Nanobio Technology Enabled Point-of-Care Devices
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Lecture - 01
Introduction

Students, hope you are very well. So, today I will start the first class on Nanobio Technology Enabled Point-of-Care. So, mainly today I will cover the basic Introduction spot on nanobio technology point of things care devices. So, why this technology is very important for the disease diagnosis and in also in the current scenario why this technology is really important for you that I will cover first.

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So, let us come to the syllabus or the topics that I will cover during the whole courses. So, mainly I will cover in the introductions of the basics point of care diagnosis, then it is

analytical parameters for biological applications and then I will cover all the diagnostic aspects and how all the biological molecules and nanomaterial they are interact and they are used for the diagnosis that I will also cover here.

Then I shall cover the nanomaterials and their fundamental concept, their synthesis, how they can be useful they can be used for diagnosis and then I will cover the basic tools for the diagnosis. Basic tools means, the technology the technique that we will use for detections of the sensors detections of the biomolecules that I will cover here.

Also, next I will cover the signal amplification signal amplification really is very important part for this nanobio science of this course. Because you know the main concept for this course is the early diagnosis. So, if you want to detect the disease at the very early level, then signal amplification is really important.

Because suppose you have some disease marker in our some blood samples or in the saliva samples on the even sample very very low level and all it can cause the disease although in the very early condition we should detect them, but if you cannot amplify the signal because and if your device cannot detect at the very low level then it is very difficult to go for some decisions at the very beginning.

So, suppose for the cancer and if you cannot detect the early stage and if you detect the end stage. So, although we know that yes this marker is present, but as it is a high concentration doctor may say go for therapy to process, but it is difficult to save the patient live that and at that time. So, detections of the disease early stage is really important that we will focus mainly here.

How we can develop a sensor device that can detect the very very low level? So, that is called ultra-sensitive way what means ultra-sensitive biosensor we will develop. So, that is a signal amplification is really important and for how we can amplify? Different kind of chemistry we will employ here I mean that is called signal to background ratio. So, that I will describe what is the signal what is the background.

So, that we will describe and we will use some redox cycling you can see here this redox cycling technology method. So, this is really important for the signal amplification. So, here we will use some amplification technology based on some chemistry also we need some electrode surface modifications with some nanomaterial.

Because in this course nanomaterial will be used always for surface modification. As I mentioned that synthesis of different kind of nano particle is really important that all the technology I will teach you in this course, it is very very important part of this course. Then how this nanomaterial can be used for the device development that is also very important part.

Because nanomaterial is unique property, they have very high surface coverage that surface coverage can be useful for different biomolecule immobilization on the sensor surface and this can help for increase the conductivity, increase the surface area, we can easily miniaturize the sensor that is why use the nanomaterial is very important.

Then I will come the lab on a chip devices. So, what is the lab on a chip? So, that also I will describe. Lab on a chip concept is very useful for miniaturize of any device we generally you can see in the lab we are using very sophisticated instruments very large instrument, but it is very difficult to use those instrument for point of care. So, what is point of care? Point of care means near the patient you are using your diagnostic method.

Suppose, in the lab we need a very bulky instrument that is very expensive, but special for the developing countries use this kind of the very expensive method of protocol is really difficult. So, point of care means at the same time we have to think about the cost effectiveness. So, it should be near to the patient at the same time cost effectiveness that also will cover in the lab on a chip I mean all the lab concept we will bring to a very small chip and that chip can be used near the patients.

So, I will give you some example, I will show you some device kind lab on a chip things then multiplex diagnostics I will cover this is very very important part of the multiplex diagnostics

because see one patients may come to the doctor. So, he has some disease like maybe some conditions doctor can find it yes, it has some disease there is may be. So, other disease also can affect in his or her health conditions.

So, not only the one disease marker at the same time we may we should detect the multiple disease marker to take the a final decision. So, doctors can only take the decisions if he can detect the multiple analyte. So, like at the rainy seasons you come to a doctors with some fever. So, it may be bacterial or you may be viral fever or you may be something else.

So, doctor should detect not only the bacterial it should detect the symptom of viral also may be is Dengue or may Malaria right. So, which one we do not know. Also, if I some other can may cause may be you know during this COVID time. So, may be due to the COVID. So, we should go for the COVID diagnosis also. So, that is why at the same sample may we can detect the multiple disease at the same time that is called the multiplex diagnosis that is very very important to the final decision to a doctors.

