**Data Analisys and Decision Making – II**
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**Lecture – 54**
**AIS**

Welcome back, my dear friends. A very good morning, good afternoon, good evening to all of you wherever you are in this part of this globe and this is the DADM II which is Data Analysis and Decision Making to course under NPTEL MOOC series the lecture series for DADM II. And as you know this is a course for total duration or 12 weeks and we are in the 11th week as you can see from the slide.

And this total contact hours for the lectures is 30 hours which gets converted into 60 lectures; each lecture being for an half an hour as you can calculate and each week we have 5 lectures. So, after 2.5 hours that is 5 into 30 minutes. So, you will have basically the first assignment. So, technically of the first assignment after first week; similarly for the second week after another 5 lectures, so, that is total 10. So, you have already completed 10 lectures 10 series of lectures and you have completed 10 assignments.

So, we are in that 11th week. So, if you remember that in the last three classes that is 51, 52 and 53 we were discussing about then GERT and Q-GERT processes. So, now, starting today we will try to cover some of the heuristic methods which are used in order to solve problems in the DADM II.

Now, to give a background of heuristic methods if you somebody you would have on the knowledge basic knowledge is heuristic methods is that you have problem to solve. And the problem solutions is you and technically at the problem can be solved using semi and any algorithm any optimization techniques, you will get exact solutions.

But, the problem is that many of the cases the problem solution which you have to solve very complicated problem like the problem can be for the TSP, problem can be Chinese postman problem, for scheduling, sequencing considering you have n machines, n jobs it becomes very difficult to solve the problem considering that it is impossible almost impossible to get exact solution. So, we will try to utilize few of the techniques of metaheuristic.

So, now, there are lot of different of a materialistic techniques in the market. So, one is very popular one is the genetic algorithm which basically works on the principle of gene replication or mutation, where two genes when they exchange the chromosomes there how the chances of the next generation which is the next solution enhances. And basically becomes much more closer to the actual values which should be obtained; that means, we get better and better solutions. In the concepts of say for example, other metallurgical techniques would basically be the concept of ant colony optimization.

So, if you would have seen when you were a child so, when ants forage through for food they basically follow a path and once they come back they keep a trail. So, that trail is basically based on the concept of pheromones, but the pheromones decay and they evaporate. So, obviously, more ants traveling through the part means more pheromones signatures are kept hence the decays even if they are happening because the amount of pheromones which is kept on this path is much more than those paths become much more traversed.

So, obviously, one can use the concept of n colony optimization to solve different type of optimization where the paths travels of the results which are here are obtained you are more and more in number; that means, they get embedded into the system as much more hope better solution than the existing one.

Another can be basically the concept of simulated and annealing. So, if you consider if somebody has done some concept of mechanical engineering or metallurgy. So, annealing what we do is that we heat up a metal to a very high temperature and then suddenly quench it bring down the temperature. So, the grain structure and all these things are retained in such a way that the hardness and all these properties are retained to a certain day. So, what are the properties that will depend on what type of temperature using what is the material to what level of decays or temperature you are planning to so on and so forth. So, the concept was simulated and in is used in order to solve different problems.

Then you have the taboo search. In the taboo search you build up solutions where one set of solutions are a taboo are not to be touched and based on that you basically build up your concept of formulation that how the search for the results would be done. So, there are other concepts also which basically builds up this different type of heuristic methods,

different type of biological concepts are utilized like bees foraging for food or amoeba buying trying to replicate and generate. So, these concepts can be utilized.

Another very interesting meta heuristic techniques or heuristic tact is basically known as the artificial immune system which we will try to discuss today. And, so in the artificial immune system what the basic concept is that our whole body has a immunity system. So, immune system that we have the skin, the hair, then we have the white blood corpuscles, the different type of systems of immunities are there which basically fights the germs or the pathogens which are coming from the outside world. So, skin acts as a as a detriment or as a shield.

Now, if you remember that when you have a cough and cold; so, after the cough and cold there is a lot of mucus secretions which come which basically the cells which are inside are fighting the germs and they basically bind in such a way that both of them become inactive and dead and they come out from the body as waste products when I am coughing and coating the cough which comes out.

