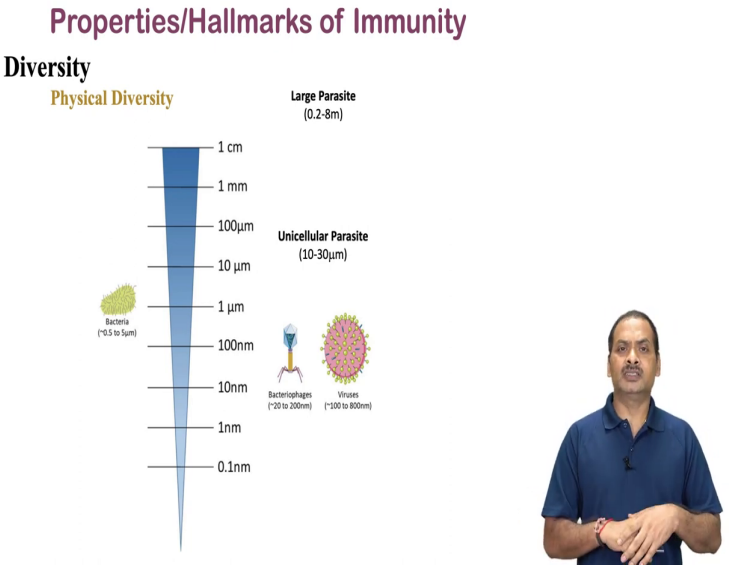
Host-Pathogen Interaction (Immunology)
Prof. Himanshu Kumar
Laboratory of Immunology and Infectious Disease Biology
Department of Biological Sciences
Indian Institute of Science Education and Research (IISER) - Bhopal

Lecture: 6
An Introduction of Immune system-immunity properties

Hi so this is athe next lecture in previous lecture you have learned about the history of Immunology how Immunology started and how it is involved and we you also learned about the various branches of Immunology like transplantation immunology and tumor Immunology or cancer Immunology all those things you have learned. So, in this in this session we will talk about the introduction of immune system what are the unique properties of immune system. And then we will also learn how this innate and adaptive immunity is linking each other.

(Refer Slide Time: 01:06)



So, we can begin this class with a few properties of immune system I will say unique properties of immune system or we can also call it as a Hallmarks of immunity and these are very important and that makes a very unique immune system. So, the first Hallmark or property is "diversity". So, when I say diversity the diversity at various level first I will discuss about the physical diversity.

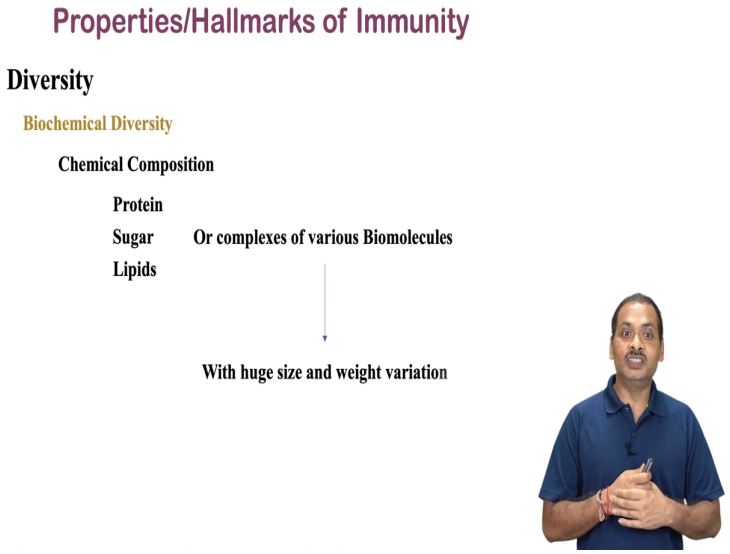
So, Physical diversity is when I want to say that it means there is a huge variation in size. The pathogen you can see the pathogen is extremely small all those microbial pathogen here you

can see in case of viruses it is extremely small it is about 20 to 200 nanometer size and our immune system can recognize such a tiny virus and this can also recognize about bacteria which is intermediate size.

And this can also recognize unicellular parasite which is about 10 to 30 micrometer and our immune system can also recognize far big pathogen the large parasite. For example, Tinea Solium you probably know that or you might have studied in 10th or 12th standard they are very long about eight meter Longs. So, these parasites exist in our body. So, our immune system can recognize that pathogen also and it can elicitate~~elicitate~~ appropriate immune response.

So, this is a very I feel very interesting. So, our immune system is such a nice system which can recognize a very wide range of pathogen. Another property of this diversity is the biochemical diversity.

