Design for Biosecurity

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Lecture 21

Monoclonal Antibody

So, welcome back to the lecture series once again. So we are starting the fifth week. So last week, we talked in depth about the AFM setup, how AFM setup is coupled with electrochemistry setup, and how these emerging integrated tools are changing the face of biosensing. In the last class, I highlighted one point: modern biosensing research is much of a multimodal deal. That means multiple detection techniques are coupled into one single device. So, in one device, you will have microscopy, antibody labelling, electrochemistry, techniques like AFM, surface plasma on resonance, and techniques like fudge display.

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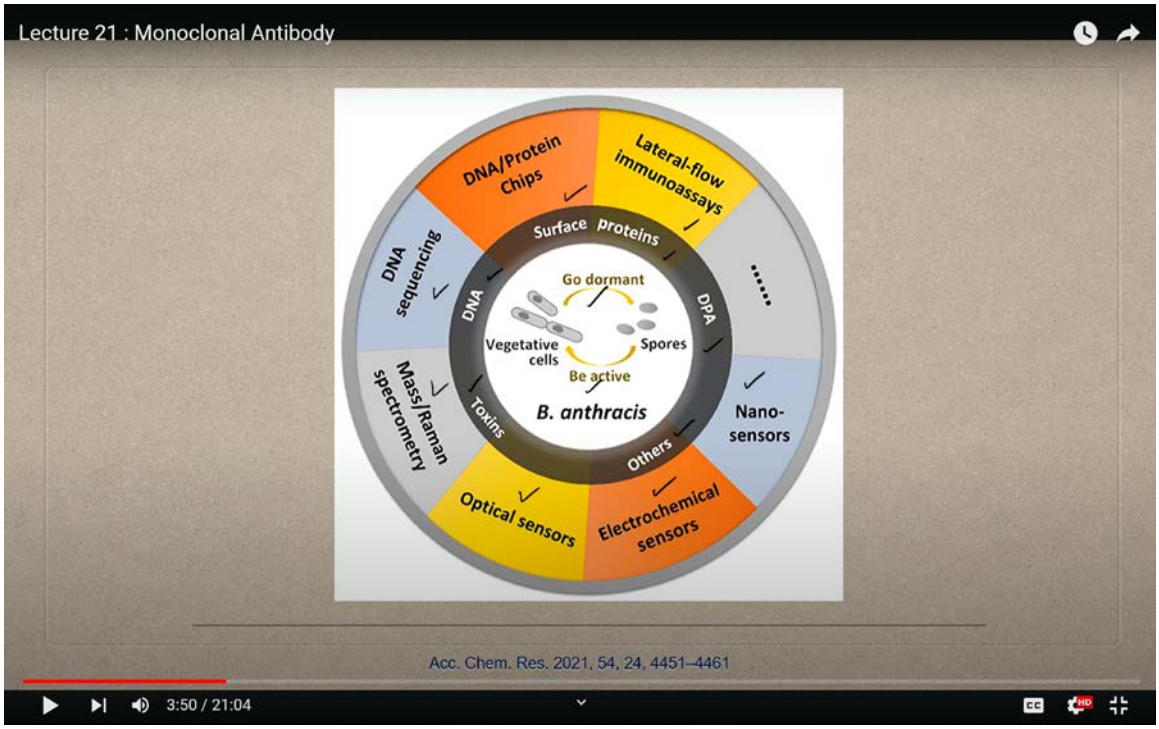

So, instead of doing or performing these operations in individual units, the trend is changing. The change in the trend of multimodal devices or setups depends on the amount of analyte. The sample size is minimal, so you cannot afford to waste it. So that's why the extremely low titer many of these technologies are now very integrated multimodal technologies and when.

Whenever multiple techniques are combined in one platform, you always have an issue of extreme noise because every modality brings its own set of noises and one set of signal-to-noise ratio into the system. Apart from that, in order to understand the systems, you have to have a complete understanding of multiple techniques in one platform. So, more and more this whole field is a huge design endeavor of individuals with varied expertise and technical know-how. So, with this small brief, I will start this fifth week from lectures 21 to 25. Coming back to this circular map, what I have been showing from the beginning, you see that what we are detecting is in the centre.