Now, if you also remember when we were a child so, you are giving some immunization shot Hepatitis-B, then tetanus and all these things which were giving when we old when we were very small kids is basically it ordered to build up some fighting mechanism in our body such that when the next set of attack happens by a similar type of disease or the same disease, we do already have a set of system inside our body which is able to fight.

Now, the issue is that there can be different type of diseases. So, is it possible that the whole system has different type of such fighting mechanism in some body? So, we will discuss very briefly about immune system and the artificial immune system and then I will also discuss a very simple problem how it can be solved. We are not going to solve the problem here; I will give you the basic background and how it can be utilized to solve the concept of in the area of finance, in the area of operation research that how can the concept of artificial immune system can be utilized.

This is a very brief background about heuristic methods based on biological inspired systems and I give a very brief background. So, with this I will start the artificial immune system and discuss few more in the remaining 12th week which will be the last week.

So, in the concept of immunology so, considering artificial immune system which I will mention as AIS if this basically protect our bodies from infection. Infection can be cough and cold, can be fever, can be hepatitis, can be dengue whatever it is. So, some pathogens so called cells and viruses which are definitely not good for our system attacks our body and our body fights. So, the fight how it happens and how what is the basic principle based on which we will proceed I will discuss that.

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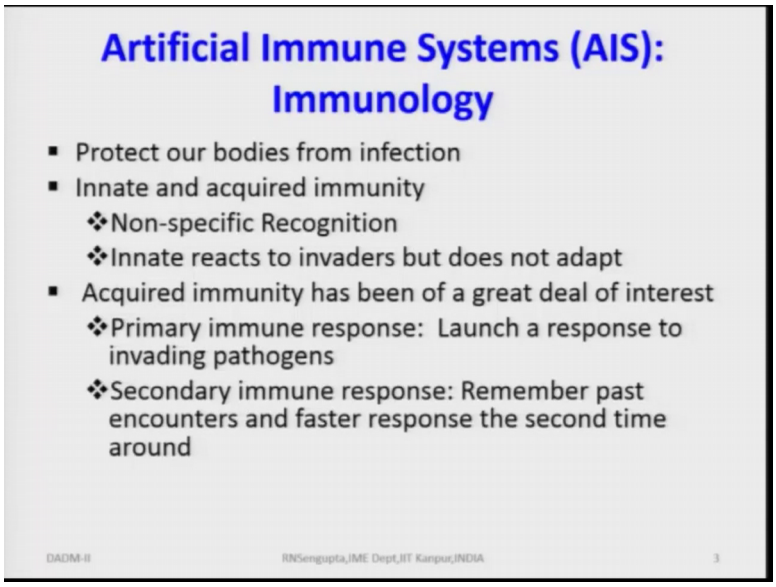


So, there are some innate and acquired immunity system buildup in the body; so some are already built and some are developed depending on the type of immunity system we have been implanted with. Implanted means the shots which you are given when we were kid or say for example, we are suffering from some disease we get in some shots which are basically in a way build up to increase the immunity system.

Now, if you remember it is also mentioned by many of the doctors and it is known fact that when you take antibiotics; so, the antibiotics basically fights the germs fights the diseases, but in the mean same way as they fights the diseases they kill the good system fighting system also in our body. So, antibiotics too high dose of antibiotics it decreases the immunity system in the body that is always mentioned many of the experts.

So, I am not going to go into that field, but I will basically consider how the concept of immunology and artificial immune system and immunity system can be very nicely replicated in a very simplistic sense to solve a simple problem.

So, innate and acquired immunology system would be one would be based on nonspecific recognition, I do not have a any information set at what type of attack as it would be who are the enemies. I am talking from the point of view of the cells you have which you are going to fight. So, they have a system and they are waiting the any pathogens to attack the body or the human being now what type of attack would be there I do not know. So, basically I have to learn the process; I means the fighting system has to learn the process in order to deactivate the external germs.

