Basics of Biology
Professor Vishal Trivedi
Department of Biosciences and Bioengineering
Indian Institute of Technology, Guwahati
Lecture 48
Homeostasis (Part 3)

Hello, everyone. This is Dr. Vishal Trivedi from Department of Biosciences and Bioengineering, IIT, Guwahati. And what we were discussing, we were discussing about the different properties of the living organisms. And in the current module, we are discussing about the homeostasis and how the homeostasis is being maintained within the living organisms. So, So, far what we have discussed in this particular course, we have discussed about the classifications, we have discussed about the evolution, we have also discussed about the different types of cells and their structures and everything.

And then we also discuss about the different types of biomolecules and how these biomolecules are regulating the different types of cellular processes, whether these processes are related to the central dogma of life such as replication, transcription and translation, or whether they are associated with the specialized function such as the vesicular trafficking and as well as the immune responses. And subsequent to that, very extensively we have also discussed about the physiological processes.

What the physiological process, is what we have discussed, we have discussed about the digestion, we have discussed about the circulatory system and So, on. Now, in today's lecture we are going to discuss more detail about the homeostasis. And what is the way in which the homeostasis can be maintained within the host or the living organisms. So, before getting into detail of homeostasis, we should understand what is the requirement of the life.

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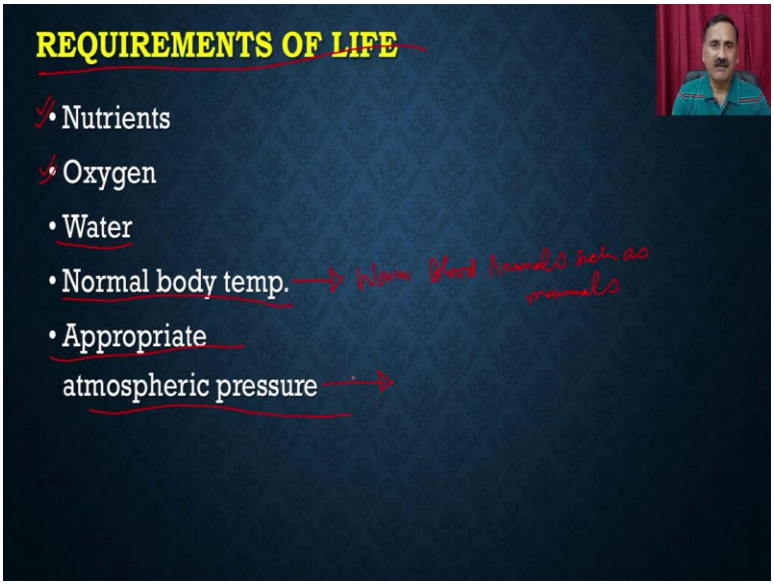

Requirement of the life is that it requires the nutrition, it requires the oxygen, water, normal body temperature, So, this is true for the warm blood animals, and, such as mammals. Then, we also require the maintenance of the appropriate atmospheric pressure because if you do not maintain the appropriate atmospheric pressure, that is actually going to cause the rupturing of the body cavities.

So, if you remember, when we were discussing about the classification, we have discussed about the different types of cavities what are present in the different organisms and the purpose of these cavities are only to maintain the atmosphere pressure because if there is a increase in atmospheric pressure, the air within the cavities are actually going to play a crucial role in terms of balancing the pressure outside and inside.

So, if a living organism actually wants to have these kinds of requirements, it also has to run the different types of physiological processes to provide this particular type of requirements.

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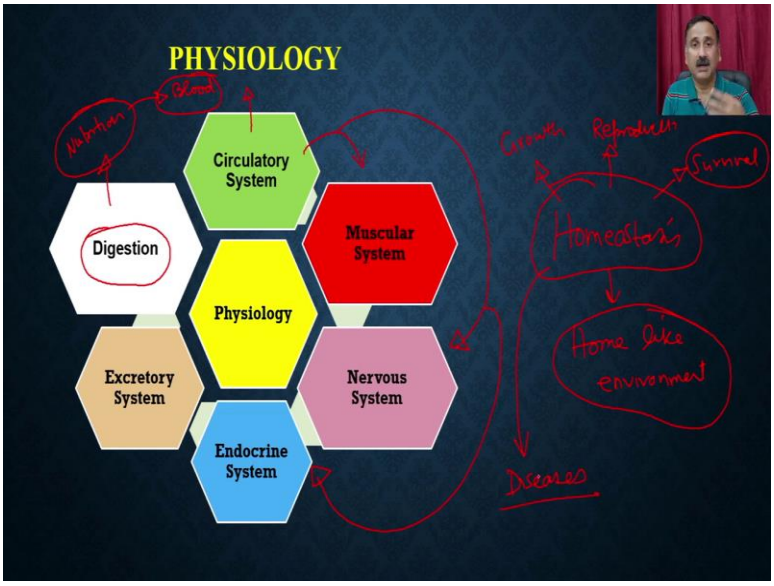

So, what are the different physiological processes, what we can do, we can actually be able to, we have discussed about the digestions and the purpose of digestion is that it is actually going to provide the nutrition because you are going to take up the large and the complex food, and that complex food is actually going to be digested into the monomeric forms, and that monomeric form is going to be absorbed into the blood and that is how it is actually going to provide the nutrition.

Now this nutrition will enter into the blood and through the blood it is actually going to be distributed throughout the body and that is the function of the circulatory system. And what is the purpose of the nutrition or the circulation or the distribution of the nutrition that it is going to be used for, by the muscular system for locomotion, it is going to be used by the nervous system to maintain the coordination between the different types of organs or the organ system.

And if you recall, in the previous lecture we have also discussed about the role of the endocrine system, and how the endocrine system is actually playing a crucial role in terms of maintenance of the homeostasis. So, as the name suggests, the homeostasis is, the homeostasis means the home like environment. So, and all these physiological processes, whether it is digestion, circulatory system, muscular system, nervous system, endocrine system or the excretory system, their main purpose is that they want to maintain the home like environment or the homeostasis.

And in detail we have discussed in the past, why there is a requirement or why there is a need to actually maintain the home like environment because that actually gives the proper environment for the growth that gives the proper environment for the reproduction, and that also gives the proper environment for the survival. So, because, if there is a disturbance in the in the homeostasis or the parameters which are maintaining the homeostasis, then it is actually going to cause the development of the different types of diseases.