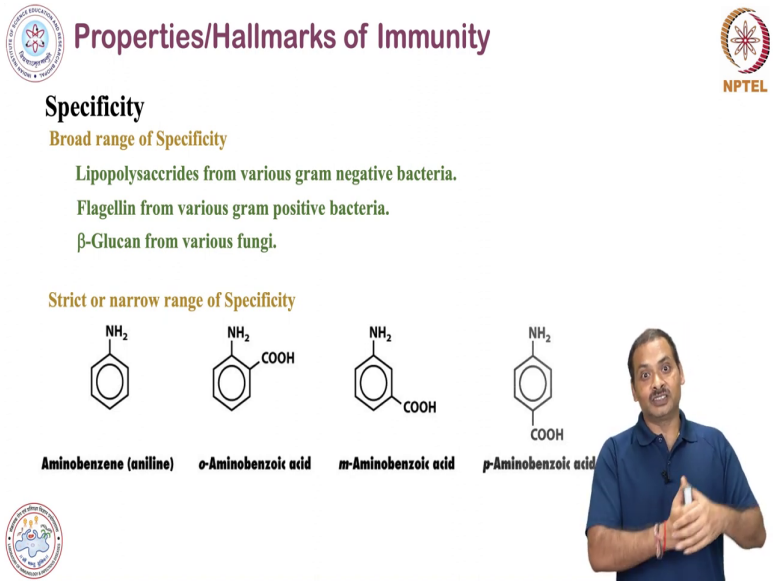
(Refer Slide Time: 03:23)



So, biochemical diversity when I say it means they can recognize various kind of biomolecules like protein, lipid, carbohydrate, sugars and it is not only recognize only this pure or one kind of biomolecule its complex can be also recognized by the immune system. And it is not only the different types of biomolecules it can also recognize a huge size variation. Huge size variation means there is an extremely small molecular weight molecule can also induce the immune responses.

As well as the bigger size molecule can also induce the immune responses. So, that what I want to emphasize on biochemical diversity. So, this is a one of a very unique property or Hallmark of the immunity.

(Refer Slide Time: 04:34)



Another property is specificity. So, specificity is very interesting for or very important for the immunity. So, our immune system can recognize a broad range of specificity a broad range of specificity means they can sense the family of molecules for example lipopolysaccharides or LPS which we commonly call it as a LPS which is present in gram-negative bacteria and you know there is a huge number of gram-negative bacteria.

And all those LPS can recognize by our immune system and when I will take the PRSR you will learn which molecule can sense the LPS. Similarly there is a flagellin protein and this flagellin proteins can be a which is present in different kinds of bacteria gram positive particularly it is present in gram-positive bacteria. This can be also sensed by the our immune system. So, again this is a very broad specificity it is a; they are recognizing a family of molecule and inducing the appropriate immune response.

Another example which you can you can see that the beta glucaon. So, beta glucaon from fungi various fungi produce this beta glucaon which makes a kind of covering of the fungi or kind of cell wall of the fungi and this beta glucan can also recognize by a immune system and then it can induce the appropriate responses. So, generally this broad range of specificity is associated with innate immunity. So, all this broad range of specificity is sensed by pattern recognition receptor.

And we will take up in great detail when I will talk about the pattern recognition receptor. So, for time being you just understand there is a pattern recognition receptor or which will sense the signature of pathogen and induce the appropriate immune response. So, specificity could be a broad range specificity or it could be a very strict or narrow specificity or narrow range specificity if you see the antibody molecules which is produced by our adaptive immunity.

So, these antibody can sense a very unique structure in the molecule and if you tweak this structure or if you make a changes in this structure then that antibody cannot recognize that particular antigen here. You can see one a very nice example here you can see that there is a aminobenzene and Ortho aminobenzoic acids, meta aminobenzoic acid and para aminobenzoic acid. So, these molecules if you generate the antibody against these molecules of course you need to put it some heavy molecule in order to get the antibody against these entities.

So, once you will generate the antibody then these antibody cannot cross react with another molecule. What I mean to say that the antibody which is produced against orthoaminobenzoic acid cannot react with meta or paraminobenzoic acid. So, they here you can see a very small change cannot recognize antibody cannot recognize this small change. So, here you can see that this has a very strict specificity.

Similarly, in T cells which is recognizing the antigen with some unique molecule which we call it as a MHC molecule. This molecule basically presents the antigen pathogen specific antigen and if there is a some change in those antigens the T Cell cannot recognize. So, this is this is this is very interesting. So, our immune system can have this very broad range of specificity and if needed it will have a very strict specificity. So, this is another property.