And, some are innate reacts and this innate characteristics reacts to the invaders, but does not adapt. So, one of them are adapting, they adapt and try to fight the system and one of them do not adapt, they fight it as it is. If they are successful they kill the germs if they are not they are basically killed in the process.

So, the acquired immunity has been have a great deal of interest primary and secondary for the reasons is that. The primary immune response basically launches a response to the invading pathogens. Pathogens are attacking I basically build up my system to defend and I basically I means the set of good cells which are there; word good I am using in a very general sense that those who will fight the pathogens.

So, they will launch a response to the invading pathogens and deactivate them. So, this how they attack and how what is the deactivation process that I will consider in a very simplistic sense. There is a secondary immune system also; that means, once the attack has happened and in the process, the body has recuperated and the body has now come back to the normal sense the germs and the disease has been overcome.

But, inside my system there are some fighting so called material which have replicated the information from the attack and they are there such that in future if some attack happens they will replicate faster in order to fight those known germs. Because I have some imprint, I have some memory, I have some food some set of information which is already there in my system that in next case if again hepatitis-B comes I am much better equipped to fight the system. So, that means, I have learned something from the previous attack. So, I am capable I am trying to replicate in a faster way to fight the system.

So, the primary one launches and responds to the first time and the secondary human system basically remembers faster encounters and faster responses the second time of the third time the attack happens and I am there to defend.

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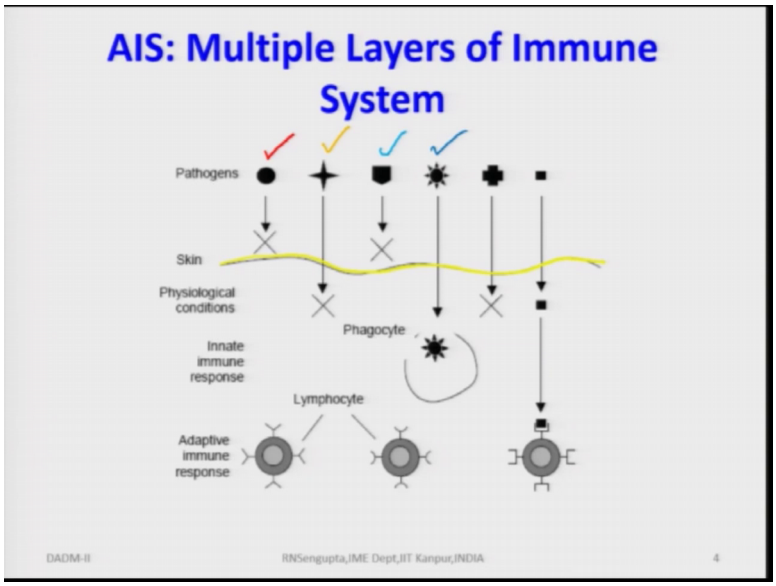


So, this is a very simplistic diagrammatic schematic diagram of the whole immunity system which is there.

So, I will consider so, this is the skin level. So, there are in my body or anybody anybody's body there are hairs hair follicles and all these things and there are different type of pathogens attacking. So, the pathogens I have made these diagrams in such a way or taken from the book in such a way that the diagrammatic representation of the other pathogens basically give you what type of different about pathogens are there.

Say for example, this is fleur influenza and let me use a different color it would be easy. This is for say for example, influenza; the next one considered it is basically for hepatitis-B; third one so, their replication I am trying to denote using different schematic diagrams. Consider the other one is basically for smallpox, consider this is basically for cholera. So, all these gems are there I want to fight them I means the body wants to fight them.

So, some of them when they come the skin is able to resist. Consider some flu germs comes. I am quite tough enough, I resist, temperature decrease, increase too much heat, too less of heat and I am outside. So, any effect from the external sources which wants to invade by body I am quite resistant, my skin basically acts as that and basically defends my overall system.

Now, consider some of them passed through the first layer; that means, the skin is not able to resist. So, they ask that the pathogens which are attacking my body are much stronger. So, the physiological conditions change. So, say for example, I get flu. My nose starts flowing because the cough and cold has set in, my eyes get red or say for example, if it is jaundice the general effect of the jaundice is shown I cannot eat too much of oily food or say for example, I have a stomach upset and all these things basic is physiological conditions are there which means the my system is trying to resist the body is trying to resist all the attacks which are happening.

