Electronic Systems for Cancer Diagnosis
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Lecture – 50
Lab: Introduction to Clean Room and Cleanroom Equipments
Introduction to Equipments: Peristaltic Pump

Hello everyone, welcome to the next module on Electronic System for Cancer Diagnosis. Today let us see how to drive fluids in micro channels? Like I have already mentioned previously, when we are fabricating microfluidic chip or a bio chip, we have channels who have cross section, I mean the channel width is as small as 100 micron in length. So, how do we drive fluids in them? And why should you even drive fluids into a channel which is that small?

So, as I have already mentioned these bio chip also called as a microfluidic chip or it is even termed as lab on a chip, they mimic the biological environment. They have multiple channels in them in order to replicate the biology the physiology of the organ functionality. So, how do we control fluids in micro channels? Microfluidic flow control is one of the critical technology, which has been widely used because of the need for precise control of fluids through these micro channels; which are very low in quantity the liquid sample what you take to flow through the channels are very minimal which flows through your bio chip.

Let us say you if you want to you know in practice how what would be the how do you quantify the amount the channel dimensions? And how much is the fluid that flows through these channels? Let us quantify what is the amount of fluid which actually flows through these channels which will claim to be you know of millimetre or micrometer length scale.

So it is say you have 1 centimetre cube, how much of the fluid actually goes in 1 centimetre cube, 1 centimetre cube is like you have a 15 length 15 centimetre scale. And then you know how much is 1 centimetre and then 1 centimetre cube and when you put some liquid, how much of it goes into this cube. So, it is 1 millilitre fluid which completely when you do the volumetric conversion it is 1 millilitre fluid into this 1 centimetre cube.

So, you now that you know it is 1 millilitre fluid we are talking in terms of micro liters of fluid going into these channels. So, now, you get the point this very minimal amount of fluid flow which goes through these channels. And how can you precisely control their flow is very critical while we do analysis and while we work with these kind of biochip.

So, when I mentioned about lab on a chip, so what is lab on a chip? It is nothing but a chip which integrates the several laboratory requirements into one single chip, the multiple functionality has been integrated on just one chip. So, that is when you call lab on a chip and you analyze when we say mimicking the entire environment. So, multiple the multiple parts of your environment gets included gets integrated on one single chip.

So, on a similar basis there you even talk about organ on a chip, this is an entire body we have multiple organs. So, how could you actually mimic an organ on a chip? So, the end the functionality of an organ can be mimicked by including the various physiological, biological, chemical properties by having multiple channels. And then you could actually integrate all of them into a chip, more of this can be studied, there are vast research which talks about lab on a chip and you could check more of this stuff online.

So, now that we know what is lab on a chip and organ on a chip. So, you understand that we are driving liquids through these micro channels. So, the liquid driving mechanism becomes very important to us. So, how do you drive liquid? I am sure you have all heard of blood being pumped to various parts of the body. So, when you are talking about pumping, pump mechanism is nothing but a driving force to push the fluids, it could be liquid or gas to push fluids across the channel.

So, in our case we have these channels and we have fluids which has to be flown through these; that can be attained using micro pump the pumping mechanism. So, that they currently we have very well known the driving horses of pumping mechanism are in microfluidic devices or biochips, mostly used are the syringe pumps and the peristaltic pumps. But today we would be studying more about peristaltic pumps and how it is used in driving fluids through your device, that is the driving fluid through the channels which are engraved in your device.

So, there are a number of on chip pumping mechanism for example, in one of the modules I have spoken about PDMS molding. So, you could actually go on and check how a pump could be fabricated using a PDMS device. So, it is an on chip pump where

the entire pumping mechanism will be taken care with your design of your elastomer. So, more on this can be studied so you can go ahead and look online how a micro pump can be fabricated using PDMS

So, most important requirements for us while we have this micro channel, while we precise, if you want to precisely control fluid flowing through micro channels are we require long term stability repeatability and we should have fine control over them. So, all of this could be achieved using peristaltic pumps. So, there are two variations in peristaltic pump; one is the tube pump the other one is the hose. The hose is mostly used with they are mostly designed for high pressure pumps, the peristaltic pump what we would be using they are designed for low pressure operation.

