Introduction to Biomimicry
Shiva Subramaniam, Chief Innovation Officer
Gopalakrishnan-Deshpande Centre for Innovation and Entrepreneurship
Indian Institute of Technology - Madras

Lecture – 21
Step 4 – Abstract Design Strategies from Nature:
The Biomimicry Design Spiral

So welcome to week 4 of the course. Last week, we started looking at the biomimicry design spiral, which is the process of understanding lessons from nature and creating innovative solutions out of it. The biomimicry design spiral was created by designer Carl Hastrich in order to be able to apply biomimicry in an easy way in order to learn the lessons from nature. Now, we have looked at define, biologize and discover which are the first three steps in the spiral.

However, we would like you to remember one important thing here which is that they are not just linear steps, step by step you go through the steps and at the end of it you will have an idea that is not how this spiral works. Remember the word, the clue is in the word spiral. Because it is a spiral, it is an iterative process. Many times, you may have to go back and forth between the steps in order to refine something that you have done earlier based on new insights or new information that you get in a step.

So, it is an iterative process and always remember that as you go through the spiral. Also, we hope that all of you have identified a UN Sustainable Development Goal that you want to work with. If you have not already done it, please do so. Look at the 17 UN Sustainable Development Goals. Find out the one that appeals to you the most, what is the emotional connect you have to that goal, understand that goal better, and look at the targets and indicators for that goal.

And then move on to the spiral. Stop at the ‘define’ step, and define the problem statement that you would like to address under that goal. It is important that you do that in order to get the full benefit of looking at the spiral because remember that biomimicry is a practice, it is not just a theory. It is not just looking at these videos and reading up on some things and you will understand, will become a biomimic, that is not how this will work.

You will have to do this yourself in order to be able to understand it better. So, please take your goal and work along with us as we go through these sessions. So, you have looked at define, biologize and discover which means that you now have a list of organisms that perform a function that you are interested in. This function is connected to the 'define' question that you have set up.

So, you have a list of organisms, you have a list of biological strategies associated with that organism in a way they perform a certain function. So that is what you must have before you jump into the abstract step. But before we go to 'abstract', there is a term that I would like to introduce to you.

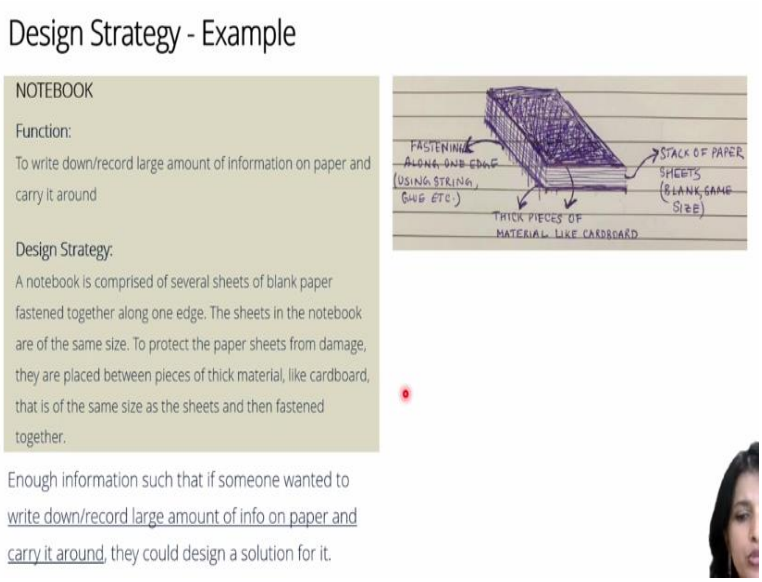
(Refer Slide Time: 03:43)

And this term is design strategy. The strategy as you know is how something is accomplished. We have spoken about this several times before. A biological strategy is how a biological function is accomplished. So, a design strategy is how a function is accomplished without using any technical terms in very simple language. And we are going to see that with an example now.

But before that, the key feature of a design strategy is that it uses very simple language and you can use simple diagrams to highlight the functional elements of the strategy. And you know this may sound a little complicated right now, but we will see that with an example shortly, so just bear with me here. Now, the important aspect of a design strategy is that anyone looks at the strategy alone, they look at the description and they look at the diagram.