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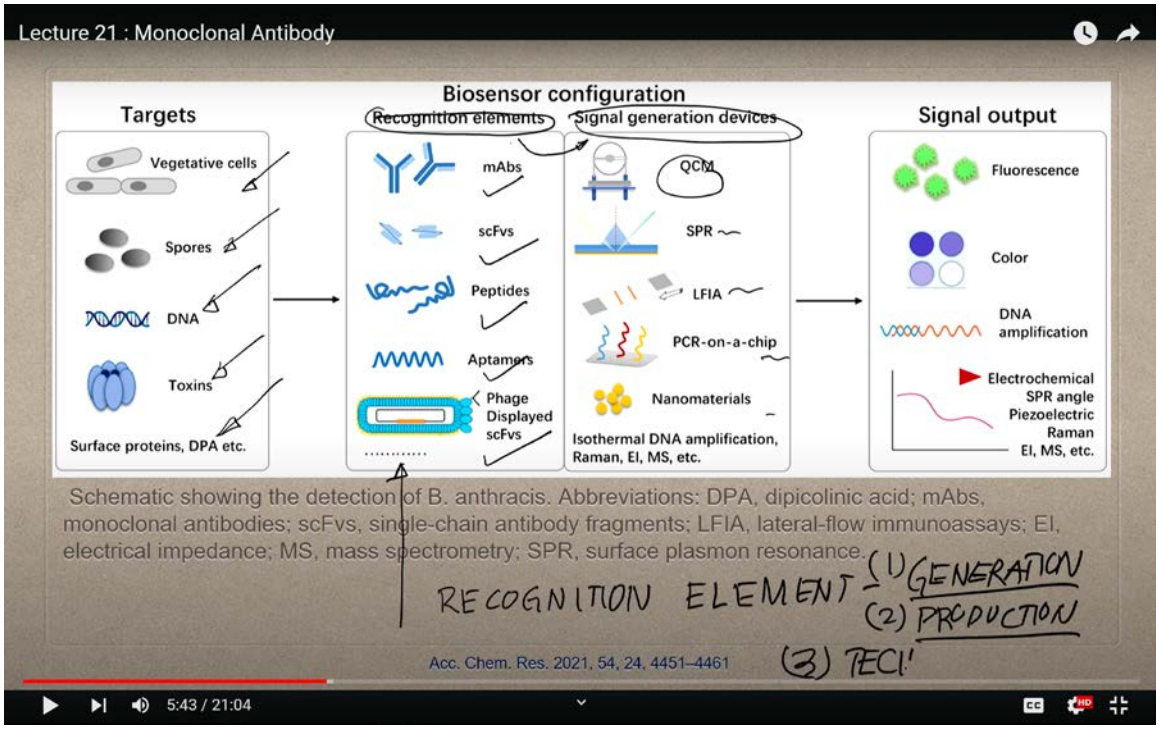

It could be in a different form. It could be vegetative form or spores form. They could go dormant, or they could be active. And there are features on them. They could have toxins.

DNA, surface proteins, DPA, and others. And then, you have different ways of detecting them on the outer periphery. So lateral flow immunoassay, which you'll be studying this week, nanosensors, electrochemical sensors, optical sensors, mass and Raman spectroscopy, DNA sequencing, and DNA protein chips. Now, when we break up this diagram, it is something like this. You have these targets.

These are the targets that you have to detect. So, the vegetative cells or the spores or the fragment of DNA or the toxins or the surface proteins or DNA. So, this is the second circle that we are talking about. Now, regarding the biosensor configuration, these recognition elements and signal generation devices exist. So, it is the recognition element that is being recognized, and it generates a signal.

