

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

**Lecture – 24**  
**How to Apply the Biomimicry Process?**

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## Case Study

### Student Project



**ISHAAN JALAN**

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We are back to the case study section. Remember we told you we are going to be talking to you, we are going to be showing you lots and lots of case studies. Why case study is because you know when you are learning biomimicry, we could simply go on and on, given you all the gyan but a case study helps you understand that there are people who have actually done and succeeded in the process, which is why it is also an encouragement. It is also nice to hear that a student has been successful in going from problem to solution.

So, the more and more case studies that you have, the more and more confident you will get that you can do this yourself. And I do not know how many times I have told you already, but can you imagine each one of you who is applying for a job, employment, actually telling in the CV saying that you are solving a world problem and you are using an out-of-the-box solution like biomimicry to solve that problem, can you imagine the power that he will have. I keep saying this.

I have said it several times. But it does not matter because I am hoping that all of you will start to choose a problem to solve and take that problem and put it on your CV and say I am solving

this problem. Because again and again, I keep telling you, employers want problem solvers. They do not care about anything else. Trust me, I have been in employment for a long time and the only thing that was expected of me is to be a problem solver.

So, fall in love with the problems. Now let us go to Ishaan, Ishaan Jalan, Department of Biotechnology, IIT Madras. What has he done? What should by now he will be familiar with? You already heard about several student projects, you will be familiar.

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### UN Sustainable Development Goals



United Nations Sustainable Development Goals. I do not know how many of you have chosen your goal already. If you have not, please choose. Ishaan has chosen goal number 7, affordable and clean energy. Why? because of the emotional connection.

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### 7: Affordable and Clean Energy

Ensure access to affordable, reliable, sustainable and modern energy for all

TARGETS SELECTED	INDICATORS SELECTED
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.2 Proportion of population with primary reliance on clean fuels and technology
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption

And so therefore affordable and clean energy information. So, now it is easy for you. Now the process is falling into place. Choose the problem, and look for information. In this case, the information is already there, target selected, indicators selected. All these things give you information. Read for about 2 weeks, you must spend at least 2 weeks reading about affordable and clean energy. Why should you read?

Because reading will tell you what is the information that you have on affordable and clean energy. And why is that important? Because that information will let you understand, which is the problem you want to solve under the larger umbrella of affordable and clean energy. See how beautiful it is coming into place, falling into place? All you have got to do is read about the problem do not jump to the idea the minute you listen to a problem.

Read, read, read, read, read, get as much information, talk to people, ask questions, watch movies, and watch anything you can on affordable and clean energy and tack, one light bulb happens one light bulb moment happens, and say this is the problem I want to solve.

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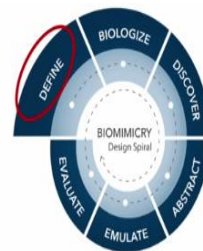
## DEFINE

What is the problem that I wish to address?

How might we cook food in a manner that does not cause pollution, health ailments, and uses readily available clean resources to reduce the effort required for cooking?

Why is it an important problem?

- Allow underprivileged citizens to have access to clean fuels and better health
- Empower women as effort required for cooking reduces
- Prevent water, land and air pollution caused due to unclean combustion



So, this is the spiral. So, with the confidence of the spiral in the background Ishaan chooses the problem. So what does he choose? He chooses a very different sort of problem. How might be cooking food in a manner that does not cause pollution, health ailments and uses readily available clean resources? So that is what he chooses. That is the problem that he is framed.

At leisure pause this video and read the problem very well. For me, the purpose of today explaining it to you is just to take you through the process. So, why is it important for Ishaan?

Why it is an important problem is because he talks about all the emotional connect he has with the problem, about underprivileged citizens and empowering women and all that. So now he has defined a problem. What does he do next?

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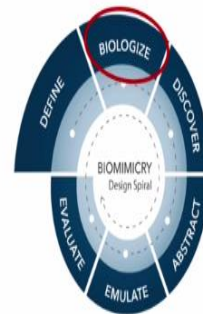
## BIOLOGIZE

How does nature accomplish what I wish to address?

Functions in nature related to the problem I chose:

- Capture and store energy
- Produce food
- Break down chemical molecules

- How does nature break down food molecules in hot weather conditions?
- How does nature capture and store energy in unclean, dark, closed environments with limited access to resources?