They will be able to design the same function without knowing anything about how you got to that strategy. So that is what a design strategy is. It has enough information so that if somebody wants to design for the same function, they will be able to do it. Let us see the example. And I have purposely picked up a non-biomimicry example here.

(Refer Slide Time: 05:07)



And the example is going to be that of a notebook. So, the first step in writing down a design strategy, and putting together a design strategy is to understand the function that you are designing for. So, what is the function of a notebook? Think about what the function is of a notebook for you. I have used to write down or record a large amount of information on paper and carry it around that is what I think is the function of a notebook.

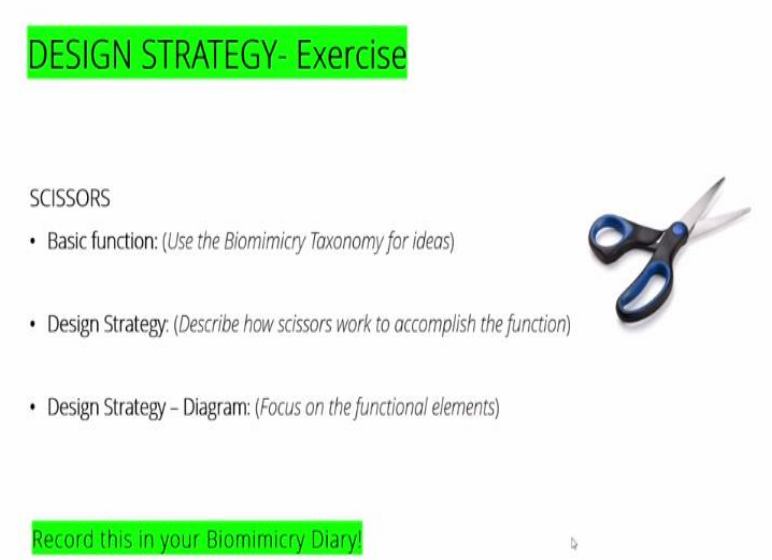
Given that this is the function of the notebook, what is the strategy that a notebook employs in order to accomplish that function? So, if I have to write down and carry a large amount of information with me, what is the strategy? How does it accomplish that? And the strategy is, remember this is a design strategy, so it has to be very simple. I am going to read it here, so you can follow it along. Let me use the pointer. A notebook is comprised of several sheets of blank paper fastened together along one edge.

The sheets in the notebook are of the same size. To protect the paper sheets from damage, they are placed between pieces of a thick material like cardboard that is of the same size as the sheets and then fastened together. This is my design strategy for the notebook given the function that I have picked up. And I have drawn a simple diagram that focuses on the key

functional elements of this strategy, which is the fastened along one edge, the stack of sheets, and the two sheets of cardboard to prevent damage.

So, this is the design strategy that you see in front of you for a notebook. Remember, the key thing about the design strategy is that there is enough information such that if someone wants to write down or record a large amount of info on paper and carry it around, they can do it by looking at this strategy. Nothing like practicing it on your own, right.

(Refer Slide Time: 07:22)



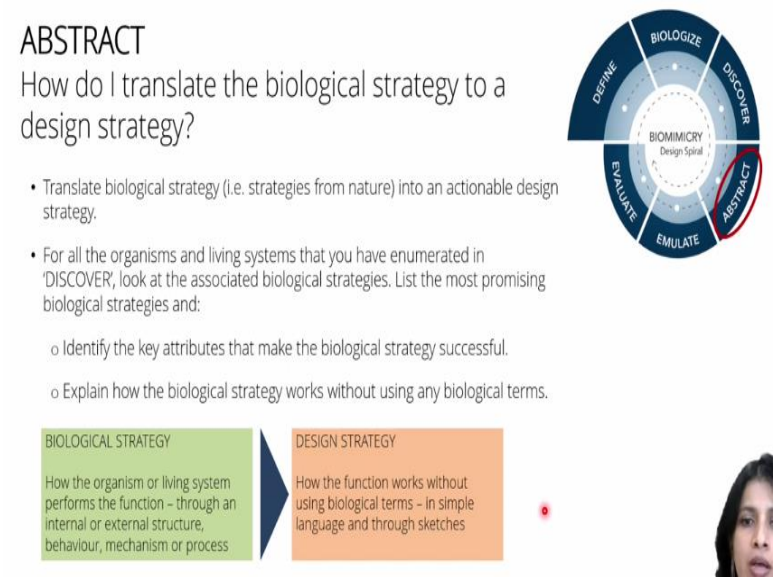
So, I urge you to pause the video for this exercise now and do the design strategy on your own for a simple object which is a pair of scissors. What you need to do is the basic function of the scissors. What is it that you are going to do a design strategy for? What is the design strategy in simple words and a simple sketch that focuses on the functional elements. Now, I have said use the biomimicry taxonomy for ideas on the function.

