Human Physiology
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Week - 01
Lecture - 04

So, welcome everyone for our next class which is the ion transport class. So, ion transport basically will take two classes. Today is the first part of ion transport. So, last few classes we discussed about like introduction of human physiology and then about our human anatomy, a brief about all our different type of organs. Finally we discussed about like what are different component of our body like cells, tissues, organs. In the last class you remember we discussed about cell and different component of the cell and their function.

Now, you remember I said like we will have a very important part which are ion transport and cell membrane is a very important component of that. So, let us see in this class how ion transport happens, what are different types of ion transport and why they are so important. So, before we go to ion transport, we should try to understand that what are different ions present inside of our cell, right. So, let us see in the left side if you can see what are different type of ions we have, like we have sodium ions.

right and we have categorically distinguish into two points one is extracellular fluid which is like outside of the cell and one is intracellular that means it is inside of the cell. So, it is very important to kind of understand that what are the ions and of course, like their concentration in extracellular and intercellular condition because this will determine how they move, why they move and their role will widely vary based on their concentration gradient, right. So, sodium is the first one you can see that sodium is high outside of the cell, right. So, if this is like a cell high outside of the cell and inside sodium concentration is too low, okay. Quite a huge difference you can see like almost like a 14 fold higher outside compared to the inside.

The next important ion is potassium. Contrary to sodium, potassium is low outside of the cell and high inside of the cell. And the difference is almost like quite a high few fold you can see like from 4 mq to liter to almost like 140. There is a large difference, right. And many of this ion transport process are closely guided or closely controlled by sodium and potassium.

So, these two are very important that many of the ion transport processes we will discuss are closely controlled by these two ions. Calcium is another very important ion because it has a lot of functions specially in the muscle contraction. We will discuss thoroughly and what you can see calcium is high outside of the cells in the extracellular fluid and low inside of intracellular fluid, right. Then magnesium contrary to calcium, you can see magnesium is high in the intracellular fluid but low in number or amount in the extracellular fluid. So, mostly these are very important apart from that like chloride ion, bicarbonate ion, phosphate, sulfates, glucose, amino acids, other proteins, fat.

So, this table is very useful and you can remember like, you don't have to remember of course the exact quantity or amount but it gives us an idea that if a certain element or an ion is present more inside of the cell or outside of the cell. Why it is important again? As I said this concentration different, the difference in their concentration largely play an important role in their movement from outside to inside or inside to outside of the cell because these ion transport controls many important and different functions of the cell. So, what are different type of

cellular transport, right, that is very important component. The first one we will discuss, mostly it is categorized into two different transport, one is passive transport and one is active transport. So, in today's class, we will mostly discuss about the passive transport process and the next class we will discuss about active transport process.

So, why we are saying passive and active transport? By the name you can understand that passive transport does not require any energy. Mostly that is the main thing that passive transport does not require any energy but in case of active transport it requires energy. So, what is passive transport it does not require any energy or ATP, but in cases of active transport I will write down here it needs ATP or energy. Another important component is that the particle movement happens from high concentration to low concentration. This is the most second important point after the energy that particle or ions move from high concentration to low concentration in cases of passive transport.

But for active transport, the particle moves from low concentration to high concentration. But for passive transport it is high to low. So, all the diffusion process mostly all the diffusion process and osmosis are example of passive transport. So, I hope you understood like a passive transport process where there is no requirement of any energy. Now, what are different type of passive transport we can think of.

right that is also very important. So, basically we have two different type of passive drops. One is simple diffusion and then second is the facilitated diffusion. As you can see the name is again coming for both cases as diffusion, right. Diffusion means diffusing in or diffusing out of the ions or molecules through their concentration gradient.

without any requirement of the energy. So, let us see what is simple diffusion. Simple diffusion is a movement from high to low concentration of the ions or molecules. Simple diffusion does not require any transport carrier or protein. In cases of facilitated diffusion you need transport carrier or protein, but for simple diffusion we do not need that is one very important component.

It is required for small and non-charged particles. So, basically simple diffusion facilitates the diffusion of the small particles and non-charged particles. What are those? Like some examples are like oxygen or carbon dioxide, these are different respiratory gases. You can see that these are non-charged and smaller in nature also. Apart from that as you know right cell membrane has this nice bilipid layer right and lipids are like non-polar in nature mostly like hydrophobic.

So, by simple diffusion lipid soluble steroids or lipid soluble drugs because they are also non-polar right. So, this type of molecules also can easily pass through by cellular membrane using the process of simple diffusion. So, mostly for noncharged small particle and lipid soluble molecules. Then what is facilitated diffusion? Facilated diffusion also happens same like simple diffusion it also happens from high to low concentration. But only difference from the simple diffusion is it requires the assistance of a channel or carrier mostly like a protein carrier or protein channel.