(Refer Slide Time: 09:19)

Properties/Hallmarks of Immunity

Memory

Example	Virus family	Persistence of antibody
Systemic infections		
Chikungunya	*Alphaviridae*	30 yr
Rift Valley fever	*Bunyaviridae*	12 yr
Dengue	*Flaviviridae*	32 yr
Yellow fever	*Flaviviridae*	75 yr
Measles	*Paramyxoviridae*	65 yr
Mumps	*Paramyxoviridae*	12 yr
Polio	*Picornaviridae*	40 yr
Hepatitis A	*Picornaviridae*	25 yr
Smallpox	*Poxviridae*	40 yr
Vaccinia	*Poxviridae*	75 yr
Rubella	*Togaviridae*	14 yr
Mucosal infections		
Coronavirus	*Coronaviridae*	12 mo
Influenza	*Orthomyxoviridae*	30 mo
RSV	*Paramyxoviridae*	3 mo
Rotavirus	*Reoviridae*	12 mo

RSV, respiratory syncytial virus; yr, year; mo, month.

Modified from Slifka MK, Ahmed R. Long-term humoral immunity against viruses: revisiting the issue of plasma cell longevity. Trends Microbiol 1996;4:394–400.

And now I will talk about another property of immune system or Hallmark of immune system that is memory. This memory is not like a neurological memory but they have a similar features similar features means the our immune system have a very very wide range of memory for various pathogen. Here you can see this table there is a; if the individual is infected with some virus such as you can see chikungunya virus.

So, if the individual is infected with chikungunya virus then the individual will have antibody up to 30 years. So, this is very interesting right and you probably might be experienced that you might had when you were a kid you might had a chicken pox or a smallpox and once you had in a whole of your life you will not have again chicken pox and or smallpox in in normal situation. So, this is a very unique feature of immunity.

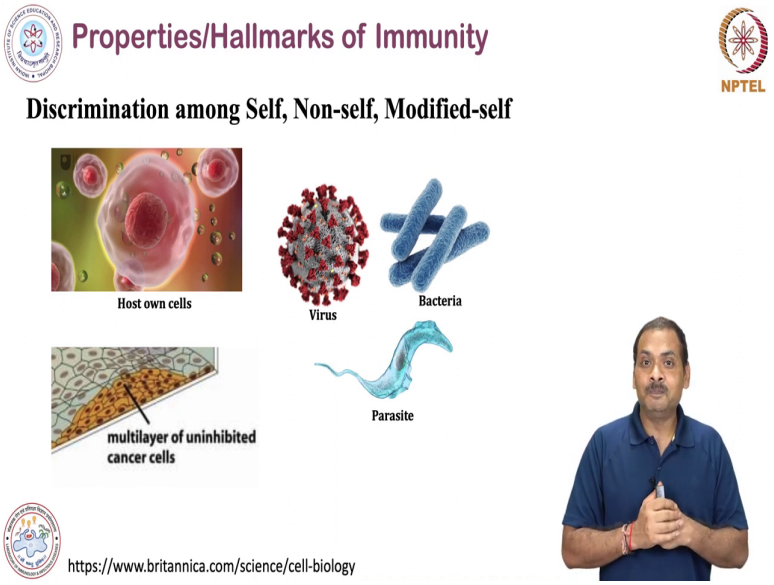
So, your immune system will have all those batteriesy of molecule which is needed for the neutralization or elimination of that pathogen. So, all those batteriesy of molecules such as B cell or antibody or T cells antigen specific T cells or virus specific T cell if the individual is again re-infect then this will be easily taken care you will not even know that you and you had an infection. So, here you can see that there is a there is a different ranges of memory in in terms of duration.

So, for example in Chikungunya this is 30 year and for vaccinia virus you have a 75 year which may be a more than the age of the individual. So, this is very interesting right and like yellow fever also they have a 75 year. So, if the individual is infected with yellow fever or vaccinia virus early in the life then this antibody will exist throughout his life. So, this is very

interesting but on another hand for some viruses for example you are seeing the coronavirus this has a short-term memory.

And this is about 12 months, for RSV this is respiratory Syncytial ~~synchitral~~ virus for this the memory is very short that is three ~~month~~months. So, this feature we use when we make a vaccine against any pathogen particularly viruses or bacteria. So, if the memory is very long we can we can make a very good vaccines. So, this is one of the features of immune system the memory.

(Refer Slide Time: 12:29)



Another is discrimination among self, non-self and modified self. So, again this is a very very unique and very important property of immunity. Discrimination among self means our immune system do not react with our own cells so, or our own molecules. So, this is very very important if it is not there then that if this this regulation or this kind of system is not present in the in the host then that will result to the disease condition and those diseases we call it as the autoimmune diseases.

