how long the hormone will remain active, how long it can bring about its effect. Now this is a little tricky because number one, you release the, okay, okay. I want to find out exactly, I want to find out exactly, let me take the example of a cortisol, cortisol, okay. What is cortisol? It is a steroidal hormone released by what? Released by adrenal cortex, okay. Now here is a thought experiment for you.

I want to know the exact half-life of cortisol in rat. Did you follow the question? Okay. Now the problem is there is adrenal cortex there inside and that adrenal cortex keeps on releasing cortisol and since it is continuously releasing cortisol, you do not really know what is the starting point, okay. I mean I may take it now but after 5 minutes it may go up. So how do I calibrate? The answer to that question is very simple.

I will remove both the cortexes surgically. You can, you can. Yeah, yeah, yeah, yeah, yeah, you can, yeah, yeah that is possible, that is possible, that is possible. I mean you can use, you have a large amount of computations, you can come, I am trying to give an old solution which my generation would use but you are right. What you can do is remove adrenal cortex, give an injection of the hormone and you know that you have injected 100 micrograms, okay.

So you know that is the amount of, that is the amount of cortisol at this moment in the system of the animal. Go on measuring and find out after how much time that 100 is reduced to 50 and that is your biological half-life of cortisol. Are you with me? But does it mean that its effect is gone in that time? No, it is only half, the effect will continue and it is more complicated because that cortisol may, maybe the biological half-life of that is a steroid hormone and this table gives us that different steroid hormones have different biological half-life but they are broad, author has given a broad range. In what range the steroid hormones go away? Half-life that is biological half-life. But it is certainly gone in 2, 3 or 4 hours, it is definitely gone, okay.

But the hormone is gone, that does not mean that its effect is gone because the hormone may trigger some other organ and that organ may continue its effect. Are you with me? So the cascading effect can continue for very long time, okay. So we just have to remember, okay, that but this gives us the approximate amines have 2 to 3 minutes which is not true actually less than a minute. I have already told you what is the biological half-life of norepinephrine.

I told you some seconds, okay. And then thyroid hormone, but on the other hand, thyroid hormone, look at this, it is very long time, 6 to 7, T4, T3, polypeptide 4 to 40 minutes, protein 15 to 170 minutes. So this is the time in which the, okay. Second thing is, whereas some of the hormones travel in the blood on their own as the molecule may be on their own, there are several molecules, there are some hormones which are generally carried along by binding themselves to a large protein. Are you with me? Okay. What would be the advantage in both these strategies? Let us take again the example of epinephrine and norepinephrine.

Once it is secreted in the blood, okay, it does not bind anywhere. It goes and reacts on its receptors, either it acts there or it is destroyed, finished, the whole story is finished. One minute, it is done. But if you take a hormone like T3, T4, in the blood it binds with a, this is a thyroxine molecule, I will talk more about it. It binds to a, so this is your tiny thyroxine molecule, it binds to a huge protein molecule, that huge protein molecule is what? Where is it? In the blood? Okay.

And so this, I can call this as a thyroxine binding globulin, okay. And then this, and this hormone is known to have a half-life of 6 to 7 days. So what might be the nature's purpose in designing, giving some hormones as a protein to which it can bind in the blood and some hormones nothing that, you be on your own. Actually I have given you the answer by telling you the respective half-lives of the two hormones. Stability, stability, when the nature wants that I want to keep this molecule in the system for a very long time, okay, because, because as long as this molecule is bound to this larger molecule, it is not broken down.

It is not broken down, not only that. Now I will ask you a simple question. As long as it is bound to that large molecule, can it get out of a capillary? It cannot, got the point, it cannot get out of the capillary, okay. It will remain there, okay. And the biology says that say it is okay, I will at any given moment, I will allow only 1 percent of the molecules to be released, okay.