And that is what is actually the ultimate goal of the homeostasis. And homeostasis is a condition which is always been challenged by the different types of disturbing agents.

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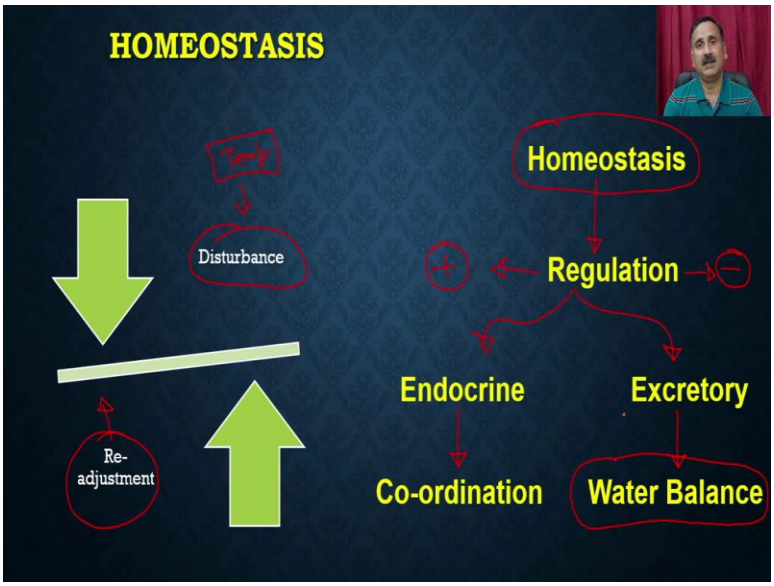

For example, there could be a fluctuation in the temperature. So, that is actually going to be a factor which is going to disturb the homeostasis. And once this happens, then there will be a regulatory mechanism and that regulatory mechanism is actually going to readjust the equilibrium in such a way that it is actually going to minimize the disturbance and it is actually going to bring the disturbance back.

So, homeostasis is largely being dependent on the many of the, many types of the regulatory mechanisms. If you remember, we have discussed about the positive regulatory mechanisms and as well as the negative regulatory mechanism. And there are two main components which are extensively playing a crucial role in terms of the regulation of the homeostasis.

One is called as the endocrine system, the main purpose of the endocrine system is that it is actually going to maintain the coordination among the different types of organs or it is actually going to be an alternate system through which the messages are actually going to be conveyed from the one part of the body to another part of the body. And very extensively in the previous lecture, we discussed about the endocrine system.

The other thing is about the excretory system, because the excretory system is actually going to be used for get rid of the waste product and that is how it is also going to maintain the water balance because the amount of water within a living organism is very important because it is going to maintain the different types of parameters. Like it is going to maintain what is the volume of blood what is going to be in the living organisms it is also going to maintain the osmolarity and all other kinds of parameters.

And you know that the, all these parameters are essential because of proper functioning of the different types of enzymes, organelles and as well as the cells. So, in today's lecture we are going to discuss in detail about how the excretory system is contributing in maintenance of the homeostasis.

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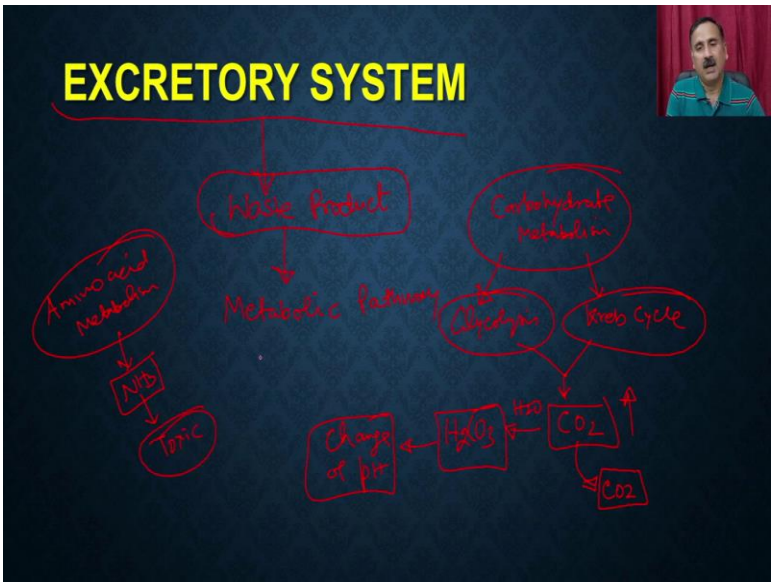

So, excretory system. So, what is mean by the excretory system is that it is a system which is actually going to be used for get rid of the waste product. So, from where this waste product is going to be generated? This waste product is always been generated by a or they will, I will say they are actually the byproduct of the metabolic pathway.

For example, if you see the carbohydrate metabolism, So, if you do the carbohydrate metabolism, and I am sure when we have discussed about the carbohydrates in one of the modules, we have discussed in detail about the carbohydrate metabolism, So, in the carbohydrate metabolism we can have the glycolysis, we can have the Krebs cycle, and we can have the pentose phosphate pathway and so on.

And after these two events, what you are going to generate is you are going to generate the large quantity of the carbon dioxide gas. And that carbon dioxide gas is not good for the human body because it is actually going to change, because carbon dioxide, it is actually going to react with water and that is how it is actually going to form the carbonic acid. And that carbonic acid is, actually if the carbonic acid or indirectly the carbon dioxide is not going to be removed from the circulations, it is actually going to result into change of the pH of the blood.

Because carbonic acid is acidic in nature So, carbonic acid is actually going to change the pH of the blood. So, that is why it is important that we should be able to get rid of the carbon dioxide what is being produced within the metabolic reactions. Similarly, we can have the amino acid metabolism. Within the amino acid metabolism it is actually going to generate the large quantity of ammonia. And that ammonia is also very toxic and it is going to be, it also has to be removed from the circulations.

So, this is the reason why we have to study about the role of the excretory system in maintaining of the homeostasis.