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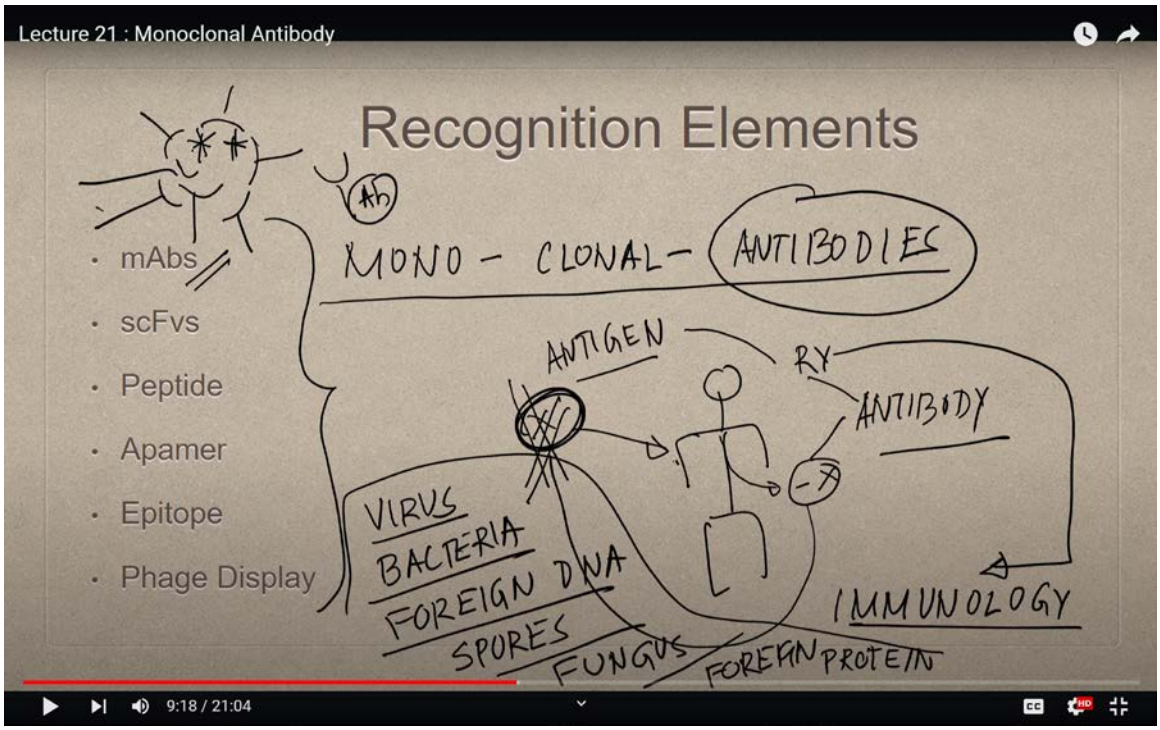

The recognition elements are monoclonal antibodies, single-chain antibodies, peptides, aptamers, and fast display techniques. Now, while proceeding with some of these

techniques like SCM, and of course, I'll be proceeding with SPR, LFIA, and eventually PCR on a chip, nanomaterials. I touched upon some of these recognition elements but haven't touched upon an in-depth understanding of this recognition element. So this week, a part of it will be devoted to how these different recognition elements are generated, the Generation of recognition element and their mass production and the technologies involved in their production. So, regarding the recognition element, These are monoclonal antibodies, which we'll discuss in the first one.