Remember that even though this is not a biological entity, it is not an organism, I have recommended that you can use the taxonomy for ideas on the function on what words you can use to describe a function. So, what is the basic function of scissors? It could be cutting, whatever it is that you want to think of as a basic function of the scissor. And then how does it work to accomplish the function?

What are the key functional elements that come together in order to make this function happen? And draw a very simple diagram, do not just draw the same diagram of the scissor, draw a simple diagram focusing on the function that is being accomplished. Go back to the

example of the notebook in case you have a question on how to actually do it. Now, do not forget to record this in your biomimicry diary because then it will be easy for you to look at it later on and refer to it later.

(Refer Slide Time: 09:13)

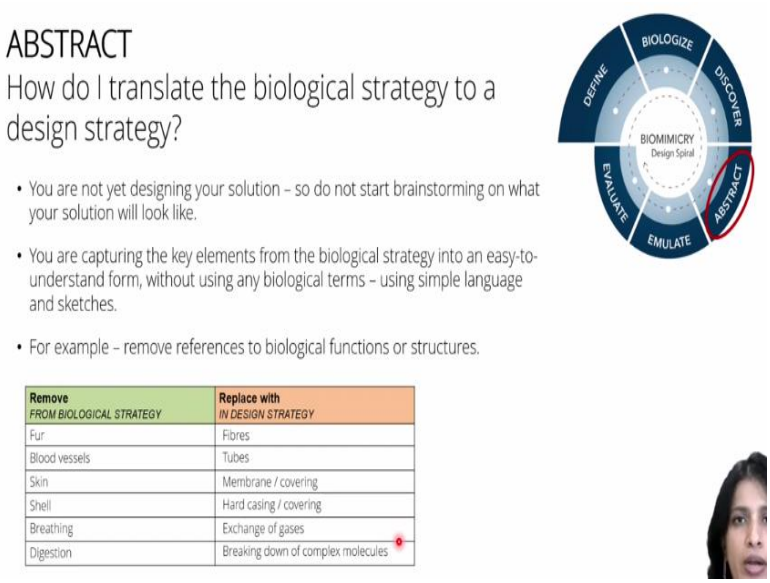


So, this brings us to step 4 of the spiral, which is abstract. And in 'abstract', what are we trying to do? We are translating the biological strategy into a design strategy. In 'discover' you have come up with a list of organisms and the associated biological strategies that they have in order to accomplish a function. Now you are going to take those biological strategies and convert them to design strategies.

And how you are going to do it is; take each organism's biological strategies one by one, identify the key attributes of that strategy, and convert it to a design strategy. Remember, you are not going to do it for all the organisms all at once, you are not going to combine all of them all at once. You are going to take each biological strategy one by one and convert it to a design strategy. Now, this is what you are going to do.

The biological strategy is how the organism accomplishes a function. And you are going to convert it to a design strategy to show how the same function is accomplished, but without any biological terms. So, you are going to translate the biological strategy to a design strategy for each organism that you have identified in the 'discover' step.

(Refer Slide Time: 10:11)



And before we go through the steps of doing that, just remember that you are not yet starting to design a solution. You are merely translating the biological strategy into a design strategy. So do not start bringing in your own ideas or brainstorming any new solutions at this point in time, this is not the time for that. Also, you are going to convert every strategy into its simplest terms.