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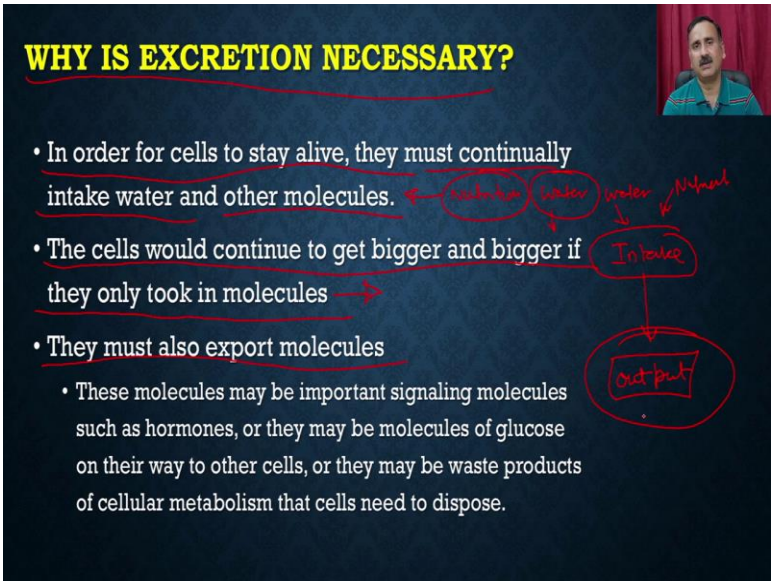

So, why is the excretion necessary? We have already discussed in detail that in order for the cell to stay alive they must but continuously intake water and other biomolecules, which means they should always continue to take the nutrition and they also should take the water. So, if you keep taking the water, for example if you keep taking the water, it is actually accumulating within the body.

And that is how you, your volume of the body is actually going to be bigger and bigger. So, if the cells will continue to get the bigger and bigger they will only took in molecules. So, if you keep continuing taking the molecules from outside whether it is the nutrition or whether it is the water, the cell size is actually going to be keep increasing.

But you know that there is a definite space or the definite size until which the cells can actually grow, and that is why this is important that whatever you have taken, for example, your intake, whatever you have the intake, should actually be able to match with the output. Which means, whatever the intake you have taken, for example intake of water or intake of the different types of nutrients, it should be resultant into the output.

Whether it will be in them in terms of the different types of waste materials or whether in terms of the energy. So, they must be exported molecules. So, they, whatever you take, there should be output also. And that is why you see that when you take the water it actually evaporates, it goes out from your body in a different way. Now, the question comes from where this waste material is being generated?

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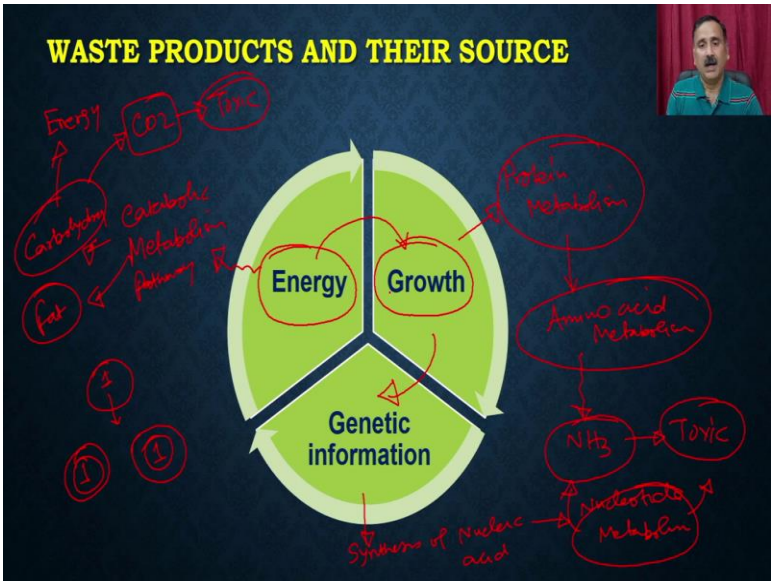

So, the waste material is being generated when the body is or when the organism is going through the different types of the processes. For example, it is mean, it is going through a process where they are producing the energy because the energy is required for the different types of processes, for example the locomotion, neural activity and circulatory system and So, on. So, that energy is requiring the metabolism. So, if you want to generate the energy, you have to run the metabolic pathways.

That means you are actually going to run the carbohydrate metabolism, or the fat metabolism, and both the carbohydrate or the fat is actually going to generate the energy. And along with the energy, it is also going to generate the carbon dioxide and as well as the other kinds of the toxic material or the byproducts. And these y products are actually going to be toxic So, they have to be get rid of this.

Similarly, the organism also wants to grow because if it is going to take up the nutrition, it also wants to grow in size. And that growing size is also requiring the protein metabolism because the protein is the major component which is responsible for the growth of an organism. And protein metabolism means the amino acid metabolism, and amino acid metabolism involves So, many of the amino acids which are actually going to be, ultimately going to produce the ammonia.

And that ammonia is very, very toxic, and that is why the organism has to get rid of the ammonia from the circulation. Now the third event, or third crucial point is the

maintenance of the genetic information, which means it is actually going to be done by the synthesis of the nucleic acid. So, synthesis of nucleic acid is associated with the nucleotide metabolism. And that is also going to be responsible for production of the ammonia, and what is also product responsive.

And since ammonia is toxic it is actually going to be also contribute in terms of generation of the different types of toxic materials. So, what you see here is that if the organism wants to continue its life, it has to generate the energy, it has to generate it, that energy is going to be used for running the different types of physiological processes and along with that it is also going to be used for the growth. And if it wants to grow then it also has to synthesize the new and new proteins So, that it can be able to synthesize the new cell.

And that is how it is also going to be run the amino acid metabolism and that also is going to generate the ammonia. And the third is it also has to maintain the genetic material of the body because if one cell wants to grow, it has to divide and form the two cells, which means if you have one copy of DNA, you also require the additional copies of DNA So, that you can be able to maintain the nucleic acid pool of the daughter cells.

So, these are the three crucial events in which the body is actually bound to produce the different types of toxic material. And these are the toxic material which are going to be removed. Apart from the carbon dioxide and ammonia, there are many other types of toxic material which are being produced within the different types of organisms and depending on which type of waste material you are going to use it is actually going to utilize the different mode of the excretory systems.