So, the peristaltic pump has rollers on them and then they are reinforced tubes which you could actually see and we will show you, we will give you a demonstration. And how are these pumps constructed and how do they work? So, they employ rollers which squeeze through the tubes and that is how the fluid could flow and you could actually fine get a fine control over the fluid flow the rate at which they flow and the volume of fluid which goes into your device could be controlled.

So, as you increase so the number of rollers could range from two, it could go on to two rollers say a 180 degree apart or it could go on to 8 or even 12 rollers. Let us see how many rollers we have in our device which we would be demonstrating and when you what happens when you increase the number of rollers, it is the pulse frequency the amount of fluid that is being pumped is what changes. So, let us get a hands on the peristaltic pump which could be used to pump fluid through multiple channels.

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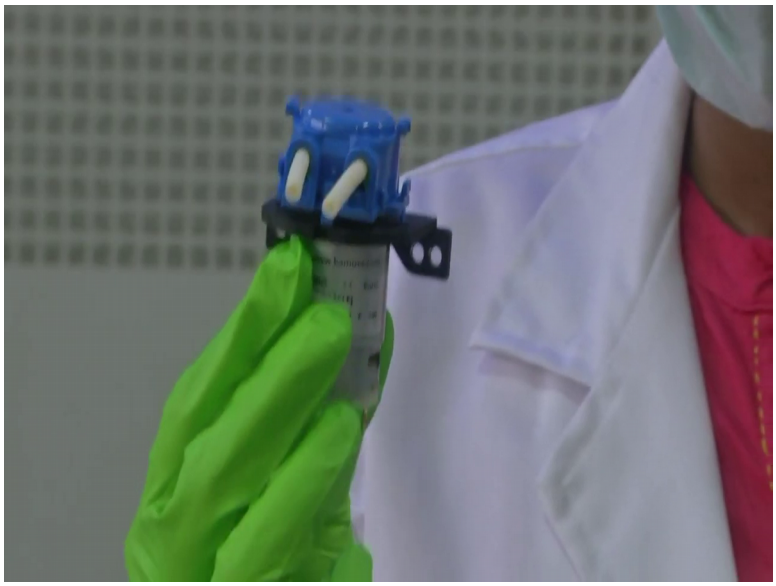

So, like I spoke about the peristaltic pump, this one in my hand is one such pump this could flow around 90 ml of fluid, let me show you part by part. So, this forms the motor part of the pump which is the driving force, and here is the casing this is the tubing through which the fluid flows in and then comes out. Let us say I remove the casing, if you could see; this if you could see this is where the motor drives in.

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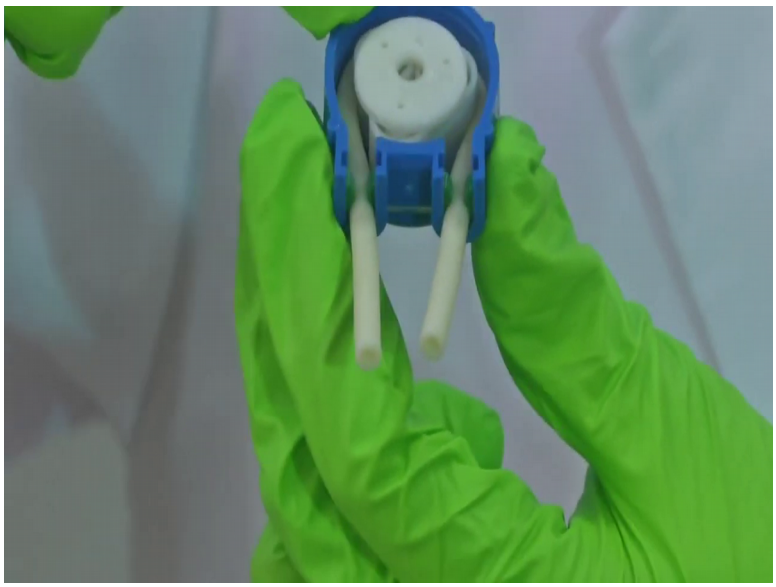