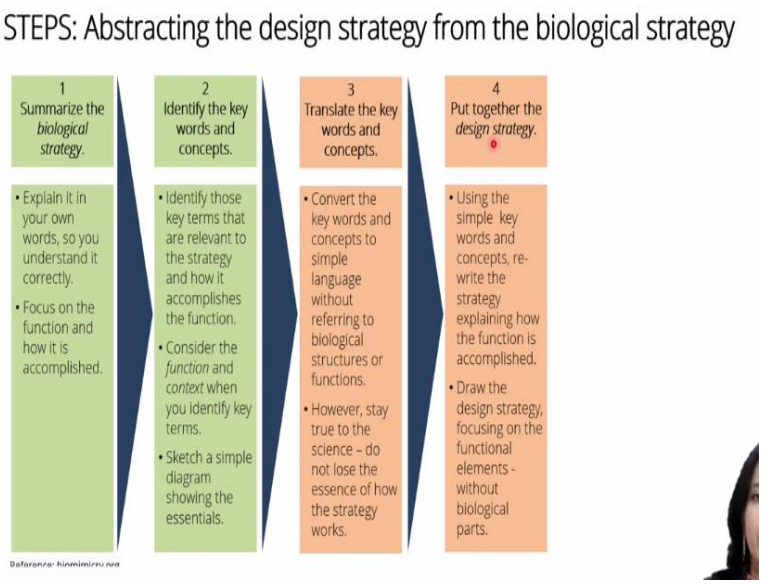
You are going to remove references to the name of the animal, the body parts of the animal, the biological processes that happen, etc. For example, if you have the word fur, you will replace it with fibres because that is what it is right fibre, in the simplest terms fur is a collection of fibres. If you have the word blood vessels, you are going to replace it with, any guesses? tubes, because that's what in the simplest terms blood vessels are.

Skin can be replaced with membrane or covering. Shell can be replaced with hard casing or covering. Breathing can be replaced with exchange of gases. Digestion can be replaced with breakdown of complex molecules. Now, this is not a hard and fast rule that I have tried to give here. I have just tried to give you examples of how you remove references to biological terms.

When you are creating a design strategy, you are trying to move from a specific biological strategy to a general strategy on how to accomplish the function. Go back to the notebook example if you are having difficulty understanding this. What is a general way of describing how the notebook accomplishes the function of carrying around large amounts of information with you? And how do you accomplish that?

So, the same way here, you are going to take a biological strategy that has a lot of specific mechanisms on how the organism does it and convert it to a general strategy that anyone could use in order to design for that function. Let us look at the steps on how to do that.

(Refer Slide Time: 12:26)



The steps would be you pick up the organism and the associated biological strategy first and summarize the biological strategy first. Write it down in your own words. Identify the keywords and concepts in that strategy. Translate those two non-biological terms and then put together your design strategy with a simple description and a simple sketch or a diagram. We are going to look at this in detail with an example.

(Refer Slide Time: 12:59)

The first step is to summarize the biological strategy. So, pick up the first organism that you have identified, take the biological strategy of that organism, explaining it in your own words. Do not just copy and paste it from AskNature or any other source, write it down in your own words because only then you will understand it fully. When you are writing it in your own words, focus on what is a function and how it is accomplished.

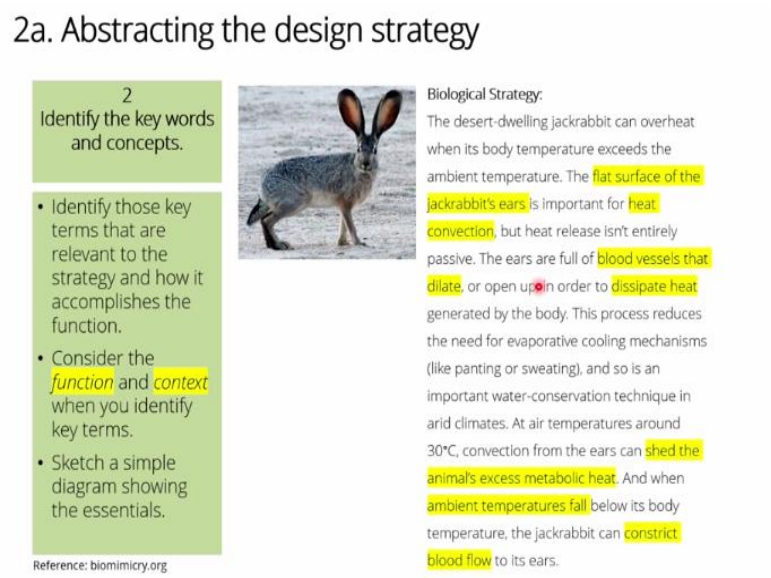
Remember, you have already identified the function in biologize which is why you came up with this organism, right? So, focus on how that function is accomplished and write the biological strategy in your own words. The example I have taken here is the jackrabbit that lives in the deserts. So, this is the jackrabbit for you with the huge ears and the biological strategy that it uses to accomplish a certain function.