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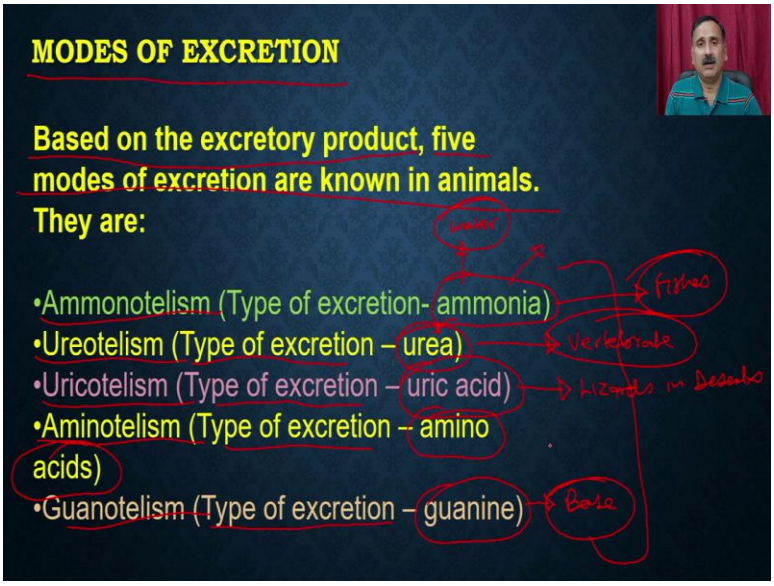

So, what are the different types of mode of excretion? So, based on the excretory products like just we said carbon dioxide and ammonia, the five different modes of the excretory systems are known in the different types of animals. They are ammonotelism, ureotelism, uricotelism, aminotelism and the guanotelism.

So, in the ammonotelism, you are, the organism is very extensively going to secrete the ammonia. Then we have the ureotelism. In the ureotelism, the type of excretion is urea. Then we have the uricotelism. Uricotelism, the type of excretion is the uric acid, and then we have the aminotelism.

Aminotelism is a type of excretion where the organism is actually going to excrete the different types of amino acids, and then we have the guanotelism where the type of station is the guanine. So, guanine is a nucleophile or the base actually, nucleophile base, which is actually going to be excreted.

Now the question comes why the different organisms or different type of mode of the excretion is taking place. This, all these modes are actually being dependent on the environment in which these organisms are actually surviving. For example, the ammonia, the removal of ammonia is associated with water, and that is why if the organism has to remove the ammonia from the body, it cannot, because ammonia is very, very sparingly soluble in water.

So, what it can do is it can actually dissolve the ammonia into the water and that is how it can actually be go out from the body. So, depending on the water's availability, all these different modes of the excretions are being adopted by the different types of organisms. For example, ammonotelism is very extensively been found in the in the fishes.

And whereas in the other organisms, for example in the vertebrates, the, since the, So, much water cannot be used, the ammonia is being converted into urea, and that is how the urea is actually going to be excreted out. And that is been a very standard way of doing it in the vertebrates.

But if there is a scarcity of water, the urea or the, its, then the excretory product is going to be uric acid, and that is going to be in the different types of organisms where the water is very scarce. Like for example, So, many lizards which are found in deserts, they are actually going to be used the uric acid instead of ammonia or urea because the conversion of ammonia to urea is also requiring the same amount of water.

And that is also very, very costly for these organisms because they are living in desert So, that they cannot survive. And the other mode also is depending on the local environment, depending on the availability of the different types of resources, these are the different mode in which the excretion is being performed by the different organisms.

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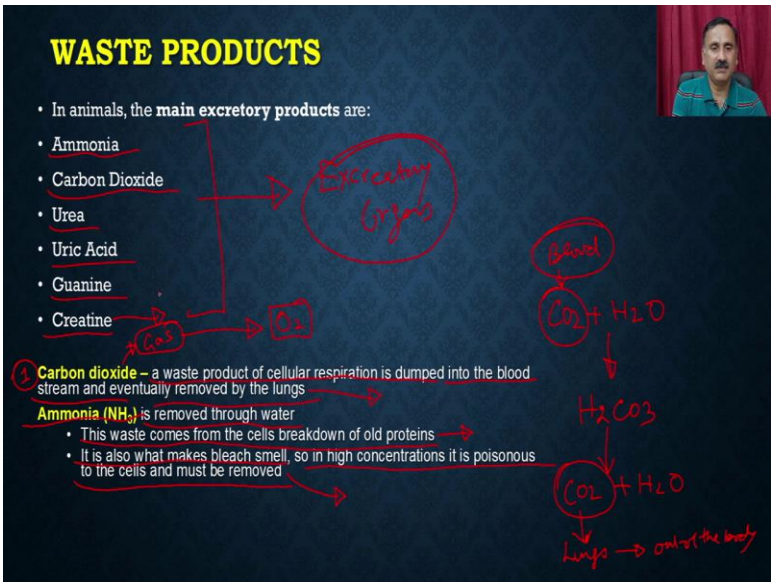

So, if we summarize, the different types of excretory products what is being found in the different organisms are ammonia, carbon dioxide, urea, uric acid, guanine and in some organism, it is creatine. And the way it is actually going to be removed is, like for example the carbon dioxide, So, carbon dioxide is actually a gas, So, carbon dioxide can be removed simply by the oxygen which is present in the environment.

So, carbon dioxide, it is the waste product of the cellular respiration and it is dumped into the bloodstream and eventually removed by the lung. So, there is a complex mechanism through which the carbon dioxide is going to be converted into the carbonic acid and then this carbonic acid is going to be travel onto the lung surface and from there the carbonic acid is again going to be breakdown and that is going to give you the gaseous carbon dioxide, and that is how the gaseous carbon dioxide is going to be exhaled out from the body.

So, in this case what will happen is that carbon dioxide is actually going to react with water and it is actually going to form the carbonic acid, and that carbonic acid is again going to be breakdown into the carbon dioxide plus water, and that carbon dioxide is actually going to be expelled out from the lung surface. So, this is the carbon dioxide what is present in the blood or the tissue, and this is the carbon dioxide what is present on to the lungs, and through the lungs it is actually go out of the body.

Similarly, for the ammonia, ammonia we have the different mode in which the ammonia is going to be removed. The one of the convenient ways of removing the ammonia is that it can be removed through the water. And this waste comes from the cellular breakdown of the old protein. So, when there is a breakdown of the some of the older proteins like it is actually going to release So, many amino acids, and every amino acid has the amino group, and that can be, when it is going to be catabolized or when it is going to be recycled, that ammonia is actually going to be released.

And this is actually going to removed through water. So, ammonia is very soluble in water and that is how it is actually going to be removed. It is also what makes bleachy smell. So, it is high concentration, it is poisonous to the cells and must be removed, and the removal of ammonia is associated with water, removal of carbon dioxide is also

associated with water, but it is being done by the gaseous exchange when the person is breathing.

