Introduction to Biomimicry
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Lecture – 30
Natures Unifying Patterns II Week 6 Part 2

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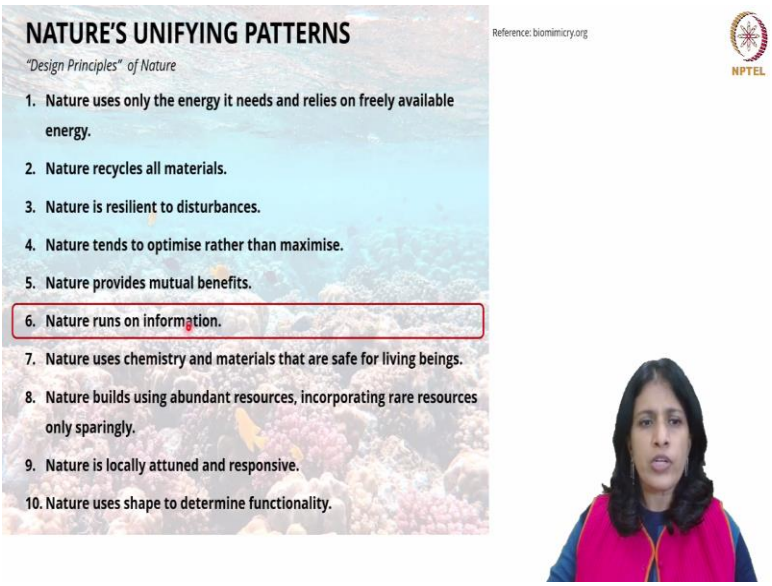

Last week we started looking at Nature's Unifying Patterns. In detail, we looked at five of these patterns and tried to understand them a little better, what do they mean, what do they imply. These 10 patterns as you know are the essential lessons from nature as far as design is concerned and by looking at these patterns, by imbibing these patters we can start designing like nature.

Again, these patterns are not just for Biomimicry, of course, they had a useful lesson in Biomimicry, but they can also be used by anyone who is willing to incorporate these in their life and work in order to build, in order to make something more sustainable, in order to build sustainable solutions and also bring sustainability into their lives. So, we saw nature uses only the energy it needs which means that organisms use low-energy processes.

They do not try to use more energy in order to get energy and all of nature's energy sources are freely available which means that you do not have to mind them, they are available locally and readily. Nature recycles all materials we spoke about how upcycling is very accurate to describe what happens in nature, the log that falls on a forest floor, how that is

broken down into components by organisms like fungi which is then used up by other organisms and so on and so forth.

So, nature recycles all materials it is an important lesson for us in all of the things that we do, all the things that human solutions do. Nature is resilient to disturbances, nature has a very uncanny ability to recover from any tough conditions from difficult conditions using four enabling mechanisms namely diversity, redundancy, decentralization, self renewal and self repair. So, that is what makes nature resilient to disturbances.

Nature also tends to optimize rather than maximize, there is always a balance between the resources used and the resources expanded. So, that is something that nature does all the time, all life forms, all organisms actually end up doing that and nature provides mutual benefit and all of nature you will see these cooperative relationships that work in order to provide benefits to all the parties involved, to all the life form involved.

And even if they are not cooperative, they actually work well in the system context we saw that already. Now, let us move on to the next set of patterns. As mentioned earlier they are not in any specific order. These 10 patterns are not in a specific order. All of them are equally important, equally relevant. So nature runs on information. Before we start looking at this also try and connect this to what you learnt about system thinking.

System thinking you learnt that there is an interconnectedness. There are relationships that exist between I mean all systems of course, try and apply that in the context of Nature's Unifying Patterns as well and you will start seeing the connections. I mean clearly right now if once you start hearing about nature runs on information you will immediately start making connections to the other patterns that you have already seen.

Out here the patterns that you already looked at, you can start looking at connections between them. Nature is resilient to disturbances. Nature tends to optimize rather than maximize. There is a connection that you can see now. There are of course other connections that you can start making as well. So, instead of looking at each of these as individual patterns, individual lessons that you need to learn, also start looking at the connections between them.

And they work together in order to help us live sustainability and create more sustainable solutions.

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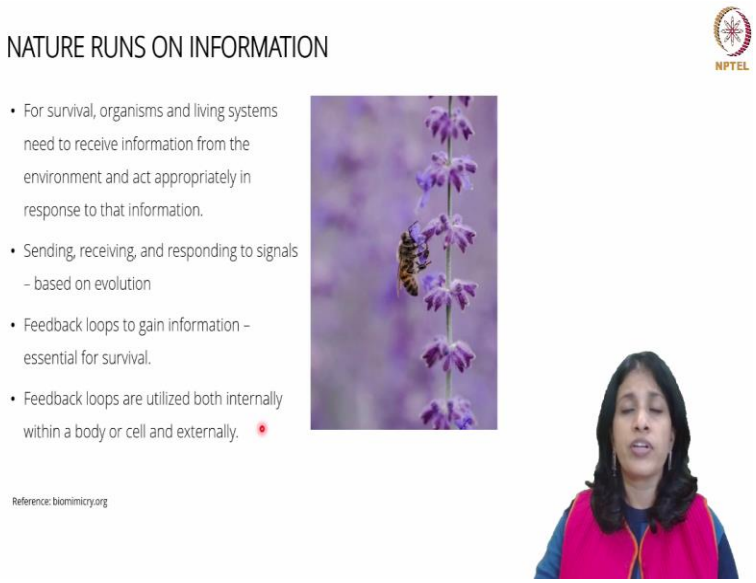

So, let us come back to nature runs on information. What does that imply? All of nature for survival of any life form or any living system they need to receive information from the environment and act on that information appropriately. Now, this is something that sounds very obvious that is an important lesson to learn because the act of sending, receiving and responding to signals is actually an evolutionary capability that has been fine-tuned for several millions of years.