I am going to read this here because then you will be able to follow along. The desert-dwelling jackrabbit can overheat when its body temperature exceeds the ambient temperature. The flat surface of the jackrabbit's ears is important for heat convection, but heat release is not entirely passive. The ears are full of blood vessels that dilate or open up in order to dissipate heat generated by the body.

This process reduces the need for evaporative cooling mechanisms like panting or sweating and so is an important water conservation technique in arid climates. At air temperatures around 30 degrees Celsius, convection from the ears can shed the animal's excess metabolic heat. And when ambient temperatures fall below its body temperature, the jackrabbit can constrict blood flow to its ears.

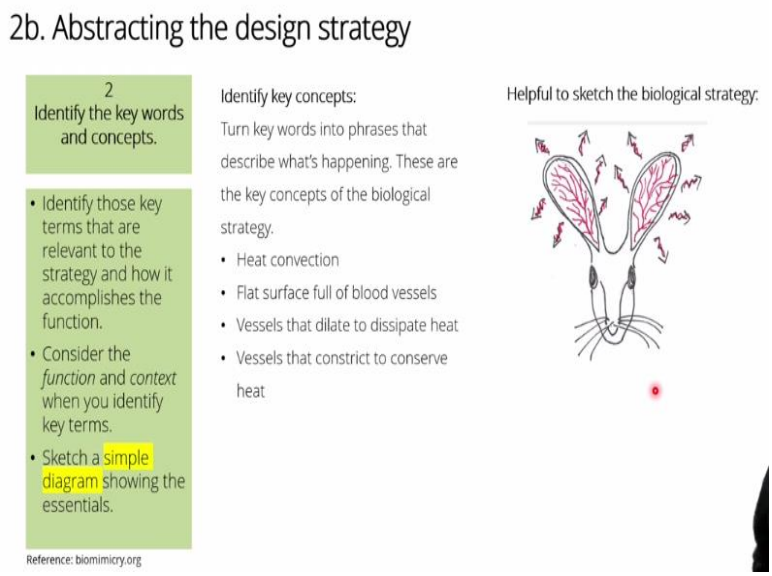
I guess you got a fair idea of what the jackrabbit is doing, the strategy that it is employing, courtesy its ears. These large ears that you see in order to maintain its body temperature. Now you summarize the biological strategy in your own words.

(Refer Slide Time: 15:17)



The next step would be to identify the key concepts in that biological strategy. So, focus on the terms that are related to the function and the context. So, with the same biological strategy that you saw in the previous step, I have highlighted the keywords and the key terms that relate to the function and the context. So, you can see the keywords here, flat surface of the ears, heat convection, blood vessels that dilate to dissipate heat, shed the animal's excess metabolic heat, ambient temperatures fall, then it constricts the blood flow. So, these are the keywords that explain what is actually happening in this case of the jackrabbit.