As it rotates there are three rollers in this case, like I mentioned there could be two which are 180 degree apart. And in this one there are three rollers this is 1 2 and 3. So, these

rollers push they compress the outer surface of this tube. So, here is the tube as you can see it is a relatively larger diameter than what we use for our bio chip or microfluidic devices. These thing, this cannot be used with this just for a demonstration how a peristaltic pump looks like and what goes into here what goes into the pump.

This is the tube through which fluid flows and while your motor drives each of this roller would compress the pump, it would compress it and then there is this compression there is this pulsation and as it releases the you see there is an increase in volume and then the fluid tends to move forward let me put it back. So, this was a tubing and then goes a three rollers, and then here is the outer casing.

So, this forms your peristaltic pump. Now let us see what kind of pump is used in microfluidic devices or a biochip there? You mimic the biological environment, flow different chemicals or you could flow alike you might flow a drug, test the susceptibility of a particular kind of cells test different kinds you could load in cancer cells and test how the drug works on each of this. So, let us look at how the peristaltic pump can be used in case of flowing micro flowing fluid through micro channels.

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Like we said there were two variations of peristaltic pump, which is the host pump which operate with higher operating pressures and the one what we have is the peristaltic pump, as you can see. So there are rollers inside, let us see how the peristaltic pump functions we will look into the different parts of the pump and see how we could operate them.

So, these the peristaltic pumps what we have here is also called the roller pump, because you can see there could be rollers which are inside which would put force on your tube, and then the driving mechanism happens. So, let us see how the tube has been placed inside; so as you can see here, there are 4 castles; 1 2 3 and 4.

So let us even before we turn on, let us have a look as to how the tubings are placed inside each of these cassettes? We have Suman who would be helping us. So, this is one cassette in his hand, you could see the tubing these are the silicon tubings and each of these cassette will have the tubing which would be enforced into the channels.

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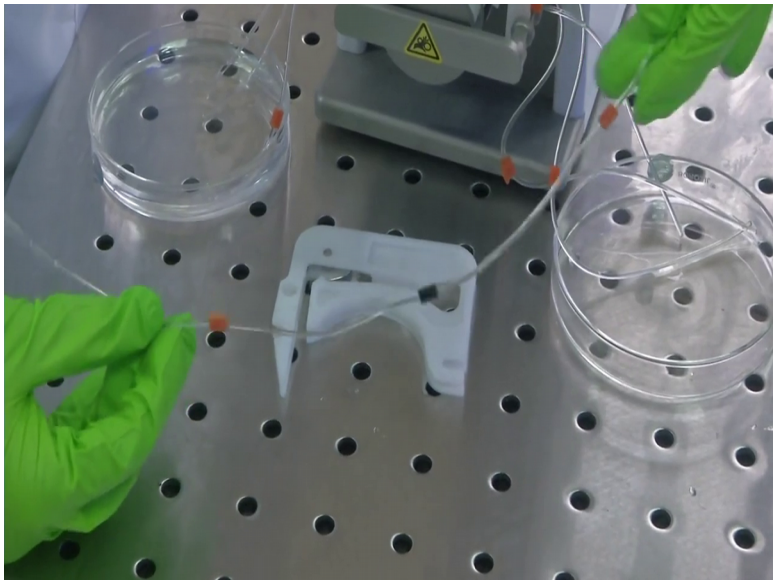

The one in his hand is the channel through which the fluid flows. Now, let us see like can you point out to the rollers? So, as Suman is pointing out we have 6 the pointing out to the rollers. So, there are 6 rollers, which triggers the entire pumping mechanism. So, it pumps the fluid through these silicon tubes. The lets you counter the diameter as you can see the silicon tube it is 1 mm outer diameter; however, the inner diameter is very small it is around 0.12 millimetre; which is very small it is like a pin hole, and then the fluid flows through these 0.12 mm channel, inner diameter channel.