Then we I will cover different kind of the non-invasive invasive approach; you know you know the detection of the glucose. So, glucose generally we are detecting the pricking the finger taking the just drop of the blood and putting in the on a chip, but this pricking the finger is called the invasive.

Because it is painful we can go for some non-invasive approach also non-invasive means without pricking any finger without taking the blood samples like saliva samples, urine samples, sweat samples they are the non-invasive approach those technique also we can use.

So, these all the techniques how these kind of the samples we can use. So, then you can ask me the questions that the why then people like the blood sample? Yes, the blood sample is a very good sample that because this is directly we can get so, many analyte in the blood and their concentrations is very much related.

I mean you can easily predict the disease level, but there is always some correlations with your saliva biomarker with your blood biomarker or maybe sweat biomarker with your blood

biomarker there is some correlations already present. So, that is why even blood is a good sample, but still, we can use the sweat sample saliva sample urine sample there is some correlations that I will describe during the class.

And that non invasive approach will very very beneficially useful for point of side applications because no need to we need some specialized person to take the blood. But common people for point of care diagnosis you can easily they can take the saliva urine sample they can easily collect the sample collection is not a big issue that is why non invasive is very important for point of care device development ok.

So, then we will come to the printed bioelectronics. So, print why the printed bioelectronics is really important for the point of care? Because we can use like a banded kind of things like flexible printed sensor, you can print the sensors even on your skin some patch kind of the sensor we can develop that can continuously it can monitor like whole day it can monitor the biomarker level like on your sweat example.

So, that is why printed sensor also very much useful for the point of care device development that I will cover also. Then some new detection technique there are although so, many detection techniques already available in the market, but still we need some new detection technique because you see during the COVID time like some new disease may come.

And how easily we can detect them when how patient easily can handle them you know many technique is already available, but in the market we can see very very less number of the device available. So, the why because there is some difficulty people are facing when they are commercializing their device.

So, we need anyway some protocol or some technique that is very useful for end user. So, end user means like you may like we can use in the like you know our home like just take the saliva sample and test it within a few minute you see the level of biomarker even we can use your smartphone we can see the value like digital value this much biomarker present right.

So, this is new detection protocol we need and we can easily. So, that this protocol or this technique you can easily integrate with our mobile device see like everyone has the mobile phone. So, if we can easily integrate our sensor like there is a you can see here is a some always like charging point. So, if we can like I can show you some chip so, ok.

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See we can develop like this kind of printed chip. So, see there is a connector say in your smartphone there is a charging point if you can easily see connect here like this. Then we can develop some app here in the smartphone. Now with this app we can control like your chip and here on the chip in the sensor surface.

Now you can drop some sample here and there is some chemical and sample chemical then will start reactions and it will generate some electron, there electron transfer through this chip

and easily we can detect and we can show on your device screen. This digital value you can see. So, that is it is see it is very miniaturized very small device.

So, this kind of electrode this is called the electrode printed electrode, we can easily develop we can use for the disease diagnosis. See this is very small and it can be easily means very miniaturized and near patient it can be handle easily. This is one simple technique that I will cover during the whole class. So, next part I will cover mainly device commercialization ok.

Device commercializations as I said there is many technique available you can see lots of publications. But why all the technique is not in the market there is certain challenges exist right. So, that challenges I will address and then also I will address how we can overcome those challenges and we can bring those technique in the market that is called commercialization possible how we can easily you can bring to the market that is really important part of this. So, this course that is why it is not only the theoretical.

So, I will teach you some practical based some lab course lab class also I will take at the end of this course and I will tell you how easily you can fabricate all the biological part and then nanomaterial part on the sensor surface and then a miniature system you can develop and how these systems you can easily bring to the market.

We are some of you are really you are you want to start your career like you want to start some startup or something your own company right. So, this is a really important part in the biomedical device development. So, this kind of new technology you can think and you can simple way you can develop some device and if it is really useful for end user you can bring to the market just for one example like glucometer.