Now, when we have the So, many different types of waste product, we should also have the different types of excretory organs. So, because, not the same type of organ is, can be able to withstand or can be can be able to handle these type of waste products.

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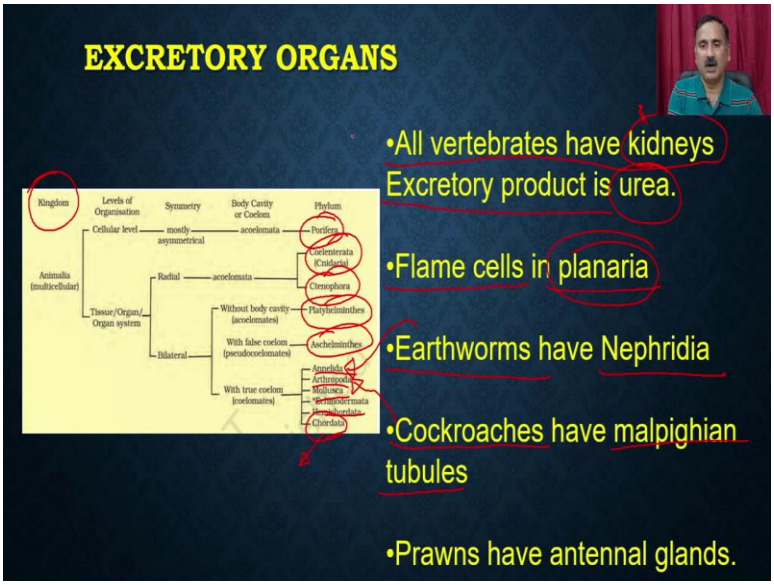

So, we have, I am sure you might have seen this. We have, when we were discussing about the classification that we have discussed about the different types of organisms whether they are presenting Porifera, Coelenterate, Ctenophora, Platihelminthes, Aschelminthes, Annelida, Arthopoda, Mollusca, Echinodermata, Hemichordata, or Chordata. And within the Chordate, we have the Vertebrata and So, on.

So, all vertebrates, whether which are present in the Chordata are actually using the kidney as the excretory organs. And what they excrete, they excrete the urea. Whereas, in the case of planaria, So, planaria it is using the flame cells, and flame cell is being used in the organism which is called as planaria. Then, we have the Nephridia, Nephridia is being used in the earthworm. So, earthworm is belonging to a class which is called as the Annelida.

Then, we have the cockroaches, and within the cockroaches we have the malpighian tubules, and that is being used. And the cockroaches are being used, it is belonging to the

phylum Arthropoda. Similarly, we have the prawns, and the prawns are using the antennal glands. And what exactly these excretory organs are doing, these excretory organs are actually taking up, excretory organs are taking up the waste material or they are collecting the waste material from the body and then they are throwing it out from the body.

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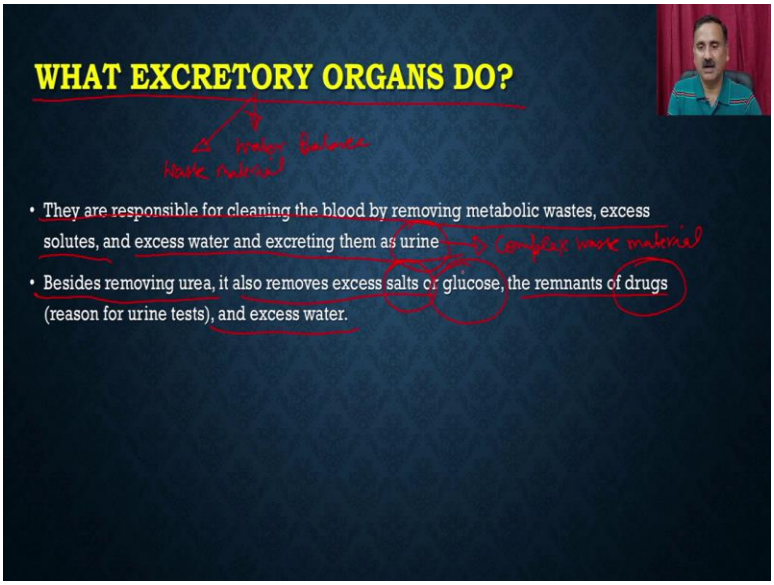

So, what the excretory organs basically do? They are responsible for cleaning the blood by removing the metabolic waste, excess solute and the excess water and excreting them as in the form of urine. So, urine is a complex waste product or complex waste material where you have the different types of material.

Like you can have the ammonia, which is going to be present in the form of urea. Within the urine you can have the different types of drugs, which are going to be present in the blood or you can also have the different types of other waste materials. Besides removing the urea, it is also removing the excess amount of salt, glucose and the reminiscent of the drugs.

And that is why the reason that some of the, in some cases you might have heard about the, that the people are testing the urine for the drugs. For example, if somebody using the power enhancing drugs like in the, some kind of athletes, So, they will actually going to test that drug into the into the urine. And the excess water.

So, basically excretory organs have the major role of maintaining a water balance, and they are also having the role in terms of the removal of the waste material. So, waste material in terms of the urea or, and the maintaining the water balance in terms of removing the excess salt glucose and the excess water.

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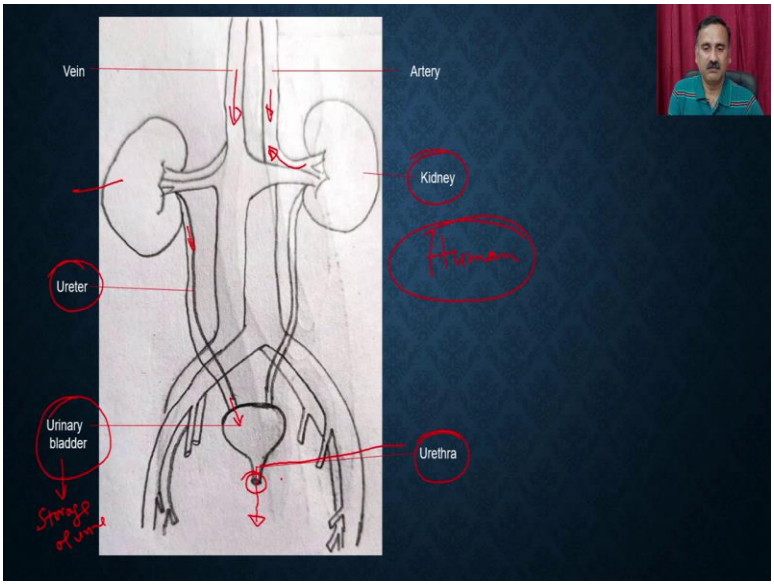

Now let us talk about the excretory organs. So, when we talk about the humans, humans have a very well-developed excretory organs where we have the two well developed kidneys. So, you have the right kidney and left kidney. Then we have the, both of these kidneys are very, very versatile. So, they are supplied by the blood through the arteries. So, you can have the dirty blood which is going through the kidney in the veins, and then there are arteries which are coming out from the kidney, and that is how they are actually containing the blood, the purified.