And in this case of acylated diffusion mostly like a charged ions like sodium, potassium, chloride. So, mostly like charged ion it helps in terms of movement of those charge ion apart from that some large molecules also, like glucose. So, I hope you understood the differences between the simple diffusion and facilitated diffusion. Next, we will go little bit deeper about the simple diffusion and try to understand how the simple diffusion work, right. So, as you

remember that our cell has this nice bilipid structure where you have like polar heads more of like hydrophilic and then you have like hydrophobic non-polar tails.

So, as these are polar in nature the charged ions will get repelled out right because the charge ions are also polar. So, generally with the simple diffusion process by the cell membrane the charge ions are unable to move or any polar molecules are unable to move. what can move oxygen right. So, oxygen is high where outside of the cell because we breathe through our lungs and consume the oxygen that got that gets supplied through our blood and then inside of the cells oxygen concentration is lower. So, from high to low oxygen can move.

Now, after the cellular respiration what it is get produced carbon dioxide right. So, carbon dioxide once it is slowly produced after the cellular respiration it get accumulates inside of the cell and the concentration gets higher. Contrary to it outside of the cells the CO2 concentration is lower. So, as you can see by a simple diffusion process, carbon dioxide can go out or emit outside of the cell. What other molecules can come inside? If you remember, we said the lipid soluble molecules like fatty acid, lipid soluble drugs, various steroid hormones because they are soluble in this non-polar area, they can easily come inside from a high concentration zone to a low concentration zone, okay.

How the rates are affected, how the rate of diffusions are affected, what are the parameter is important to kind of know. So, rate of the diffusion is dependent on the surface area that means, like as big the surface area are the rate will be proportionately higher and then the concentration gradient because through simple diffusion as you know like the molecule or ions mainly the molecules non-polar molecules they move from a high concentration to low concentration area. So, these two parameter like the surface area and the concentration gradient is the directly proportionate to the rate of diffusion. Contrary to it the thickness of the cell and the molecular weight of the substance is inversely proportional. Why? Because if the thickness of the cell is more, it will take more time, right.

If the thickness is more, it will take more time for a molecule to come in or come out. Same way, if the molecule is large. compared to a small molecule. Which one will take longer time to pass or come inside or outside? Obviously, the bigger particle right. So, I hope you understood that surface area and concentration gradient are directly proportional and it influences the increase of the rate of diffusion if surface area is more and concentration is more gradient is more contrary to a thickness of the cell and molecular weight or the size of the molecule inversely affect the rate of diffusion.

Then from the simple diffusion process where we saw right mostly the non-polar molecules and some gaseous molecules can take part in terms of movement, let us come to discuss about facilitated diffusion because there are lot of charged molecules right. We discussed like few important ions like sodium, potassium, calcium, chlorine ions, bicarbonate ions. So, how they will then come because these are kind of polar in nature and they cannot pass the cell membrane without help of a facilitated carrier or a facilitated protein channel. So, basically facilitated diffusion in this case also it is diffusion that means the ion will move from a high concentration to low concentration. So, this will maintain the molecules will move mostly the ions from high concentration to low concentration.

Because this is diffusion process, this is a passive type of transport, which ions mostly take part sodium, potassium, calcium, chloride, right. And then another important is what are different type of acylated diffusion, right. We have to know like what are different type of

acylated diffusion. For example, let us start with the leaky channel. So, by the name you can understand that cell membrane has some leaky pore.

So, this leaky pore can easily leaks out ion from one side to another side. So, these are basically protein pores, these are like channels and there are sodium leaky channels like what different type of leaky channels we have like sodium leaky channels, potassium leaky channels. So, from the outside part of this cell there are lot of like sodium leaky channel. The outside part of the cell membrane we have lot of sodium leaky channel and from the inside part we have lot of potassium leaky channel. But one thing to notice that potassium leaky channels are much higher in number compared to the sodium leaky channel.

So, I hope you understood the difference and what is the role of this leaky channel? Basically, it helps to maintain or to attain the resting membrane potential of the neuron. We will of course, discuss what is resting membrane potential, how it happens in our neuron class, but just for the time being you try to kind of keep it in your mind that sodium and potassium leaky channels are important to attain the wasting membrane potential which happens in the neuron. Next one, what is the next facilitated diffusion? It is the voltage gated channel. So, by the name you can understand that voltage influences this type of protein channels or the ion channels right. So, that means, what? That means, when a certain membrane potential or membrane voltage it attains this channels will either open or gets closed.

That means, when a certain voltage if the membrane attain, it will either open or close helping a movement of ions. Which ions? Of course, sodium. Sodium is high in where? Sodium is high outside of the cell. Sodium is low inside of the cell. So, what happens when neurons or neuronal cells has a specific membrane potential like minus 55 millivolt this channel gets open and sodium from high concentration outside it flows by a diffusion process inside where the sodium concentration is low.

Simultaneously, calcium is also high outside and low inside. So, with sodium when the channel opens, there is a chance of like calcium ion movement also that comes inside of the cell. You can see this is so important and it is also important to generate action potentials of the neuron. We will again discuss what is action potential, what is all about this different membrane potential in our neuron class, but at this point just remember that voltage gated channels are a important component of accelerated diffusion and these are controlled by the membrane potential. So, third facilitated diffusion is the ligand gated channel, the first one was leaky, the second one was the voltage one and now we will discuss about ligand gated channel.