So, now the innate immune system; so consider the for the first time they attack. So, they the first time I attack all the WBC is which you want to fight they go against them and fight. So, consider the innate immune response is there and the primary case they fight and many of the WBCs or the soldiers you want to fight or me are dead because in that process they had to also tried to deactivate the pathogens which are attacking. So, if there is these equal fight; it continues for a long.

If say for example, the WBCs which are going to fight are much stronger in number, I am able to my whole system is able to fight the external pathogens whatever the disease is and I am again hale and hearty after few days or few weeks. And, if I succumb that my WBCs are not able to then obviously, I have to take medicines. So, the medicines which I have mentioned few minutes back the antibiotics are too strong they kill both the pathogens as well as the good fellows, so, obviously, the immunity decreases.

Now, when the attack happens in the sense and the lowest lower level means as they enter the body those adaptive immune responses response would be there immediately they would go and attack in order to defend my system which is the body. Now, the overall fighting of these WBCs of the antigens with the pathogens is such that they would be locking; locking by the good guys with a bad guys locks in such a way that both get deactivated and they flow out of the system. You see to remember I mentioned few minutes back that I have a very strong cough and cold and my nose is flowing and that comes as a cough and cold after as I recuperated.

Now, the lymphocytes which I have the direct immune system have has locking systems it is like a lock and key. So, consider the locks and keys are circulating in this case. In some case they are triangular and some case they are square. Now, where the speciality

happens is there see for example, this disease which has let me use a different color. Which should, let me use the violet one.

So, the this square black one enters the system and I have the adaptive immune response immediate and the overall dope tailing happens in such a way that the square cube sort of thing whatever it is 3-dimension let me consider 3-dimensioni, it gets interlocked and they bind together permanently the moment there does. This adaptation is in a system where I will consider each of them soldiers or the WBCs have four such locking system. So, once four of these pathogens are locked; that means, my WBCs gets deactivated it cannot fight, but in the process which is also able to deactivate four of those attackers.

But, interesting to see if this black box one now; so, consider the WBCs of these type are not there. So, these type is not there consider it is not available. So, what happens when the black box or say for example, whatever disease attacks, then if the dope tailing happens with the semi circle one on the triangle one then the fit does not happen which means the fighting mechanism from my body is not adequate in order to fight the attack which is happening from the external source.

So, here if you remember I did mention when I started that when you were kid few shots were given; that means, purposefully some cells or some small amount of disease was put in your body such that you would not be harmed, but those small amount of disease would be there in the system as a replica in order to fight any attack which is going to happen in the next near future. So, say for example, hepatitis-B shot is given; that means, if I am affected by the hepatitis-B my overall system knows it has a signature or it has some memory that they will replicate in order to basically do the binding such that in future I am able fight the system in a much more robust manner.

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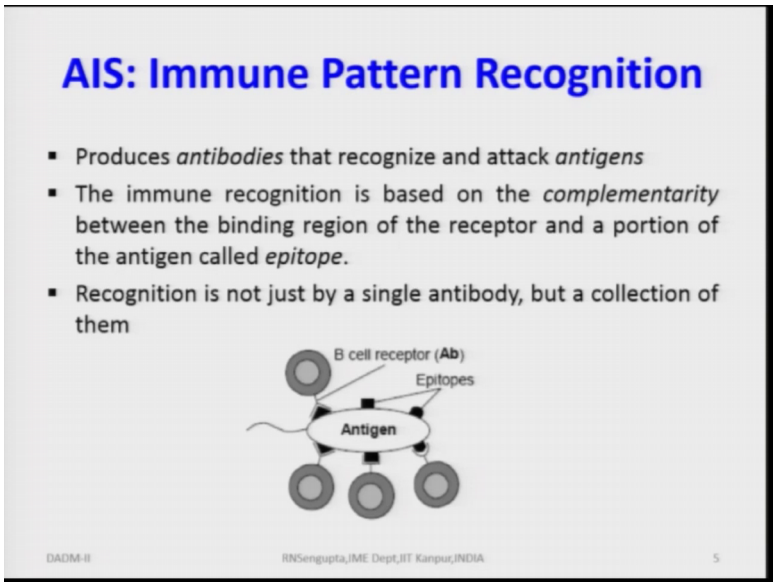