So, it is see huge market it has because it is very simple method and just drop up the blood and see and you can detect the glucose, I think nowadays everyone every home they have one glucometer. Because it is now not that much expensive at the same time it is user friendly.

So, similar kind of device if you can develop and you can if you can easily commercialize it will really impact not only for your own career at the same time it is good for your society

right you develop some technique that is useful for common people. And again, I will discuss some biosensor device that can be useful for environmental monitoring.

So, not only the disease this kind of device can be useful for onsite for field testing like a health can be our health there is a different kind of issue can be possible because of water contaminations right like arsenic lead this can heavy material. So, can contaminate the water it can also impact our health.

So, this is a health related right if you can measure the arsenic level lead this kind of level in a drinking water or even in the soil that will be huge impact right. So, that is how you can I will show you some sensor development that can be useful for also at the same time environmental monitoring that can be useful for field testing also the food safety. So, we are taking the food that food may not be the good condition right.

So, how you can determine the food quality that is also directly related to your health. So, you have to determine the food quality that sensor also we can develop and the say and finally, security means, you know like bio terrorism can some can happen any time or so, some this some molecules maybe in your environment or during the terrorism attack maybe some biomolecules, they can spread and that can effect on your health.

So, this kind of biomolecules also different molecules we can detect from different different samples even in the water or some other samples also you can collect and we can use this for security purpose. Even in the alcohol detection that is also useful for different security purpose we can check that I will cover it ok.

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Now, come to the main keywords for this basic course that I will cover. So, main is the nanobiosensors means why is the nanobiosensors. So, what is the biosensors? That I will teach you today and what why it is called nanobiosensors that I am going to tell you in the next slide. Now point of care. So, point of care means, the near the patients how you can use a technology that you are developing in your lab near that can be useful in for patient near the patients this is something called the bench to bedside applications.

So, point of care application sometimes its called bench to bedside. Bench means, in the lab what you are developing that you can bring to the near the patients. Then lab on chip this is a very fundamental and very important part for this course means all the lab technology you will bring on a single chip like I told you like single chip that I showed you this kind of single chip.

So, there you can bring then smartphone based sensor like this kind of chip you can easily integrate with a smartphone because many people now everyone has the smartphone right. So, how you can easily if you can develop some sensor if you can easily integrate those sensor with your smartphone, then easily you can use that is a smartphone based platform is very important then finally, commercializations of the device ok.

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Let us start the current medical conditions this is the very important part of this course this is a very basic introductions now I am going to tell you that what is the current medical conditions and its diagnosis. So, you know there are many kind of disease now like HIV, Malaria, Tuberculosis this is the very common disease nowadays and recently I think you know like a SARS, CoV-2, this COVID-19 this times we really want to detect like this kind of virus.

And then this if you can detect this kind of virus very easily for point of care setting it is really important and very you it will be very useful. So, that we can stop the spreading this this SARS, CoV-2 right. So, if you can; if you can yourself sometime people actually worry to go to the hospital and go for the diagnosis for SARS, CoV -2 right.

But if you have their own like device in their home they can easily detect and they can tell their family members yes, I am affected. So, I can keep myself in the quarantine in the separate place. So, that this virus will not be spread among our family member at least at least among my society.

So, this kind of some decision you can take right and different chronic disease like diabetes, obesity is very very common nowadays. So, this kind of medical condition if you see like almost in our in if you think of India also I think people are almost many people they are affected in this diagnosis this kind of disease and we need some certain diagnosis so, that at the very early stage we can take some decisions.

But the what is the problem in this current stage? If you go for and if you ask the doctor sir I want to go for this diagnosis all that disease, then they will collect the sample what sample mainly they are collecting the blood and then they will send to the laboratory mainly laboratory base like this kind of like very highly expensive and big instruments they are using right and this diagnosis protocol or method is very very laborious.

Because first they will process their your blood sample they will they will separate the blood cells they will collect the serum then from the serum sample they need some time the pre-processing they for the some pre-processing some time it is very expensive they are using many chemicals.

And this kind of sample handling some time we need the very large volume of the samples like collecting very large volume of the blood samples and also it is very time consuming process because some trained personnel they need, they will handle your samples. And they will use this kind of expensive instruments and they will incubate your samples and it may

take longer time around more than sometime few hours that is you have to wait maybe at least one day sometime to get your diagnostic report.