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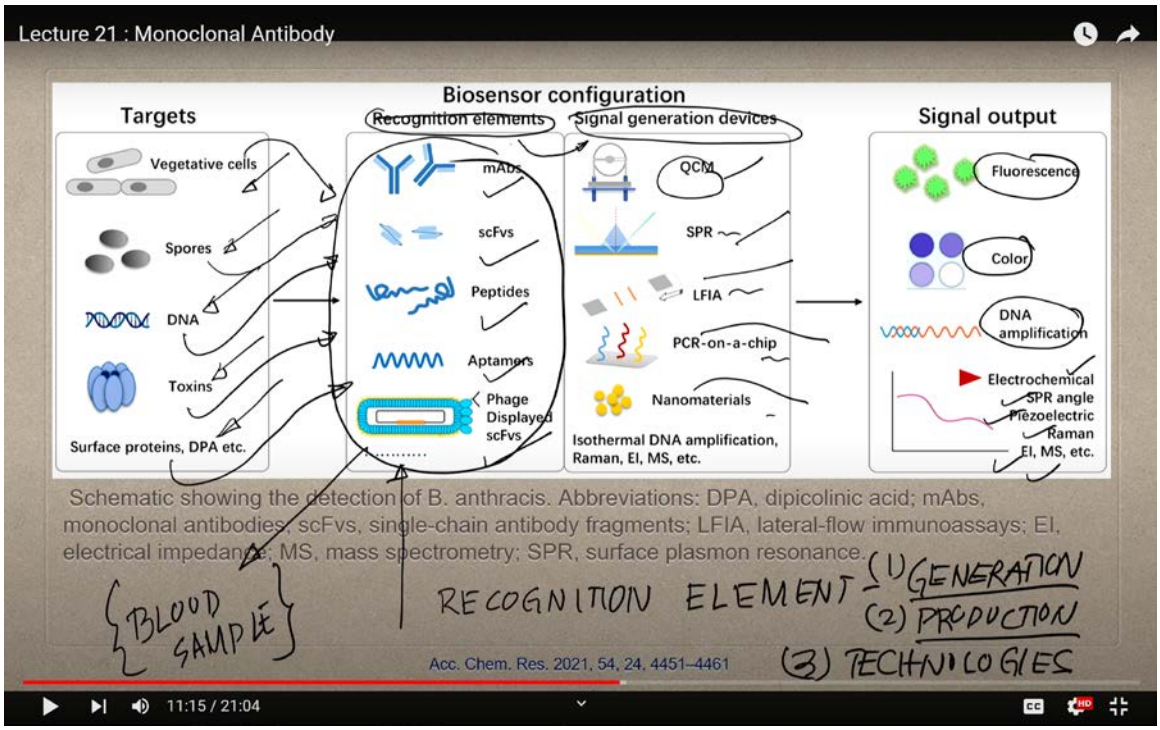

As the name indicates, mono means single, and clonal means a clonally produced monoclonal antibody. For those of you who are not from a biology background or coming from other backgrounds where you haven't heard this word, So first, what you have to understand is antibodies. What are antibodies? So whenever there is a foreign element that enters your body, the body has the capability to distinguish between its own and what is not its own. So when a foreign element is not part of the body, it generates an array of proteins that try to capture this foreign material. So, it's something like a foreign element, say x, inserted into the body.

So, what this individual will do to counter x is produce from its own body something called minus x. So, this minus x is going to nullify this x. So, this minus x, generated by your own body, is called an antibody. And this x, injected or got into your body, is called antigen. And this whole orchestra of antigen-antibody reactions is the whole field of immunology.

Now, when we are talking about any pathogen entering your body, be it a virus, be it a bacteria, be it foreign DNA, be it spores, be it a fungus, or a foreign protein, the body will generate antibodies against all of them. And these antibodies are very, very specific. And some of the ways this antibody works, so say for example, this asterisk shows your foreign material. So what will happen is these antibodies will come close to them, and they will surround them like this. So, this white thing that I'm drawing is the antibody AB.

They will nullify these antigens and clear up your body. So when the body fights, it is basically against some pathogen. It is the antibodies in your body that are fighting against the antigen. So, to prevent you from any kind of disease, starting from cancer to a bioterrorist agent, the body will be producing antibodies. And these antibodies, now if you look at the charts, are those recognition elements.

Because corresponding to a spore, corresponding to a vegetative cell of the pathogen, corresponding to a DNA, corresponding to a toxin, corresponding to a surface protein or a DPA, the body produces an extremely specific set of molecules or antibodies. So, if you know the antibodies, you can take a blood sample. If you know the antibodies being generated against it, you will be able to detect whether this pathogen is present in the sample. This is how this whole thing works. To detect, you have all these different signal generation devices, including coarse crystal microbalance, surface plasma on resonance, LFIA, PCR on a chip, nanomaterials, and, of course, the signals could be in the form of fluorescent signature, colour, DNA amplification, electrochemical signature, SPR angle, piezoelectric, Raman and EIMS, etcetera, and all these other techniques.