So, in the AIS, so, on the immune pattern recognition concept, they produce antibodies that recognizes and attacks the antigens. So, pathogens which are coming they will be attacked and I will be able to replicate and amble it accordingly. The immune recognition is based on the complementarity between the binding regions of the receptor and the proportion of the antigen cause the epitope.

So, what I would have basically had that the antigens which will be there they would be attacked such that the epitopes of the antigens would be bound binded onto the receptors of the antigen; antigens epitope should be bounded by the cell receptors. Cell means which we are going to find such that the overall surface by which the bad cells were able to affect my total system my body system are deactivated and they are made dead.

As I said in this process both the good guys and the bad guys are killed hence the overall and if the number of good guys are more in number; that means, they are able to overcome the so called bad guys which enter or affect my body system and then I get slowly healed and I am hale and hearty in the long run; that means, my immunity system is there. But, as I mentioned in many of the cases that acts is to a quite severe then he use strong medicines antibiotics which as I mentioned also kills the good guys along with the bad guys. So, the and bad guys are dead, but the good guys are also affected. So, your immunity system decreases and you become very weak.

So, let me read it. So, the immune pattern recognition process produces the antibodies that recognize an ant attack the antigens. The immune recognition is based on the complementary; so, how complement they are how the dope tailing can be done based on the complementarity between the binding region of the receptor and a portion of the antigen called the epitope. The recognition is not just by a single antibody by it by a collection of them such that all of them attack in such a way that the antigen which may have different ways of replicating all of them would basically be made redundant.

So, if you consider here you have a hemispherical linkages here, you have a triangular linkages here these are the epitopes you have a circular linkages here such that different ways of binding by the cell receptor would happen such that the antigen would be in a collectively made dead; dead means deactivated.

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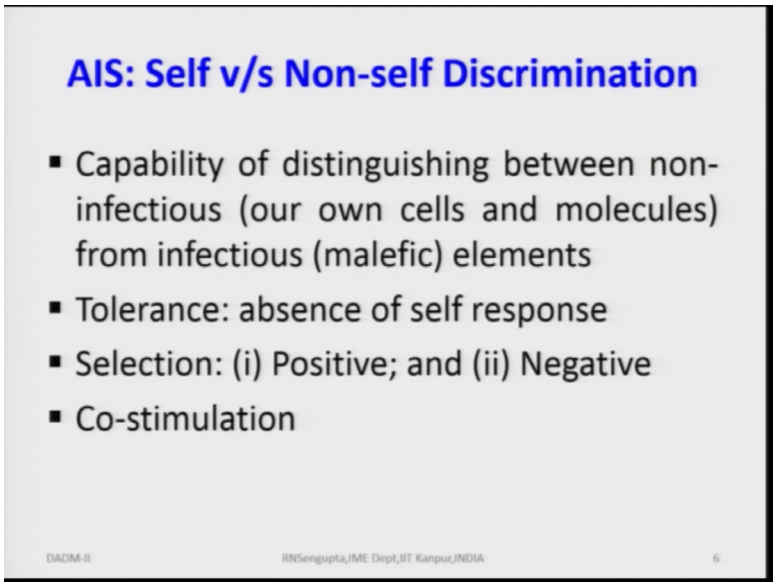


Now, in the immunity system there is a self versus non-self discrimination because when I am attacking the bad cells which are coming, it may happen that the good cells also attack their friends. So, in this attacking process rather than killing the bad cells only I also I am able to deactivate kill myself, but in the process kill my soldiers also my friends. So, this way the overall effect may not be as good as it should be if the attack on the other attacking principle was between the good and the bad guys and not between the good and good as it happens in general.