(Refer Slide Time: 16:02)

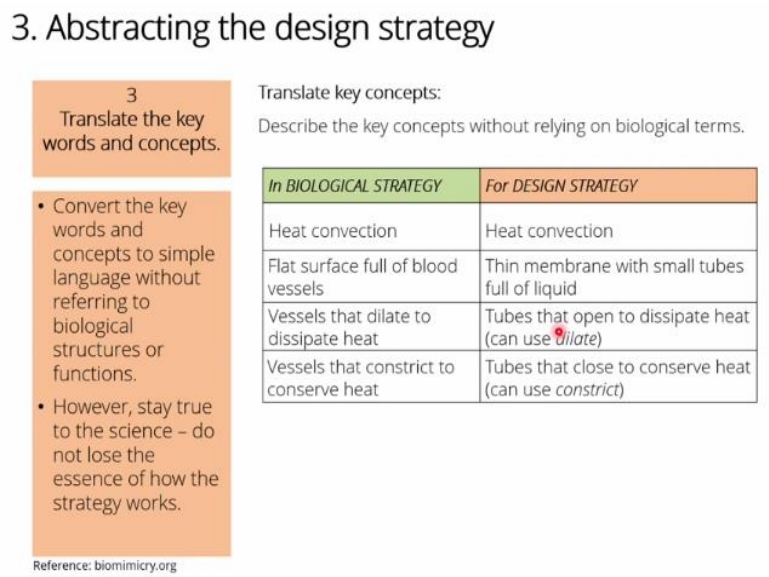


The next step would be to identify these key concepts. I have written down the key concepts here and sketched a simple diagram to show the biological strategy. Remember that this is not yet the design strategy, this is still the biological strategy. So, I have identified the key

concepts in the biological strategy and I have incorporated them into a simple sketch. So here is the jackrabbit. And you have the huge ears here.

The surface of the ears is full of blood vessels that open up in order to give out the heat and will close in order to conserve the heat. So, this is a very simple sketch to explain the biological strategy. Now, these steps that we saw, 1 and 2, are very important because they help you understand the biological strategy very clearly in your head before you can proceed to convert this to a design strategy.

(Refer Slide Time: 17:03)

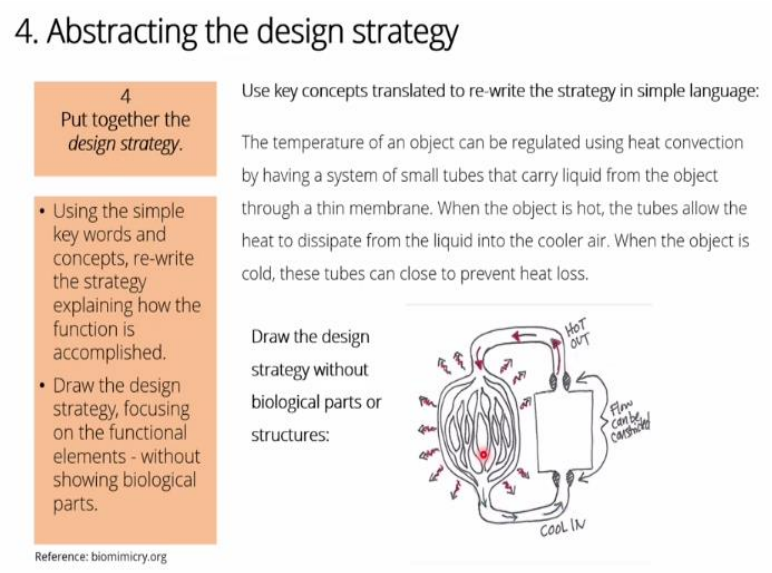


So now that you have the biological strategy in simplest terms, with maybe a simple sketch here, you move on to converting the keywords and concepts that you identify, basically these keywords and concepts that you identify to nonbiological terms. So, the keywords are identified here, what could be the nonbiological terms? Heat convection can be heat convection, remember that there are some terms that you cannot convert to nonbiological because they relate to physical processes or something, so do not worry about that.

Flat surfaces full of blood vessels could be thin membranes with small tubes full of liquid. See here, the reference to blood or blood vessels have been completely removed. Vessels that dilate to dissipate heat, tubes that open to dissipate. Of course, you can use dilate too if you want, but tubes that open to dissipate heat is simpler to understand. Similarly, vessels that constrict to conserve heat can be tubes that close to conserve heat.

So, in the third step you have taken the keywords and concepts from the biological strategy and converted them to nonbiological terms. Now, this may take some doing on your part, there will be some practice involved here. So do not get disheartened if you do not get it right the first time.