Sometimes, it is very urgent because you wanted to see is in that value this diagnostic value like within a minute because you have to in a critical condition this thing with ICU in a critical conditions, you have to know you should know this value immediately. But this diagnostic method is taking too much time it is something difficult to save the patient life that is why.

And always we need the trained personnel and complex set up we are using and there is a lack of miniaturization because this is the bulk instrument we cannot use near the patient. So, we need some special setup and no onsite this kind of setting we cannot bring to the bring onsite near field testings this is the problem we have. So, we need to solve these all the problem. So, that how we can solve that I will discuss.

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That problem we can solve using one very important tools that is called biosensors. So, then what is the biosensors? So, biosensors is a analytical device with one or more biologic recognition element just see biologic recognition element we are using there is a very very specific biologic recognition element we are using that can detect the certain target analyte of interest.

So, biosensors is a technology that can help to detect some certain molecules and we can easily we can make very small device and user friendly device by using the biosensor technology. So, I just last slide I discussed so, many problem that all the problems can be addressed can be solved by using this technology. So, let us come. So, biosensors I told you different kind of bio recognition element generally we are using in the biosensor what is the bio recognition element?

Like antibody, like peptide, like aptamer, enzyme, DNA, RNA this kind of bio recognition element we can use. So, you know the antibody they are very much specific if you have some this is like malaria. So, we can use some malaria specific antibody and that can target on your malaria antigen only in your sample and we can detect those. So, this is called the bioreceptor or bio recognition element they will capture your disease marker. So, I will come slowly one by one.

But in my whole course. So, not all see they all are the recognition element, but for example, mainly I will use the antibody. So, this antibody I will use just for as a example this receptor on the biosensor surface by anything you can immobilize on the sensor surface to detect the disease ok.

See here in the right side the application of the biosensors just I have covered, it can be useful for the disease diagnosis, water monitoring, toxin detections, drug discovery, it can be useful for environmental monitoring. So, there is lots of applications we have in the biosensors. Now come to the left side in this slide you can see the for the development of biosensors some schematic I we have drawn here. So, we need some part development for this biosensors one is the transducer.

So, transducers just a surface, it can transform your one energy like chemical energy to the output energy like the electrical energy. So, on this transducers in my biosensor part I will teach you transducer just a electrode surface because I will cover mainly the electrochemical biosensors here what is electrochemical biosensors? Just I am coming.

So, transducers is just a surface where we will immobilize this kind of bio recognition this all the bio kind of bio recognition element we will immobilize on the transducers surface. Then we will drop the sample and this sample will come to the antibodies or peptide this bioreceptor on the surface then it will be; it will be I can say that at absorb on the surface means they will target the your biomarker.

Then we can apply some chemical here and that chemical reactions we can convert to a signal and like the in the form of current in the form of some charge you can see in the display. So, that current or charge we can amplify there is a some processor amplifier then finally, we need display like this mobile phone there is a display here you can see the data some value.

So, there is different kind of biosensors available kind of biosensor like electrochemical biosensor, calorimetric biosensor, mass biosensor, thermometric biosensors.So, electrochemical means there is a change of the electrochemical signal means, we can we can may use some chemicals on the transducers in this surface then it will convert that signal to the electrochemical output like charge or current.

Colorimetric means color change mass biosensors means there is change of mass on the sensor surface and thermometric biosensors thermometric biosensors means there is change of the temperature. So, there is a lots of this kind of technology we can use. But among those all the technology we will use the electrochemical biosensor mainly. So, why mainly electrochemical part I will cover here?

Because it is very simple technique and it is sensitive technique it is we can easily miniaturize and it is very affordable technique that is why mainly I will cover the electrochemical part and also, we can develop like smartphone based platform so, that we do not need any specialized any persons we do not need any specialized equipment, we do not need any local reagent and we can go for multiple detections.

So, this is the main driving force of this course that we can bring the rapid test method convenient near immediate near proximity to the patients right ok.

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So, this is the some references in this introductions part you can check and in the next class then I will cover the lab on a chip or lab on a PCB technology that will be very much useful to bring the all the lab setup that I taught you on a chip that I will cover in the next class.

Thanks, thank you all.