So, this tube is tensioned between the tubing bed and the rotor. So, this is the rotor this is the tubing bed and then we have the rotor which goes which actually drives this rotor is this way; and the rotor drives and then this forms the tubing bed. Now each of these rollers will compress the fluid as the road as each of these rollers move they compress

they form a compressing action on the tube. The tube will be squeezed continuously through the roller and displaced the liquid in the direction in which the roller head is moving, say this roller head moves in this direction clockwise direction.

So, your fluid will be displaced in this direction say clockwise direction. It also depends on which direction your motor is rotating and once you say this is the tube. So, let us say we put the tube into the cassette and then place it on the rollers.

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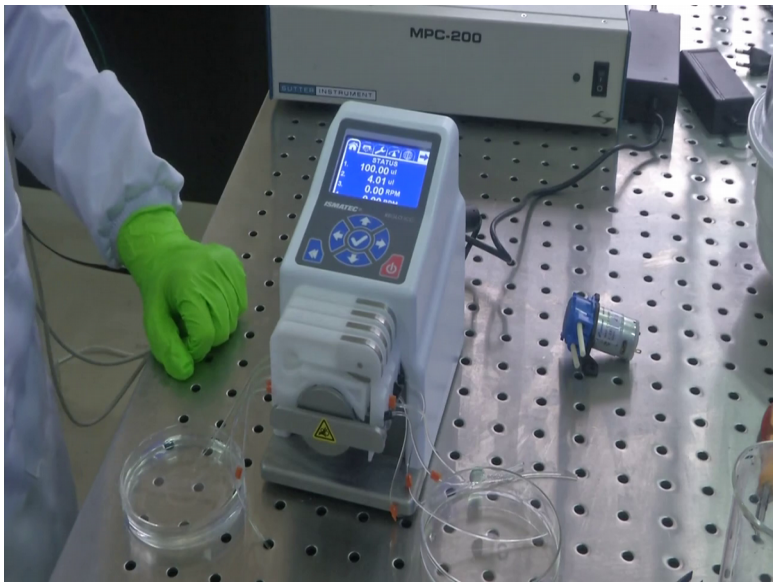

So, as it goes into the casing as you can see, the tube which rests on these rollers and then between the two rollers there is a gap, and as the roller resumes the part of the tube which is behind the roller this if this phases the compression force; the one which is on the roller. And the one which comes between the two rollers as it moves towards phase is compressed and there and then it resumes the shape as it goes away from the roller.

So, as it moves from this point to this point, it relaxes it resumes its original shape comes back to the original diameter and the compression is on the roller point. So, that this creates a vacuum and suctions the liquid. And then the entire process repeats. So, this is more like a positive displacement pump. So, it pumps the fluid you know in the in terms of fluid out in the direction in which the roller rotates.

The now you can see these they do not have valve or seal. So, this is a very inexpensive you know pump and it permits easy flow of solids and viscous lick and viscous media.

So, let us see how each of this functions. So, as we can see there is a digital display for us a user interface and let us see how to operate this pump. So, say we turn on the pump, so now we know that there are 4 cassettes 1 2 3 and 4 here with 4 channels on one side they are parallel channels.

As you can see the digital display the first is the home, and then the second talks about the configuration of the cassette. It tells how much microliter and the RPM in which it is running. So, this is telling say the symbol what is on the left side is rotating the clockwise. So, the first cassette would rotate in clockwise direction; and what is the amount of volume the fluid it draws? It is 100 micro litre and per second. So, 100 micro litre per second fluid will be drawn through this tubing.