So, you understand it is a very integrated approach. So, if you do not know about antibodies, it will be very challenging for you to understand the whole concept of what we are going to talk about. Now, what are monoclonal antibodies? Now, next thing. So, in terms of definition, we talk about monoclonal antibodies, also called MO, that is,

monoclonals and ABS, antibodies or MABs. In short, these are the short forms of proteins made in laboratories that act like proteins called antibodies in our bodies.

Antibodies are part of your immune system, as I mentioned earlier. They seek out antigens or foreign materials and stick to them to destroy them. Regarding sticking to them, is this reaction what I was showing you? So, for example, these are the antigens. Then, the antibodies will surround them like this. They will locate them in your body and flow in the blood vessels.

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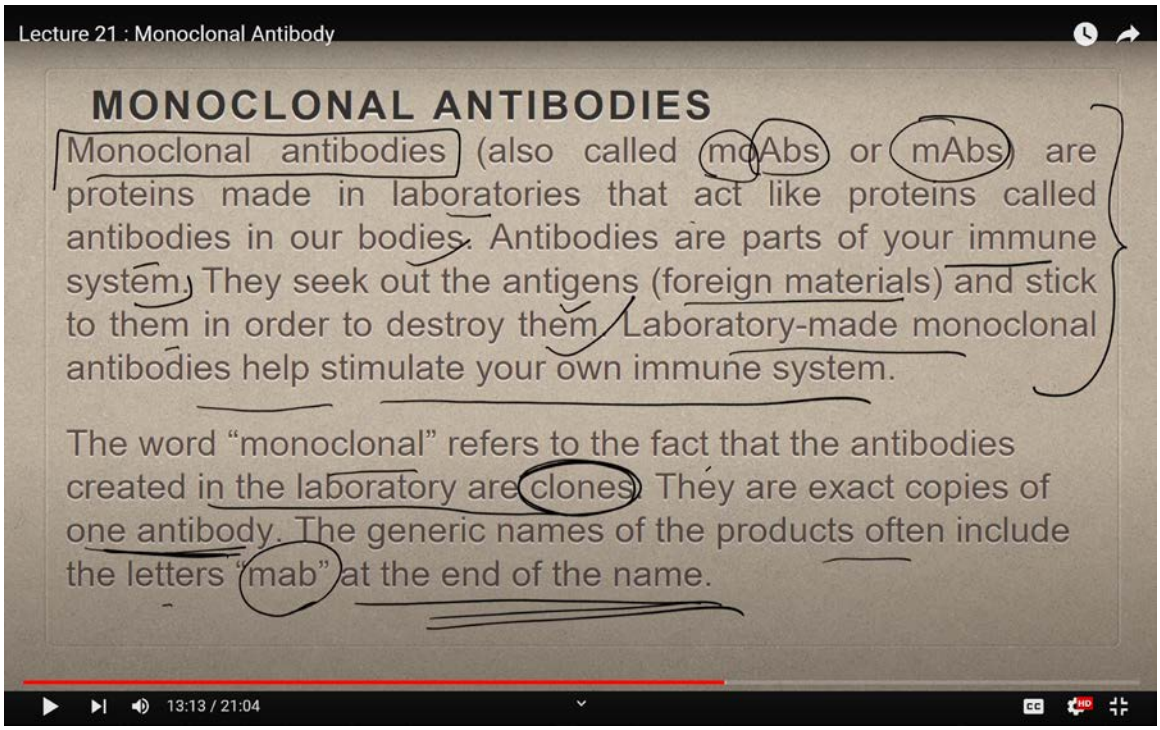

So, most of these antibodies travel through the blood and limb vessels and run after the foreign material, capture it, and neutralize it. This is how it works. I am coming to monoclonal antibodies. They seek out the antigens and stick to them to destroy them. Laboratory-made monoclonal antibodies help stimulate your immune system.