So, the capability of distribution between the non-infectious one which are the good guys and the infectious one is very important. So, you should and the whole system should have a capability to distinguish between the non-infectious one; that means, our own cells and our own molecules in the system from the infectious one which is the malefic elements which are coming from outside.

So, obviously, there should be a tolerance level to what level I am able to tolerate the attack. So, the tolerance would be levels would be the absence of self response which in many of the cases may not be there and when you are basically doing the selection process of what to attack, what not to attack, whom to be deactivate, whom not to deactivate it the general principle is based on positive selection and one is basically based on the negative selection.

So, positive selection and negative situation basically means that it is in a very simple way that I am seeing that I have some my friends who will be able to fight and another case in the in the sense I have some negative selection process; that means, the these are the concept where if I bind I get deactivated. So, I would try to basically build up my immune system on both the effect; that means, there are some friends which I will try to build up and they would be some enemies of my enemies who will also try to build up in such that I am able to fight the enemies which are basically the pathogens which are attacking the body.

And, in this both the process of selection of positive and negative I will basically have a co-stimulation process such that this process of building up my friends in larger numbers or enemies of my enemies in my larger numbers would be build up in the system the such that I am able to fight; I means the overall body is able to fight the pathogens who are attacking to the best possible way.

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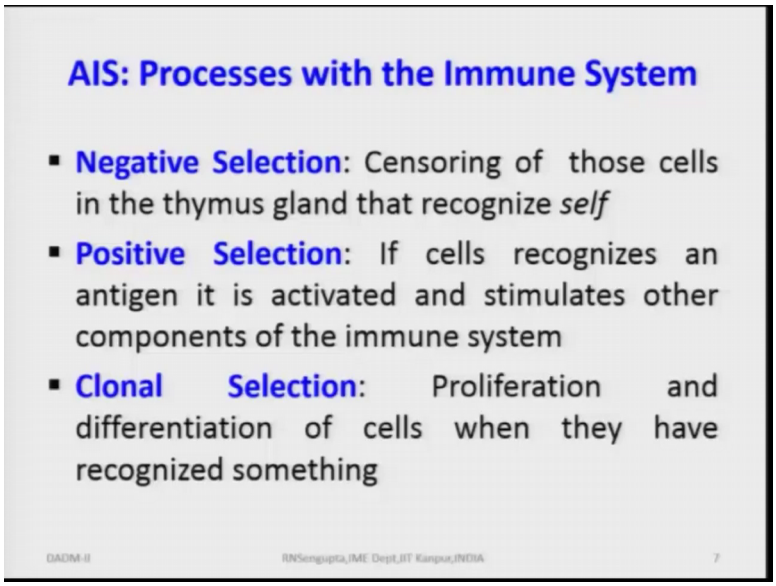


Now, the process of AIS basically works as I said on the negative selection, the positive selection and another is basically the clonal selection. I will go very briefly as I mentioned to them. The negative selection process once works on the concept of censoring of those cells in the thymus gland that recognizes the self based on which I replicate myself more and more are replicate; so that means, I recognize myself and fight the people whom I do not recognize.

In the positive selection if the cells recognize and antigen it is activated and the stimulated other components of the immune system such that I am able to fight the system. So, both works in a in a in a complementary way that in one case I am positive I build up my system accordingly, in the other case I am negative I am basically build up the enemies of the enemies to fight my overall system.

In the clonal selection process, the proliferation and the differentiation of the cells when they have recognized something is basically build up. So, in the clonal selection if I am able to recognize my good friends I will try to basically build and build up a huge army and in the negative sense in and that means, I find out some enemies of my enemies I will try to basically inculcate them in a big number such that they help me to fight my actual enemy. So, technically they would be positive negative which I will discuss with a very simple example.

Now, in AIS they basically this affinity maturation. So, as I build up how close I become or how fast I am able to build up my team. So, team would be both from the positive sense and the negative sense. Now, they the whole system will mutate. So, if you remember I do we do mention like this medicine is not working for this type of disease or the mosquito repellant which I utilizing does not affect the mosquitoes because they roam about as they like.