Then the, both of these kidneys are filtering the material from the blood which is coming through the into the kidney through the veins and whatever the filter material that comes in the form of urine, and that the tubing which actually carry the urine from the kidney is called as the ureter, and the ureters are discharging their content into a bladder which is called as the urinary bladder. And the purpose of urinary bladder is that it is actually going to use for the storage of the urine.

And the terminal end of the urinary bladder is actually a urethra which is actually going to be used for discharging the urine. So, whenever there will be urge to do the, to remove

the urine, then this, it is actually lined by the different types of muscles and those muscles are actually going to be relaxed and that is how the urine is actually going to be passed from the urethra.

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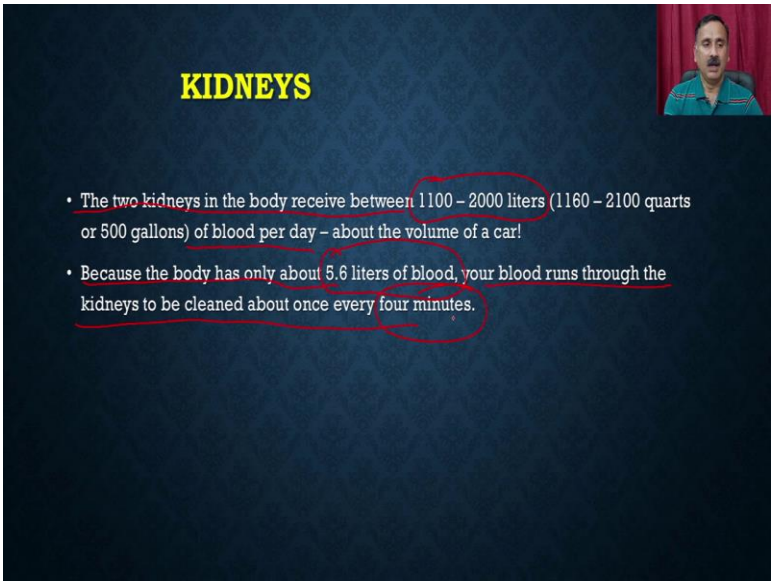

Now let us talk about the kidney. So, we have the two kidneys in the body which actually receives approximately 1,100 to 2,000 liter of blood per day. And because the body has only 5.6 liter of the blood, you can imagine that the blood runs through the kidney to be cleaned after every 4 minutes, which means in every 4 minutes the our whole blood is actually going to be passed through the kidney.

And that is why that whenever you are actually going to generate any kind of waste material, it is actually going to be removed. So, and why it is so, because it does not want that the waste materials concentration should shoot up beyond a particular limit.

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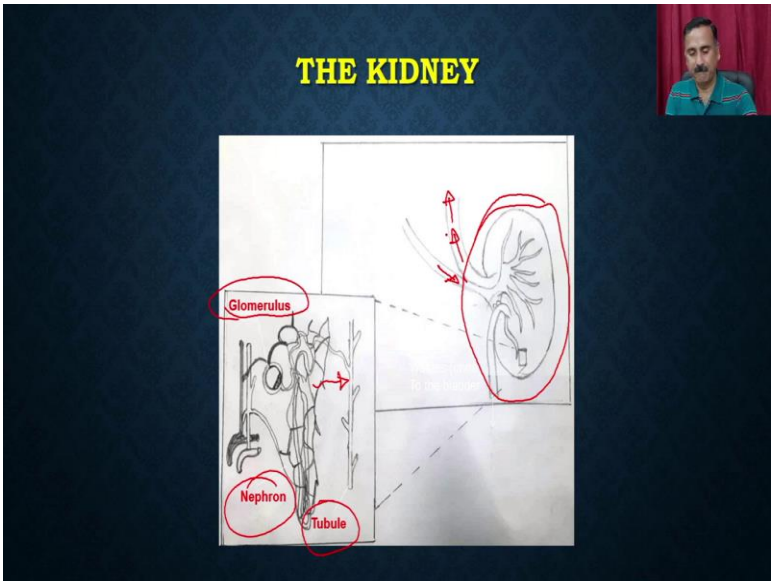

And what is there in the kidney? The kidney is a vesselized organ where you have the different types of nephridia or, and within the nephridia we have the glomerulus and we have the nephrons, we have the tubules, and all these tubules are being used where the, there will be an exchange of material, and that is how the urine is going to be retained into these tubules, whereas the good material like the glucose proteins and the other kinds of salts are actually going to be absorbed back.

And the kidney is actually extensively been supplied with the high quantity of blood. So, it is actually going to be connected by a vein, and as well as it is actually going to take up all the material from the kidney. So, it is going to bring the dirty blood or the unpurified blood and it going to purify the blood.

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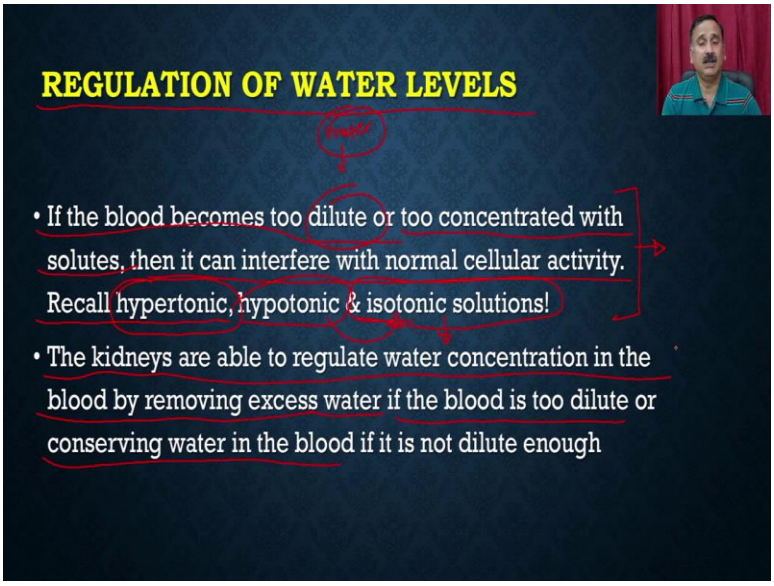