He does 'biologize.' By now all of you will be familiar. He says how does nature accomplish what I wish to address? When you are sleeping, when you are waking up in your sleep, you are going to be starting to ask these questions. It is going to become part of you now, how does nature accomplish what I want to address? So, therefore what should you look for? The functions.

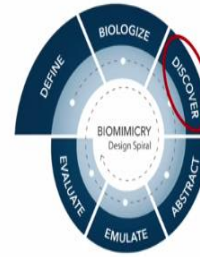
The functions in nature that are related to the problem. Here, what are the functions that are related to the problem? Capture and store energy, produce food, break down chemical molecules. So, therefore, the question he asked is how does nature break down food molecules? So, the function that he wants to accomplish and the function that nature accomplishes are the same. And therefore, he asks 'how does nature accomplish that function?' so that he can discover the organism that accomplishes the function.

How does nature break down food molecules in hot weather conditions? And how does nature capture and stored energy? These are the two functions he wants to ask. How does nature do it? What does he do next? He does discover.

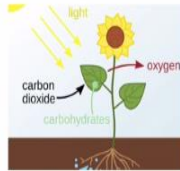
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## DISCOVER

What organisms or systems perform the same function that I am trying to address?



### 1. PLANTS



- Photosynthesis is a process that takes place inside the chloroplast cells of a plant which contain water and carbon dioxide.
- The chlorophyll acts as catalyst for the reaction and light is used as a source of energy.
- The reaction produces glucose as a product and oxygen as by-products.

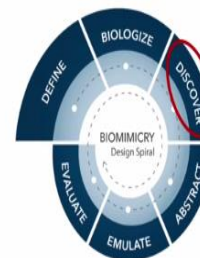


He goes to AskNature.org and looks at those organisms that perform the same function that he wants to accomplish. And he looks at plants and he looks at what the plants do and says oh, plants also do what I want to accomplish. I am not going to get into it, but you must read it at leisure, to find out the strategy that plants have.

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## DISCOVER

What organisms or systems perform the same function that I am trying to address?



### 2. ORIENTAL HORNET



- The oriental hornet's body consists of an outer layer called a "cuticle" in two colors brown and yellow, which help in harvesting solar energy.
- The cuticle has grooves and bumps to increase the surface area for energy capture.
- There is a voltage produced when light falls which is then stored as electrical energy.



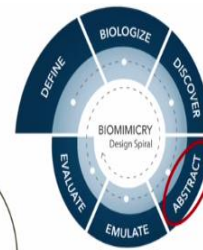
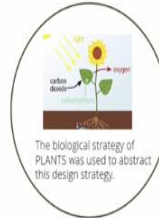
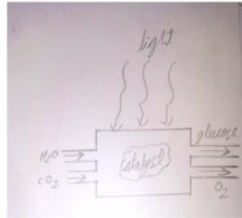
Then he chooses the oriental hornet. The oriental hornet. Very strange, right? It is also beautiful. Imagine, right in front of our eyes a problem is being solved and that is the beauty of biomimicry. You know what I did not even know the names of many of these organisms before I started learning, what a shame, but I am glad I am learning biomimicry, at least I am able to understand the engineers that these organisms are, oriental hornets and therefore the oriental hornets accomplish some of the functions that he is trying to accomplish. And then what does he do? He does abstract.

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### ABSTRACT

How do I translate the biological strategy to a design strategy?

1.



Light energy can be converted to chemical energy to drive processes. The system contains a catalyst that gets oxidized when light energy is absorbed. The loss of electrons is compensated by oxidizing the water molecules to oxygen, the electrons reduce carbon dioxide to glucose which is then circulated around as fuel. Reactants like carbon dioxide and water are input from the surroundings.



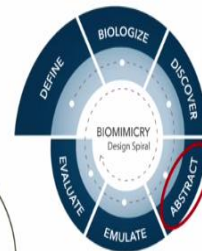
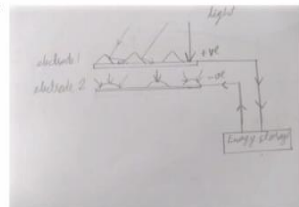
‘Abstract,’ is making it simple. So, in the organism called plants, this is the biological strategy that is translated to a design strategy. He has made it very simple, looked at the strategy, and abstracted in simple language what plants do.