(Refer Slide Time: 18:26)



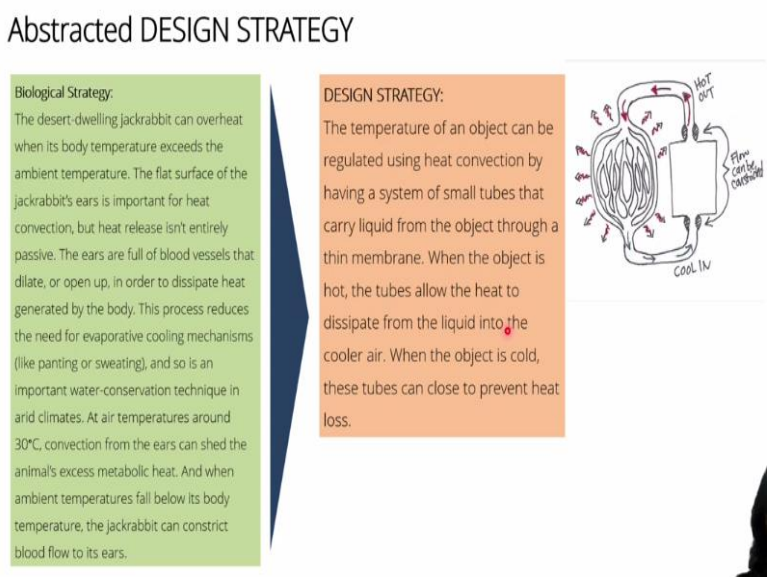
Then, the last step would be given that you have identified the nonbiological terms to describe the strategy, you put together a simple description of the strategy. Remember that the design strategy is a general way of accomplishing the function and you know the words that you have to use to accomplish that function to describe how the function is accomplished because you have already identified the words that you are going to use in order to describe the design strategy.

So, let us see how that can be done. I am going to read this again. The temperature of an object can be regulated using heat convection by having a system of small tubes that carry liquid from the object through a thin membrane. When the object is hot, the tubes allow the heat to dissipate from the liquid into the cooler air. When the object is cold, the tubes can close to prevent heat loss.

This is how the biological strategy has been rewritten in very simple terms by removing all the biological references. You know, you cannot even see that this is from a jackrabbit or it is about ears and blood vessels, none of that is here. It is a general way of how a body is conserving or dissipating heat depending upon whether the body is hot or cold. And here is a

simple diagram that explains the same strategy here. So there is a constriction or the dilation of the vessel of the tubes here in order to dissipate the heat or conserve the heat.

(Refer Slide Time: 20:04)



So, what has happened at the end of the four steps is you have this biological strategy which is a very specific way in which the jackrabbit maintains the temperature of its body. And you have converted it to a very general strategy of a body maintaining its temperature using a strategy and that is what the abstract step entails.

(Refer Slide Time: 20:28)

You will notice that it is no longer describing a biological system. You have no reference to jackrabbit or ears or blood vessels, etc., in the design strategy. But at the same time, if anyone wants to design a body or design a function for a body to maintain its temperature, they can

look at this and still design it. So that is even though they do not know what a jackrabbit is, they do not know what the biological method is, etc., the designer can still do that.

And that is what you need to try for when you write down the design strategy, when you sketch the design strategy. Once you have done the first design strategy, you must critique it on your own. You must look at it and evaluate it, wants to make sure that you are capturing all the essential information. So, the three things you need to do is make sure you have all the relevant information.

Now sometimes what happens is when you are enthusiastic to simplify it, you may lose out on some information and make sure you have not done that. Also, remember your define question, and the function that you brought up in your 'define' question. Make sure that you have captured that in your design strategy because there is no point if you lose right off the function that you are designing for and write a very beautiful design strategy that is not going to work.

So, therefore, make sure that you have captured that. And also try and look at whether you have been able to get some new insights in this process because that will help you move on to the next step. Remember, you will have to do these steps for each of the organisms that you have identified in discover, go through the four steps in order to come up with design strategies for each of the organisms.

So, if you have 3 three organisms, you will have 3 three design strategies. If you have 5 organisms, you will come up with 5 design strategies. Do not try to combine all of them together and create one mega design strategy. Also, remember that you should not bring in your own ideas into the design strategy right now. Just translate what the biological strategy is into the design strategy.