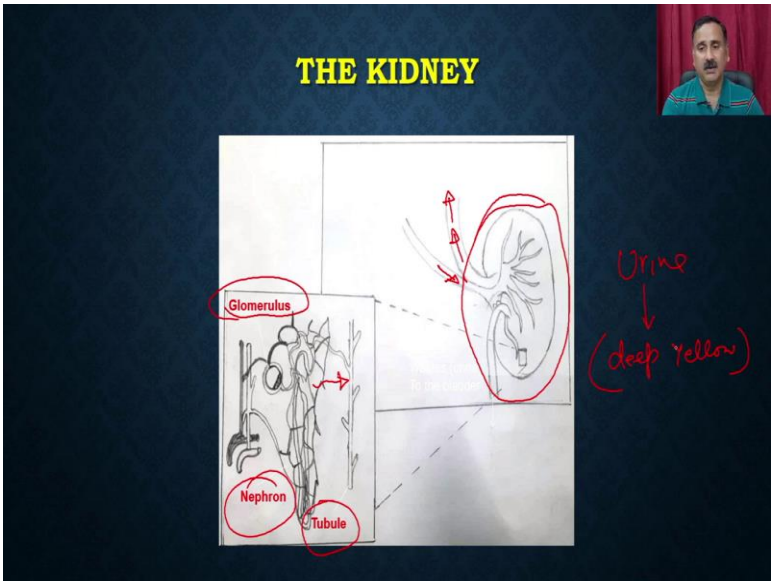

Then the, how the kidney is going to do a regulation of water levels? So, if the blood becomes too dilute which means you are going to have the large quantity of the water, or it becomes too concentrated with the solute, then it can interfere with the normal cellular activities because it is actually going to change the osmolarity. And once you change the osmolarity, most of the biological enzymes are actually going to be get affected.

So, you can, it can actually be, you can imagine, recall the situation like the hypertonic, hypotonic and the isotonic solutions, and you always want that the body should maintain the isotonic solution, but that is always not been possible because whenever, suppose you

take the food, a large quantity of nutrients, as well as the water is actually going to be absorbed.

So, all that time, at that particular small moment, the liquid, the water could be, the blood could be hypotonic. So, in that case some amount of the salt or other things has to be retained So, that it is actually going to be again go back to form the isotonic condition. And that is the major function of the kidney, which means it is actually going to maintain the proper balance of the salts, proper balance of water and proper balance of different types of waste within the body.

The kidney are able to regulate the water concentration in the blood by removing the excess of the water. So, if you drink lot of water it is actually going to be removed that water So, that it can avoid the dilution of the blood, or it may conserve, it may actually in reabsorb, keep reabsorbing the water. For example, if you might have seen, here we have the different types of tubules, and the purpose of this tubule is that they are actually going to allow the reabsorption of the good material.

So, in some cases when there is a scarcity of water, then there will be a more and more reabsorption. And I am sure you might have noticed that when there is a, for example when you are dehydrated, like, for example in summers, when you do not drink the water or when you do not drink enough amount of water, the, these reabsorption event is actually going to allow the reabsorption, more and more amount of water going to be absorbed.

And that is why you might have seen that the urine is actually, color is changing. It becomes deep yellow. And that is because the amount of water is being reduced. So, concentration of the toxicants has actually gone up, and because of that, or the pigment what is present in the urine is actually gone up, and that is why it has shown a very deep yellow, a deep yellow color.

So, that is something what is the very crucial thing for the human body or for an organism to maintain the osmolarity because if there is no osmolarity, it is actually going to interfere many events. It is going to interfere in terms of the transport of the biomolecule from the one part of the body to another part, it may affect some of the enzymes and their activity.

And the same, the same is actually reversed. If the blood is too thin, which means lot of water is there, then the kidneys are actually going to, not going to absorb the reabsorb the water. So, it will, they will allow the bladder to go through, and in that case you might have seen that the urine color becomes pale yellow or almost whitish.

So, that is why the, when you go to a doctor, they always ask what is the color of urine and what is that, because that gives an idea what will be the internal environment of your body because that will give the idea whether you are properly maintaining the water balance within the body or not.

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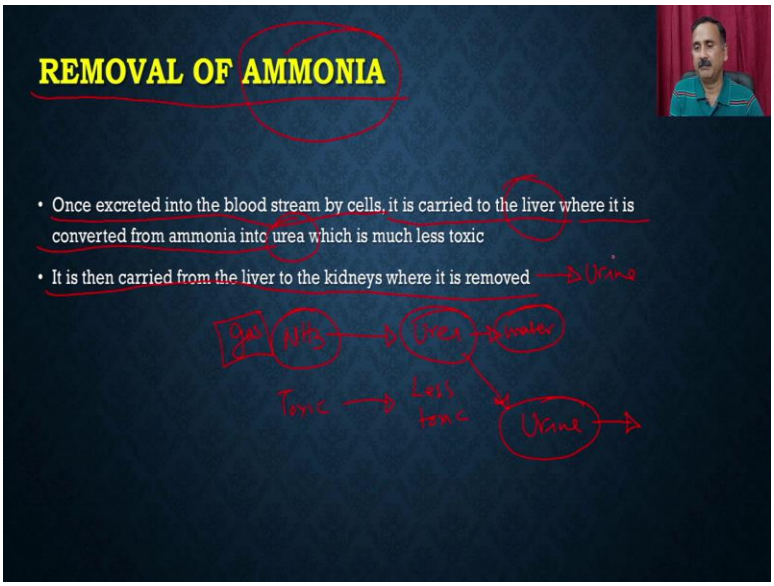

Now, let us talk about how we are going to remove the ammonia. So, once excreted into the bloodstream by the cell because ammonia is actually going to be a metabolic byproduct of the different types of cells, they are actually going to throw these by-products into the blood. The ammonia is going to be carried to the liver where it is converted into the urea.

So, ammonia is actually going to be very, very toxic. So, ammonia is actually going to be get converted into the urea which is less toxic compared to, So, this is toxic, and this is going to be less toxic. So, body is trying to convert a more toxic material into a less toxic material So, that it is easy for that particular material to transport.