So, our immune system can discriminate between self means our own cells and this can also discriminate between self and non self. So, when I say non-self it is basically pathogen originated molecules. For example, virus has ~~a some~~some protein over the envelope or on their surface or there could be some protein which is present on bacteria or it could be present on virus parasites it could be present on fungi and so on and forth.

So, this can differentiate between pathogen and non-pathogen means our own cell and pathogen. So, this is very unique feature and very interesting but here I will say that our immune system can also discriminate between self and modified self. So, what I mean to say about for modified cell. So, you know that the individual can have some transformation of cells and that transformation of cell result to the development of tumor or cancer.

So, our immune system can discriminate between normal cell and these modified cells. So, modified cells are like cancer cell or tumor cell. So, our immune system can discriminate between the normal cell and modify itself and this can trigger the immune response and clear the or eliminate those modified cells. So, this is a very unique property is not it?. So, this is a very interesting and appealing to all immunologists.

So, that is why because of this property we have variety of therapies against cancer which we call it as an immunotherapy. So, what we do we somehow activate our immune system in such a way so that this cancerous cell will be recognized and this will be eliminated. So, there is no drug in this thing. And one very beautiful example you might heard in newspaper or in some scientific article there is a CAR T cell mediated immunotherapy for blood cancer.

So, here we exploit all those one of this property. So, this is an another unique Hallmark of immunity.

(Refer Slide Time: 16:16)

And another is tight regulation. So, tight regulation it is not only important for immunity for all kind of biological system or even non-biological system. If you do not have a tight

regulation. So, it will create a havoc in the system right. So, tight regulation here the tight regulation is very very important if there is no tight regulation again that may result to the development of autoimmune disease.

So, tight regulation can be achieved at various level one could be a molecular level and when I say molecular level it means it could be a transcription level. So, you know from DNA to RNA this process we call it as a transcription and probably you might be aware now you might be aware about that about two percent of genome is only expressing the coding protein or those transcripts make a coding or they make a protein coding sequences.

And rest of genome now it is very interesting to tell that rest of the whole genome is mainly involved in regulation and that regulation is generally post transcriptional regulation. And this post transcriptional regulation is basically mediated by variety of short and long or circular RNA. So, this short RNA we generally call it as a micro RNA. So, these micro RNA basically work along with circular RNA which is encoded by our genome and they basically involve in regulation of amount of transcript in the cell.

And long non coding RNAs are also playing a very very important role in expression of Gene or coding part of the transcript. So, all these things we call it as a post transcriptional modification or post a transcriptional change which is playing a very important role in regulation of expression of Gene. Another molecular level regulation could be at protein level or when mRNA is translated into the protein we call it as a translation.

So, there is a there is a post translational modification you know that and once the protein is synthesized then there will be addition of various group in order to make that protein functional. So, this is a one way another way is you might know that some active molecules or some active enzymes they are synthesized in inactive form a pro form or or in zymosain form. So, and some enzyme will come and cleave and then that protein become active.

So, this kind of Regulation is also there and just for your information once cytokine IL1 family of cytokine is there which we call it as a IL1one family cytokine the production of this cytokine is basically controlled at this post translational level and post translational level means there is some group of protein complex which will come and then that will cleave that protein and then that cytokine become active and secreted it will be secreted out of the cells.

So, this is a translational level regulation. Another is positive and negative feedback system this positive and negative feedback system is basically present all over the all over the cells wherever when there is a need then this production of that molecule will be enhanced and if there is no need of molecule or no need of a particular protein or which result to some response then this will be inhibited.

Another is a synthesis of pro or anti basically I want to say that cytokine you might heard that there is a pro-inflammatory cytokine and there are anti-inflammatory cytokine. So, in many scenario when there is infection then there will be a synthesis of pro-inflammatory cytokine which will what it will cause; it will invite the immune cells at the site of infection in order to clear the infection.

So, this is a pro-inflammatory process or this is basically mediated by pro-inflammatory cytokines but when the pathogen is removed or eliminated then there is no need of this pro-inflammatory cytokine. So, in that scenario what is happening this anti-inflammatory molecules are synthesized and then this molecules basically damp the this inflammatory environment. So, that what I want to say.

Another is it could be a cellular level regulation. So, you may know that there are some cells which activate the responses or activate the signalling and that basically is needed for the elimination of pathogen. But there are some cells which is which plays a very important role in damping those activated cells. So, there are some cells for example M1 and M2 macrophages they are both antagonistic to each other.

Another is another example is T~~x~~reg or T regulatory cells and these T regulatory cells are very important in damping the in the damping of the immune responses. So, so these are all Hallmarks of our immune system I hope you understood all this thing. And in next session I will discuss about how this innate and adaptive immunity communicate each other and that is all.