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This is the configuration in the first cassette which is this one so what are the other options available and then we have the settings and. This is a settings option and then when you is now as you can see he is moved to the second cassette. So, that is running at 4 micro litre per minute. And at what direction you could see it is running in the clockwise direction and we will also show you how you could change the RPM. The rotations per minute and you could even control the amount of fluid which flows and even the time. So, let us say this is my second cassette, and now currently this 4 micro litre per minute.

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Say I want to and this is running at 100 RPM say I would like to change the RPM. Now it is at 100 RPM and then I will reduce. So, like I showed you could change the rotation that is rotating at anti clockwise direction. And now from 100 RPM say I will reduce it to 50 RPM 50 revolutions per minute and the direction is in the anti clockwise direction.

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So, let us see what is the 4th channel? So, the 4th is set at 100 RPM and it is set at clockwise direction. Now let us run and see how the rollers rotate. So, as you can see channel 3 the cassette 3 is rotating in the anti clockwise and the 4th one in the clockwise

direction and the relative change in speed can also be observed as you could observe the variations now. Let us see what are the other configurations we can do? So, let us stop and then do the other configurations.

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Now, as you can see the cassette 4 now we are in volume, you can even change. So, let us say we do the volume per time settings. So, let us say we will drive around 2 micro litre fluid. So, we set it to around 2 micro litre per of 2 micro litre say for 5 seconds because the time is 2 micro litres very small amount of fluid. So, let us say we increase their time to around 5 seconds.

Now, let us see how is this is the 4th cassette configuration which is running at 2 micro litres per five seconds. So, say we have taken a Petri dish with water. And let us see how the fluid flows so this is the clockwise direction we have some amount of fluid in the Petri dish here, and this is the fourth one.

So, let us fix the 4th cassette and also let us fix the third cassette. So, this entire pumping mechanism, you know the compression and the decompressing of the tubing it is to allow force to fluid to flow from one direction to the other. As you can see this working is very much similar to how our body pumps blood nutrition and oxygen. And this is why we are using this mechanism when we are mimicking the entire bio environment the physiology the chemistry and the biology on to our bio chip. And hence using these pumping

mechanism becomes very important and controlling the amount of fluid which flows through them becomes vital for the accurate functioning of our device.

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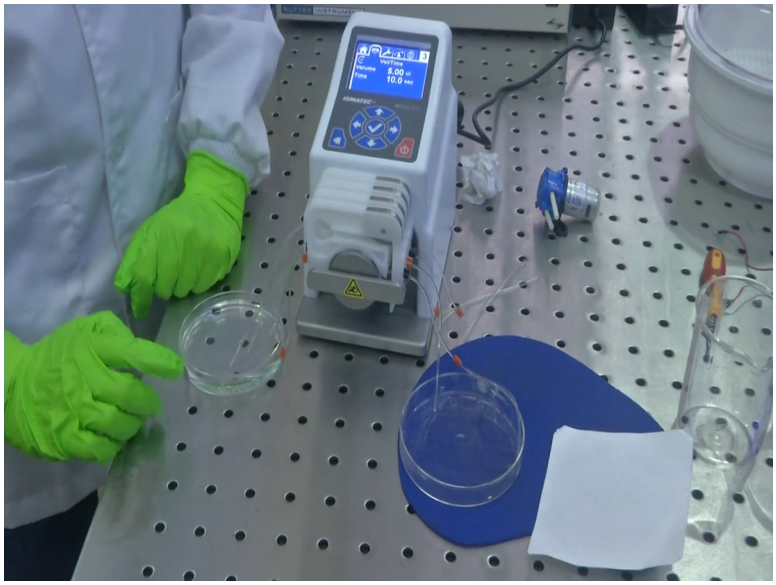

So, let us say in cassette 4 we are driving 40 micro litres of fluid and let us say said this time to around a minute say 60 seconds. So, we will flow 50 micro litres per minute. So, that it becomes easy for us to visually see how the fluid flows.

This is volume contained this is your volume this is your time. If this is 28 seconds; that means, till 28 second it will flow only this much.

[FL] in that time.