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### ABSTRACT

How do I translate the biological strategy to a design strategy?

2.



Surfaces with bumps and grooves that are used as electrodes to generate a voltage

The outer surface is a collection of increasingly thin, colored electrodes layered over each other. When exposed to light rays, a voltage difference is generated between electrodes which is stored inside the system in batteries. The electrodes consists of grooves, bumps to increasing the amount of light received, absorptivity of the surface.



Similarly, the same thing he has done abstract for the oriental hornet. His constant quest is the ‘define’, what is the ‘define’ for him? The ‘define’ for him is how might we cook food in a manner that does not cause pollution, and then he has gone to how does nature accomplish the function that he wants to accomplish. And then he discovers plants and oriental hornet and he abstracts the principle, the biological strategy of those two organisms in simple language.

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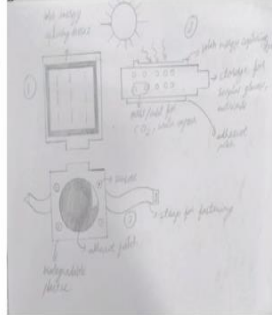
## EMULATE

How do I apply the bio-inspired strategy to the problem that I wish to address?



### Device that produces and injects nutrients into the body using sunlight.

- A wearable device that attaches to the forearm by the means of an adhesive patch that has micropores which transfer the glucose, nutrients produced in the device to the bloodstream of the user.
- The device uses carbon dioxide, nitrogen, sunlight and water vapor in the air to manufacture glucose, vitamins, proteins.
- The outer casing of the body is made up of a biodegradable plastic which is skin-sensitive, robust and extracted from bacteria.
- The solar-energy capturing aspect of the device is based upon the working of the oriental hornet to make it less resource intensive, more efficient and sustainable.
- The device also has sensors so that it can store the produced nutrients inside the storage chamber when the body doesn't require them and pass it on to the body at times like night or unclear skies when the device cannot receive sunlight, just like how plants do.



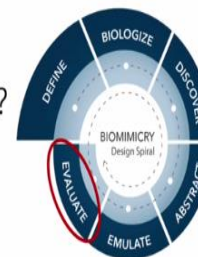
And now, this is the time, from abstract to emulate, where the bulb starts to shine in his head. He could have thought about a thousand ideas, but he chooses to think about this idea. So, he thinks about a device that produces and injects nutrients into the body using sunlight. So, there is a device, a wearable device that produces and injects nutrients into the body using sunlight. I am not going to get into the details because it is going to be boring to read it for you, but you must.

You must pause at this moment and read it because that will help, that encourage Ishaan's work. Because he has worked so hard on the strategy, emulate on the idea and therefore that is what he wants to do. He has drawn us a picture of this idea, the solution.

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## EVALUATE

How can my solution be applied in the real world?



How will I follow nature's 'design principles' in my solution design?

- Solution uses sunlight as the main source of energy which is abundant.
- The patch uses skin-friendly adhesives and the inner chemicals responsible for the working of the device are derived from nature hence safe and non-toxic.
- The solution uses biodegradable plastic materials which can be broken down easily and is extracted from bacteria.

What are the next steps to implement or deploy my solution?

- Do feasibility checks on my assumptions, hypotheses by consulting experts, professors.
- Experiment with plants and oriental hornets to abstract their biological strategies.
- Form a team and make a prototype of the product.



And he has done the 'evaluate.' 'Evaluate' is looking at nature's principles, finding out if I can design something according to the way nature designs. Reading the first line will help you understand 'evaluate.' The solution uses sunlight as the main source of energy, which is abundant, the principle is nature uses only abundant resources and therefore he looks at nature's principles, and sees to it that he follows nature's principles.

And the next question is what are the next steps? He says again feasibility study on the assumptions and all that, but ultimately what has happened? From a problem he has come to a solution using a disciplined process. Remember, that this spiral is iterative. If you are not satisfied with your final solution, you can go back to biologize, you can go back to define, you can go back to discover.

So, what have we learned? We go from problem to solution using the spiral. And Ishaan has helped us understand how he has gone from problem to solution. I hope the more and more case studies that you see the more and more inspiration you have. And it is important therefore now to be starting to be believing in yourself and saying, I want to solve one of these problems too. And look for answers from nature.