Which means, that the mutation or the change in the overall gene structure has become in such a way that many of the cells which should be basically binded in such a way that at a they are the pathogens should be deactivated they do not become deactivated because they have change their shape and size has that the linkage is not done properly.

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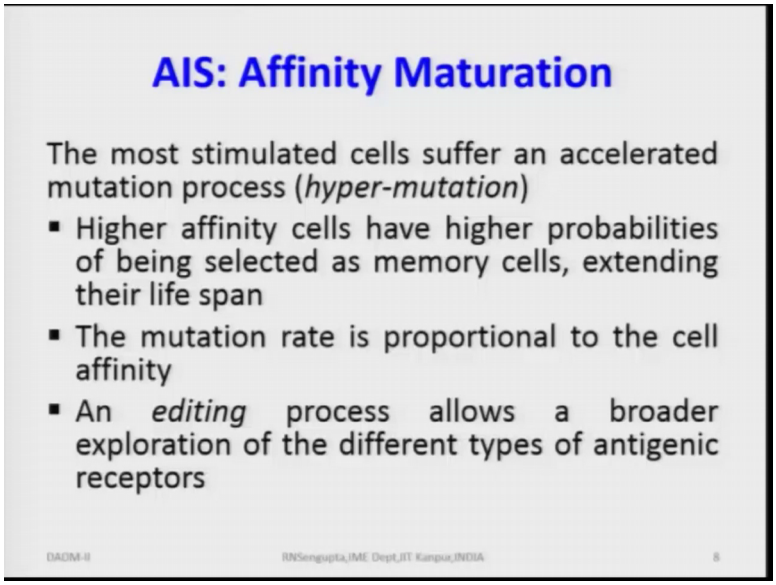


So, the most stimulated cells suffer an accelerated mutation process; that means, if they muted if they are stimulated very highly they will try to mutate very fast and in large numbers. So, obviously, that need not be actually needed and that is not advisable for the whole body to fight the attacking or the pathogens which are coming. So, higher affinity cells have higher probabilities of being selected as memory cells extending the lifespan. So, that means, probabilities high of association so, they would probability of them being built up in larger numbers continuing for a longer duration of times would be much higher.

Now, the mutation rate how the replicate would depend and what is basically the proportions to the cells affinity? So, how closer I am with the characteristics. How what the what are this is the closest closeness property I will come to that later. So, but if I know somebody's like this if I know somebody I would definitely try to rebuild my empire in a much bigger way, if I do not know; that means, I am in disadvantage, so, I cannot build my system accordingly. So, this mutation rate how fast I am able to grow would depend on how close I am to the overall mutation system or which is basically instigating me to grow.

An editing process would also allow a broader exploration of different types of antigenic receptors and how they can be considered in our overall discussion.

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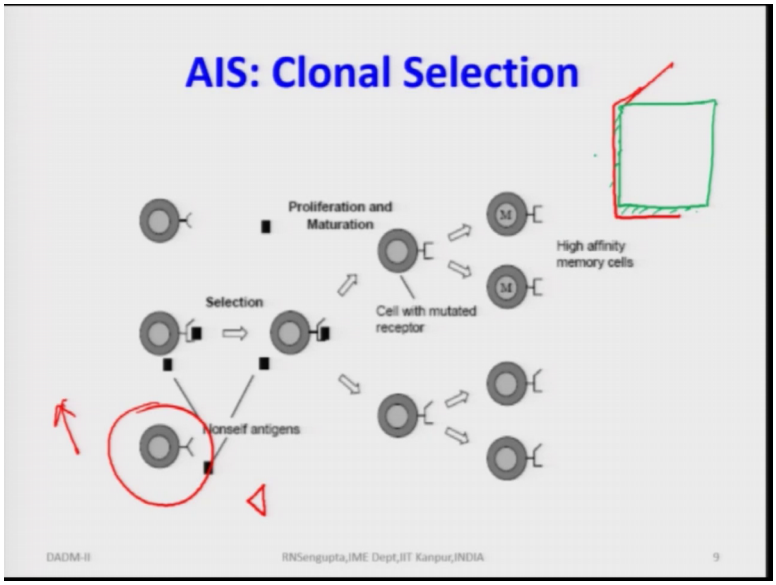


So, consider this clonal selection process which I have. So, here I have the concept as I would like this.