So 99 percent molecules are still bound. So if that 1 percent is used up or destroyed, then I will release another 1 percent. So for a steady supply, at steady supply for a prolonged period, okay, whenever nature wants that, then nature has the molecule being bound to a large protein molecule and those protein molecules are generally globulin molecules in the blood, okay. So here is your box diagram. Endocrine cell gives rise to a free hormone. The free hormone may be bound to a carrier bound hormone or the, if it frees itself, it can be degraded or the free hormone can combine with its receptor and exerts its biological effect, okay.

Its biology, you cannot have an active molecule available forever, okay. No you want to destroy it everywhere, okay. So acylcholine is destroyed in a millisecond, acylcholine at the level of a synapse, okay. So you need to destroy, so you have to, so what are the different methods? The thing is the hormones are generally, one way to do that, one way to do that is that has the, mostly happens in the liver and also to some extent in the kidney is some enzyme will make a slightly change in the structure of the hormone. As a result of that the hormone cannot bind it with its receptor.

So you have made it ineffective. Are you with me? Hello, hello. So whereas these, whereas the endocrine glands on one hand, depending on the message they get, they keep on generating the hormone and they keep on exercising their biological effect. At the same time as the hormone molecule happens to pass through liver, okay, the liver will, you will make a change, enzymatic change in the structure of the molecule. And what has happened to that hormone now? It is inactive, okay, because in this new form, changed form, it cannot bind with its receptor. So and then of course it would be degraded and it will be broken down and then it may be thrown out by way of urine or it may be put in the, by bile into the alimentary canal or whatever, okay.

So these are the two, okay, you see the, you can see the liver there, you can see the kidney there and it is at these places that the, okay. Then we have in the endocrine system, particularly in the vertebrates, in what vertebrates, we have two systems are prevalent, like what, like what, okay, you take glucose, you take food, okay, as a result of that the blood glucose level goes up, the glucose is sensed by the beta cells of islets of langerhans, their cells release insulin, the insulin will act on its target organ, those cells will now have more gluten in their plasma membrane, the glucose molecule, the glucose molecule is now more permeable, we are good, right? The glucose will be taken in the cells, taken into the cells and the glucose will be utilized. Over a period of time, the blood glucose level has fallen down, it has fallen down to such an extent that the, it has fallen down below 80 mg per 100 ml of blood, as a result of that now the glucagon cells are excited, the glucagon cells will bring the glucagon into the circulation, glucagon will act on the, its receptors which are sitting in the plasma of the liver cell, under the influence of that the liver cells will convert their glycogen into glucose 1 phosphate, 1, 6 phosphate, glucose whatever it is and glucose molecules will be brought down, brought into the circulation and so that our homeostasis with reference to glucose is maintained. Very short story, okay. This is, this similar story you will get with reference to maintain of calcium level, calcium in the blood, okay, you will have, you will have hormones like parathermon, calcitonin 1 pushing it up, 1 pushing it down, homeostasis mechanism, same thing like sympathetic, parasympathetic, two opposing systems working here and that is one way.

The other way in which our endocrine system, other paradigm in which our endocrine system operates is an hierarchical system, means what? The message is taken by the brain, message is taken by what? Brain then the brain informs the hypothalamus, then the hypothalamus informs the pituitary gland, the pituitary gland by way of hormones it may inform the thyroid or it may inform the adrenal cortex or it may inform the gonads and those hormones will go into the circulation and go to the target organ, okay. So there is an elaborate, there is elaborate, so let us see this here, endocrine axis is driven by negative feedback. So here we have the hypothalamus, I will talk more about this, hypothalamic hormones, releasing hormones, pituitary gland, tropic hormones like LHFSH, LHFSH etc. They will act on the peripheral endocrine glands like gonads and then they will rise to hormones, those hormones will have what? So that they will inhibit, okay, so this is how it is controlling its own secretion or it will go to the target organs which may be the gonads and then you may see the physiological effect whatever it is, okay. Thank you.