So, you can understand, by the name this type of channel will have a ligand binding site, right. This is like a ligand binding site, whenever there is a ligand will attach to this, this will help to open the gate. So, initially the gate will be closed. Whenever a particular ligand comes and sits to this binding site, it will help to open up the channel and then ions will be flooded in or flooded out.

I hope you understood. So, ligand-gated channels are facilitated by attaching of certain For example, here we are giving an example of this acetylcholine. If acetylcholine binds with this channel, what will happen? The closed barrier will get open up causing a flooded of ions like a sodium ions. As you know, sodium is high outside and low in inside of the cells. So, whenever the influence of ligand binding happens, the sodium will flood in, okay. So, this is very important that it enters, it allows the entry of sodium ions and overall it also triggers action potential and it plays important role in neuromuscular junction and muscle contraction.

Again, when we discuss in detail about the muscle contraction and neuromuscular function, we will see how it works. The next facilitated diffusion is mechanically gated channel, this is the fourth one. Again the role is the movement of sodium ion where sodium is high outside of the cell and sodium is low inside of the cell and by the name you can understand these type of channels are pressure stimulated. That means, whenever there is a pressure mechanical stimuli these channels will be opened up allowing the ions to move from a high concentration to low concentration area without the need of any energy where these are mostly present in the pain receptor. So, whenever there is a pain or mechanical pressure this site or the this channels will get open up allowing like flooded of sodium ions.

which will send eventually the pain signals to our body because if there is a pressure point for example, if we are walking all of a sudden a rock just hit our leg if we don't generate this pain signals right in the body what will happen will not move that leg from that heavy rock it will cause further damage. So, it is so important that in cases of a certain mechanical condition it can be like heavy pressure It can be high heat also. Our body or nervous system should create a reflex action so that we feel the pain and we remove our body part from the region of pain generation. So, this type of channels which facilitates the facilitated diffusion are called mechanically gated channel.

Last but not the least, the osmosis. So, basically what is osmosis? It helps to move water molecules from high concentration to low concentration, right. You can see here the water concentration is high and here water concentration is low, but there is a catch, right. You need a specific ion concentration gradient for the salt in order to stimulate the osmosis process. So in the last few facilitated diffusion like mechanically gated, ligand gated, voltage gated, one thing you have followed that majority of those cases sodium ions here are coming inside in a regular diffusion because sodium ion is high outside and low in inside. So, you just think if continuously different type of facilitated diffusion or normal diffusion is happening and lot of sodium ions are coming inside of the cells, what will happen? Sodium ions will build up, the concentration of sodium will build up inside of the cell right and that is not good for the cell.

Because if the sodium concentration is build inside of the cells, what will happen? The water molecule will get attracted by this sodium and it will move against the concentration gradient of the sodium from outside of the cells to inside of the cells using aquaporin's type of receptor or the channel. So, basically osmosis is the process where water molecule moves against the concentration gradient of the salt. So, these are all about different examples of facilitated diffusion and the last one we will discuss is the carrier mediated facilitated diffusion. For example, there is like this receptor called GLUT receptor. What it helps? It helps for the diffusion of glucose because in terms of consuming of food eventually it breaks down to glucose.

So, glucose is high outside of the cells and glucose is low inside of the cells in normal condition and the cells require all the time the delivery or the supplement of glucose for its energy production. So, who will help for the consumption of glucose or the internalization of the glucose inside of cell this glut receptor. And then one of the important GLUT receptor you can see is the GLUT4 receptor, which is present in the adipose tissues and the muscle. Insulin, which is very important, which is produced by the pancreas and helps in the glucose homeostasis. What it does? It helps to enhance the expression or the production of GLUT4 protein, right.

So, basically insulin comes and it enhances the expression of the glut receptor and if it happens, the attachment of glucose and the internalization of glucose from outside the cells to inside cells facilitate. In this way, insulin helps to distribute an internalization of the glucose molecule to various part of our body. I hope you understood various part of facilitated and like simple type of diffusions. These are hugely important for the ion transport process to maintain cellular activity.

So I will give you a activity to do at room. Can you do something you get a bowl of water and then put some color in one side. Just add few drops of color in one side and what you will see, you see like a slow dispersion of the color from one side where we have added that ink to other side in a manner of diffusion. So you can do that simple experiment that in the water container when you add a concentrated ink in one corner it will move from high concentration area to low concentration area in process of simple diffusion because here we do not need any type of acceleration or any participation of any energy also. If you keep it in a static condition slowly slowly maybe after a minute or 2 or 5 minute The molecules will get dispersed from high to low concentration.

So, you can do that activity and let me know how it worked. Thank you again. I hope you like the ion transport class. This is the first part of course. In the next part of ion transport class, we will thoroughly discuss about the active transport where all the transport process will be controlled by the energy.

and involvement of the ATP. Thank you again, again I thank for taking this course.