So, I have the non-self antigens. So, the non antigens basically are now as they replicate and so, as they are replicating getting this the selection happen. So, one is a triangular one, one is basically not a triangle one is basically box which has been basically elongated shape.

Now, consider they have been selected because the binding pattern if you check the square one which is basically a pathogen would not fit into the triangle one, but it would

definitely fit into the not the exact square gauge, but there is some space where the binding would be much better than triangular one. So, obviously, the selection would stimulate them that you yes, you should replicate more and more. So, they would basically start replicating in larger numbers while the triangular ones I am using the symbolic representation would not be replicated to that degree. And, obviously, the semicircular one would not be there.

But, say for example, if a triangular pathogen comes. So, hence the replication of this triangular ones would be much higher while for the squared ones would be much lower. So, depending on what type of pathogens which are attacking . So, as they come these proliferations and the maturations works and the self with the mutated receptors basically grows in number; so they would basically be higher memory cells.

Now, remember one thing the actual replication should be exact box which means the initially dope tailing maybe say for example, 80 percent correct not for the triangular one. For this concept the box one which comes is 80 percent; that means, I have deactivated this side, deactivated this side, but this side is not totally deactivated which means the fightings cells would now basically slowly replicate such that the dope tailing happens 100 percent.

So, if you see this diagram, cell with mutated receptors they have made their dope tailing to a square one such that they would replicate more and more depending on the number of such pathogens and which are going to attack my overall system. So, now, if in case if there is a triangular one, obviously, triangular ones would be much more. If it is a combination of triangular and a square one then they would basically replicate accordingly such that I am able to fight the system in much a much better manner.

Now, this is with a very simple background I have discussed the general framework of immune system, in general. I am not going into biological details I have not been may not be have been able to give a much thorough understanding as a doctor and a biologist would have been able to give, but I have tried my level best to give a good background.

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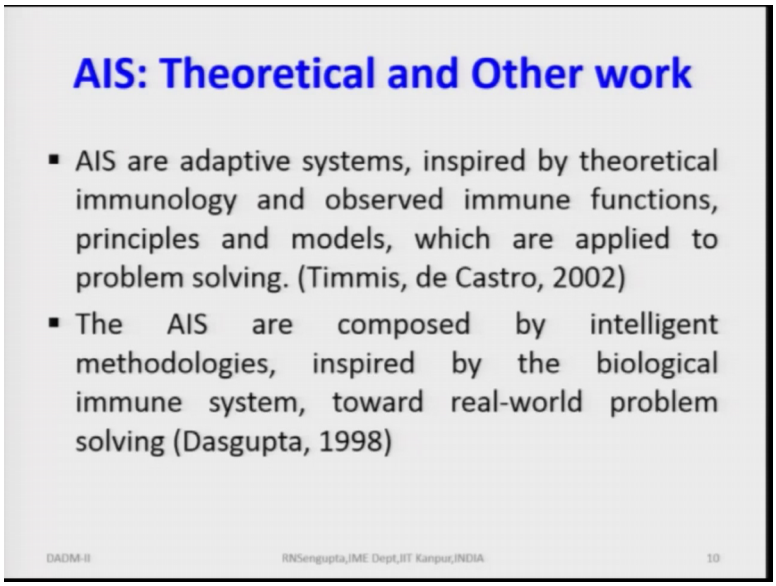


So, artificial immune system is an adaptive system which adapts itself. It was and inspired by the theoretical immunology and observed immune functions principles and the models have been employed. So, two of the very or three of the very good researchers in this area is Timmis and de Castro and one and another one is basically Dasgupta.

So, in this, by Dasgupta the AIS are composed by the intelligent methodologies inspired by the biologically immune system towards the real base problems lot of work has been done by this gentleman. With this I will end the fifty fourth class and discuss more of the AIS system in a much more generic manner how it can be applied for a very simple example which will solve and give the results accordingly. Have a nice day and.

Thank you very much.