The word monoclonal refers to the fact that the antibodies created in the laboratory are clones. As I mentioned, these are all clones. They are exact copies of one antibody. The product's generic name often includes the letter MAB or monoclonal antibodies at the end

of the name. Monoclonal antibodies are powerful tools in immunology research, biowarfare and bioterrorism research, and biosensor research.

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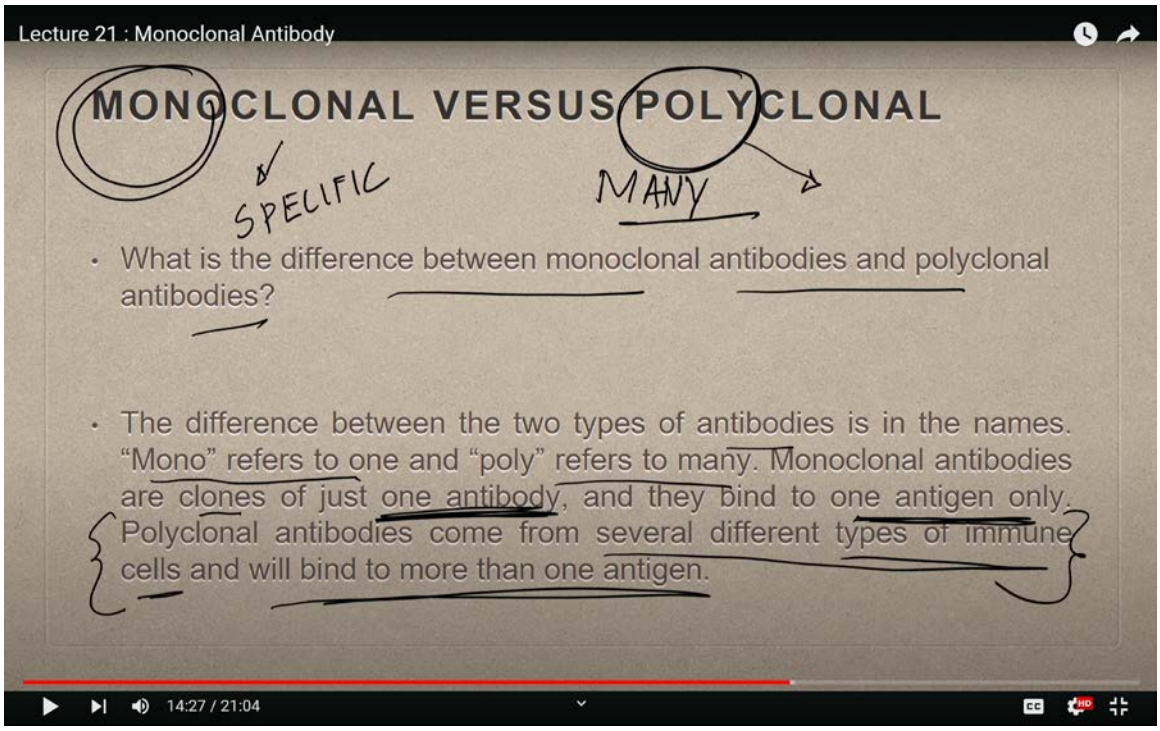

Now, you will also come across a word called polyclonal. If you come across the word mono, then you will come to poly. Poly means many. What is the difference between monoclonal antibodies and polyclonal antibodies? The difference between the two types of antibodies is in the names. Mono refers to one, and poly refers to many.

Monoclonal antibodies are clones of just one antibody, binding to one antigen only. Polyclonal antibodies, on the other hand, come from several different types of immune cells and will bind to more than one antigen. So, as the definition says, it must be clear that monoclonal antibodies are far more specific than polyclonal antibodies. So, whenever people do immunocytochemistry or immunohistochemistry assays if they find a strong binding with one monoclonal antibody, that gives them more authentic confirmation that the reaction is working in the right sense. So this is the first difference between monoclonal and polyclonal antibodies.