Between may be 10 seconds or even 5 seconds; 5 second or 50 micro litre then within 10 seconds we will get something here.

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So, that is the thing I am looking.

I think that is very much that is too high, you can actually put only 20 micro litre for say 5 seconds.

20 micro litre 5 seconds.

I have seen that.

He put 4 micro litre in 3 seconds.

What is the flow rate?

This thing I am not holding it water is also not possible.

We will check check we can change the RPM then

Change the time into 3 ok, stand. Let us see now we are in cassette 3 clockwise direction, and the volume is set at 5 micro litre which will flow for 10 seconds. 5 micro litre of fluid flows for 10 seconds. So, we use observe where is the source and then we have the sink. So, we have taken some DI water and let us see, in 10 seconds 5 micro litre of fluid should be flown from the source into the sink in the clockwise direction. Let us see the other setting as you can see this droplets, let us check what is the setting in the 4th cassette.

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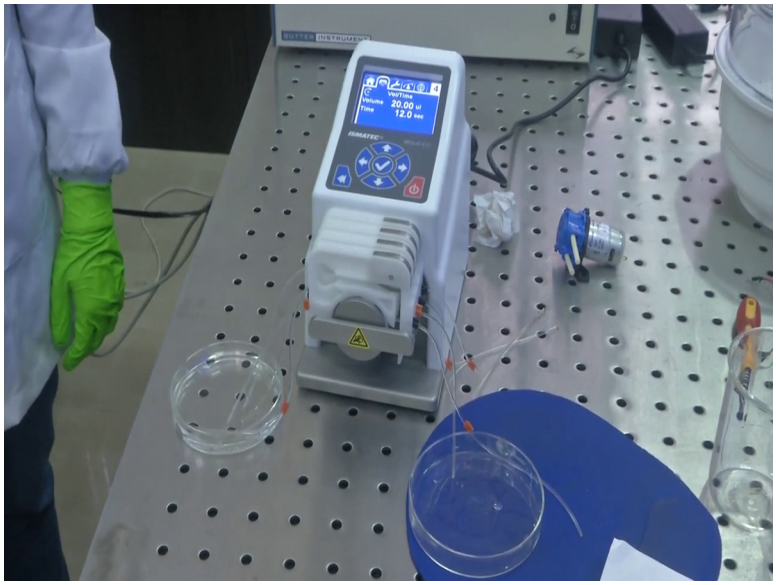

So, this is 20 micro litres so this is a higher volume. 20 micro litre of fluid should flow across the source to the sink in 12 seconds the one in Sumans hand is he is holding the 4th channel and then the other one is the third channel.

So, let us see 12 seconds there should be 20 micro litre of fluid which has flown across the 4th channel. So, and now that you have seen we have done the setting. So, in the

third cassette will have some 5 micro litre of fluid and the 4th one is 20 micro litre fluid. As you can clearly observe the volume of fluid which is coming out of the channel here as you can see this is.

4th channel.

4th channel with a higher volume and the time what we set is very small like we have just set it for 5 seconds and 12 seconds which is very small. But you could set the timing and you could relatively get your hands on the device. So, now that you have got the idea about the functioning of the peristaltic pump how you can change the volume? You can change the time, you could change the direction of rotation and there is another feature you could actually flow the fluid pause it for some time and then again continue.

So, we are on the 4th cassette and you could change now we have set the volume and time. So, this is at the volume setting. So, let us see if we could change so this is the time and this is volume plus pause.

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So, when you get into this option you could control the rate at which it is rotating you could control the amount of volume you could pause it. So, so there is 20 micro litre you could every time it flows through the times there is a pause of 2 seconds and then you can set the number of cycles.

So, like we said it repeats the flow repeats. So, you could set the repetition rate. So, this is your cycle which can be set. So, these are the features through which you can work on and then accurately control, precisely control the amount of fluid flow through multiple channels across your device. So, this was the hands on experience on the peristaltic pump that is it for today.

Thank you.