And the other advantage is that the ammonia is a gas. So, if you want to try, if you want to transport the ammonia from the site of its production to the kidney, that is not possible because the ammonia is a gas. So, it has to be converted into a form which is actually a transportable form, and the urea is the transportable form because urea is water soluble. So, it is actually going to be used.

And then once it reaches to the kidney site, it is actually going to be put it into the kidney and then it will actually go through the different types of tubules ascending tubules and descending tubules and the reabsorption and all that, and the urea is actually going to be concentrated into the, in the form of urine, and that is how it is, the urine is actually going to be escaped out to the urethra. So, it is then carried out from the liver to the kidney where it is being removed in the form of the urine.

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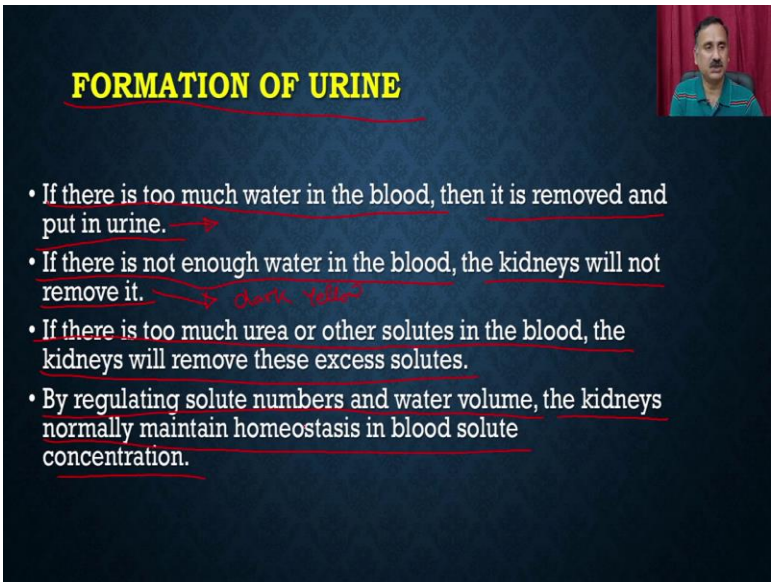

So, how the urine is going to be formed, So, if there is too much water in the blood, it is removed and put it into the urine. And that is not the urine is actually going to be pale yellow or clear color. If there is not enough water in the blood, the kidney will not going to remove it, and that is how it is actually going to be dark yellow or orangish color. If there is too much urea or other solute in the blood, the kidney will remove these excess solutes, and by regulating the solute numbers, and the water volume, the kidney normally maintain the homeostasis in the blood solute consultations.

Now once, since the kidney is doing So, many important functions, the kidney's function also can be get affected by the many types of the functions or many types of the molecules.

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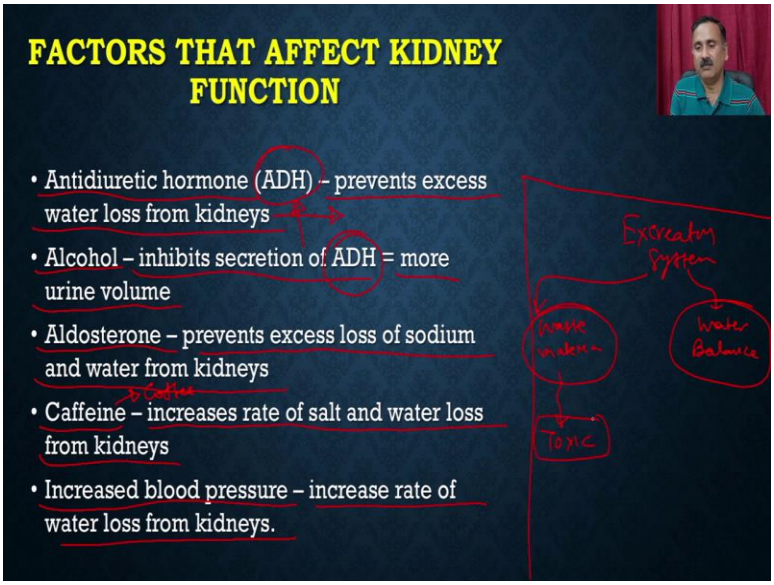

One of the hormones which is called as the ADH hormone. So, it is called antidiuretic hormone, that is actually going to affect the function of the kidney, and it is going to prevent the excess water loss from the kidney, which means it is actually going to stop the, stop this, So, it is actually going to enhance the reabsorption.

Similarly, when we have the alcohol, So, alcohol actually is going to inhibit the secretion of the ADH. If there is an inhibition of the ADH, which means there will be a more loss of water, and that is how it is actually going to increase the more amount of volume, and that is why you might have seen that the people who consume the alcohol, they are actually urinating more frequently because of this event only, because of the ADH.

Then, we have the Aldosterone, and that prevents the excess loss of sodium and the water from the kidney. Then we have the caffeine. So, caffeine is present in the coffee, and caffeine what present in the coffee is also increases the rate of salt and water loss from the kidney, and that is how the caffeine is actually going to be antidiuretic agents. Then, it also increase the blood pressure. So, increase the rate of the water loss from the kidney, that also increase the blood pressure.

So, this is all about the role of the excretory system in maintaining the homeostasis. Excretory system is doing two jobs. So, what the excretory system is doing is in terms of contributing in maintaining the homeostasis is that it is actually going to remove the waste material, and it is also maintaining the water balance, which means it is actually going to, it is going to regulate the amount of water what is being present in the blood.

So, that is why it is actually going to make the blood more concentrated or less concentrated. Similarly, it is also going to remove the waste material. And these waste materials are mostly being toxic. So, once you remove the toxic waste material, you are actually going to not allow these waste material to disturb the homeostasis. Similarly, since you are going to maintain the water balance, it is also going to contribute in terms of the maintenance of the homeostasis.

So, this is all about the excretory system. And with this, I would like to conclude my lecture here. In this lecture what we have discussed, we have discussed about the role of the excretory system in maintenance of the homeostasis, and how the different organisms are actually utilizing or doing the excretion in the form of different types of waste materials or waste products, and how the different types of organs are present in the different organisms to tackle the different types of waste material.

And in the end, we have also discussed about the structure of the kidneys and the functioning of the kidney and how the different types of factors are affecting the functioning of the kidney. So, with this, I would like to conclude my lecture here. In our subsequent lecture, we are going to discuss some more aspects related to living organism. Thank you.