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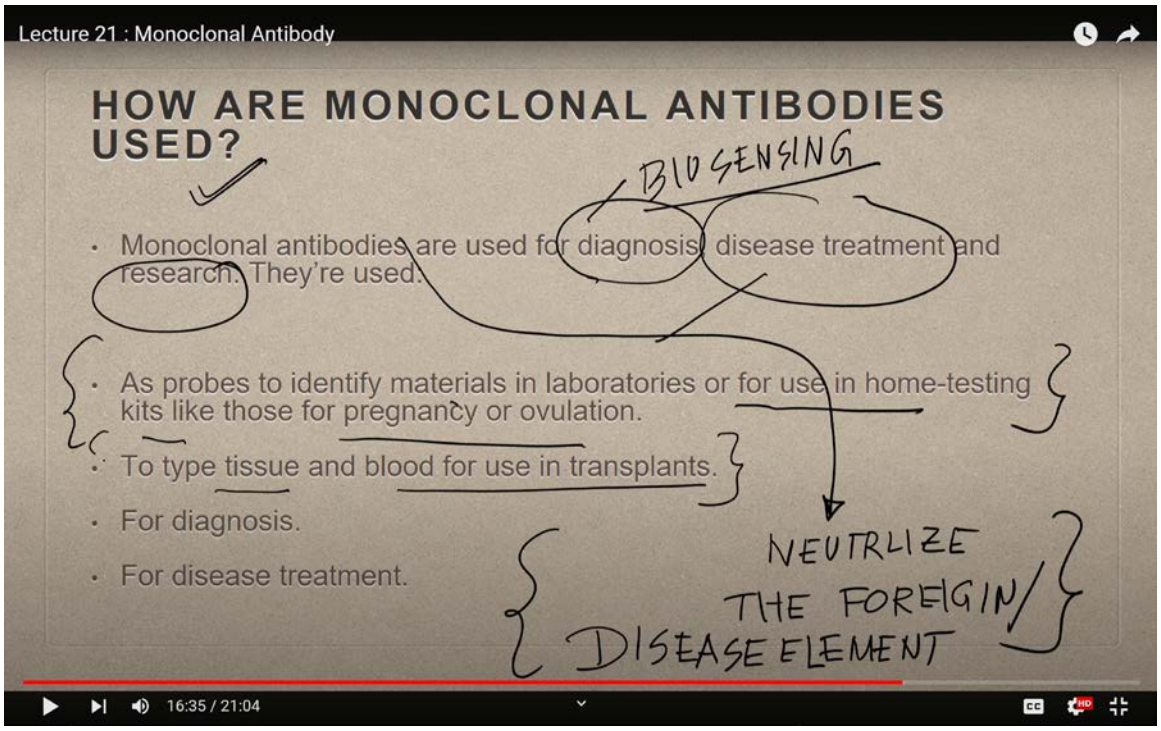

How are monoclonal antibodies used? Monoclonal antibodies are used for diagnosis, disease treatment, and research. Now, when we talk about diagnosis, this is the area of what we talk about in the field of biosensing. And when we talk about disease treatment, it is essentially when this monoclonal antibody is there to neutralize the foreign or the disease element. So, monoclonal antibody therapy, monoclonal antibody therapy is a promising therapy with its own pros and cons, but it definitely finds application in diseases like cancer and neurodegenerative diseases. In a huge domain of biosensing as probes to identify material in laboratories or for use in home testing kits like those of pregnancy or ovulation.

So, most of the pregnancy kits use monoclonal antibodies. This is the second most popular application for typing tissue and blood for transplants. Most of you have seen blood testing where you are testing the blood or tissue, so this kind of testing and tissue testing for transplantation. So, we want to graft a particular tissue from one person to another. Most of this screening is done with monoclonal antibodies for diagnosis and disease treatment.

Now, monoclonal antibodies have been treated following the conditions I mentioned. It is used against cancer cells; for example, cancer cells produce some specific antigen on the surface. So, if you could generate specific monoclonal antibodies against this specific antigen of cancer cells, you can if these are the cancer cells with the specific antigen on their surface. And if you have the specific monoclonal antibodies, these monoclonal antibodies will go. They will surround these cells and will try to neutralize their effect.

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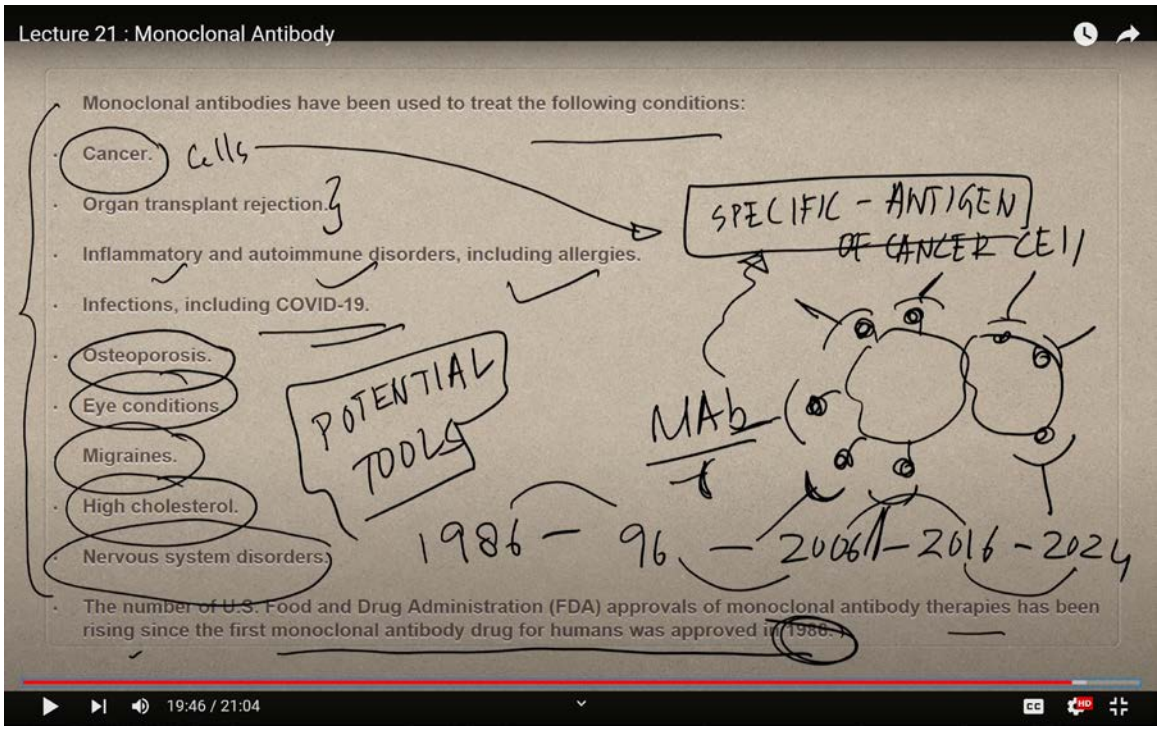

They are used for organ transplant rejection identification. They're used for inflammatory and autoimmune disorders, including allergies, and infections, including COVID-19. There are monoclonal antibodies produced against COVID-19, osteoporosis, a bone-related disorder where there is degeneration of the bones, eye conditions, migraines, high cholesterol levels, and nervous system disorders. So, you see, almost every spectrum of our health is being tackled at some point or another using monoclonal antibodies. So, it is a very, very potent and potential tool for a wide array of disease conditions, a wide array of degenerative conditions in your body.

If you look at the number of US drug food and Drug Administration, approval of monoclonal antibody therapies has been rising since the first monoclonal antibody, which was approved in the year 1986. So, if you look at it from 1986, when the first time it was approved, the technology was running much before that, almost 20, 30 years before that. So, 1986 to 96, 2006, 2016 and now we are almost to 2024, so 10, 20, 30 and almost now four decades. So, monoclonal antibody technology is now ushering into almost the fourth decade or eventually half a century till travel and many breakthroughs, promises and at times, there are dejection, rejection, and so many things. Still, this is one of the most potent recognition elements for biosensor research, and we'll study a little bit more how they are being produced in the next class about hybridoma techniques, about selection techniques, about fast display techniques, and how they are produced in the industry. Thank you.