Some organisms have a very narrow range of optimal conditions in which they can function. So, therefore it is very critical for them, it is very critical for those living systems to keep monitoring their environment in order to ensure that they are able to survive appropriately, other organisms still have a broad range, but they need to make sure that those conditions are not actually approaching the limits.

Whether it is something like availability of oxygen or whether it is the maximum survival of temperature, organisms, and living systems constantly need to monitor the environment to ensure that they are the optimal conditions are available to them and if not what they need to do, how do they need to respond to those conditions. So, these kinds of feedback loops are critical for organisms' survival.

I think this is something that you would have observed even by looking at nature generally and these feedback loops are available not just between the organism and at the environment external to it even within the organism own body, within a cell you will actually see these kind of feedback loops where some conditions are constantly monitored and the organism keeps receiving information and acts on that information accordingly.

Now, these feedback loops could also be positive feedback loops or negative feedback loops. Positive feedback loops are loops where a process is speeded up based on the information receipt, a negative feedback loop is when the process is delayed based on the information receipt. So, this kind of mechanism exist in all of nature, in all life forms, in all living systems and critical to the survival of the living system as a whole.

And that is what it means when we say nature runs on information. Information is one kind of critical resource.

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So, one example of nature running on information would be the wood wide web. A fascinating phenomenon briefly explained in this video the link to which you see on the screen here. The link is also posted below the recordings. So, you can stop this recording and actually look at the video, it is not a very long video. It will give you a quick sense of what it is.

The wood wide web, just like the world wide web is a complex network, but this network is a lot of fibers optic cables etcetera. This is a network of fungi and bacteria that links trees

together. So, under the ground, there is this extremely complex network. These fungi and bacteria grow around the roots of trees and create this network which not just swap nutrients between trees.

So, the trees actually send nutrients to each other especially the older trees send nutrients to the younger trees, the younger plants. They also exchange other types of information. So, if one plant or a tree is under attack by pest it sends chemical signals to the rest of the network saying that hey I am on the attack. So, the other plants can raise their defenses. Similarly, if there is a plant that is diseased, a tree that is diseased it sends chemical signals to the rest of the network saying that it got some sort of disease.

And it can also dump all its nutrients into the network so that other organisms, other plants can actually pick up nutrients so that is the wood wide web very close to the way our internet functions and something that we do not even realize because it is under the ground. So, do look at the video and try and learn more about it not just from the video, but from other sources as well. A fascinating example of how nature runs on information.

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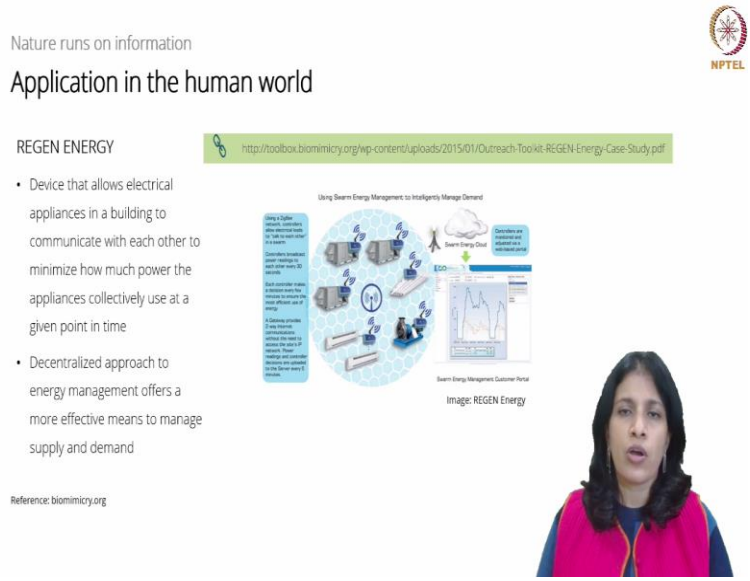

An example from the human world is this system created by a company called Regen Energy. There is a pretty comprehensive case study on what Regen Energy has done. They have used something called swamp energy management based on what these do in order to create that system, but briefly I am going to tell you about it here. What they have created is a decentralized network of appliances within a building. Now, these appliances talk to each

other to ensure that the collective power consumption of the appliances is kept to an optimal level.

So, instead of using a top-down approach where each appliance talks to a server. They talk to each other and they determine how to optimize the amount of energy that they use in order to keep the energy consumption peak loads at an optimal level. This is not just about nature running on the information this is not just a lesson taking the lesson on nature running on information, you can clearly see the connections to the other patterns as well.

I urge you to start looking at this, start looking at the connections between all the patterns and you will start seeing the kind of insights and perspectives that you start getting when you start looking at these patterns holistically rather than as individual patterns.

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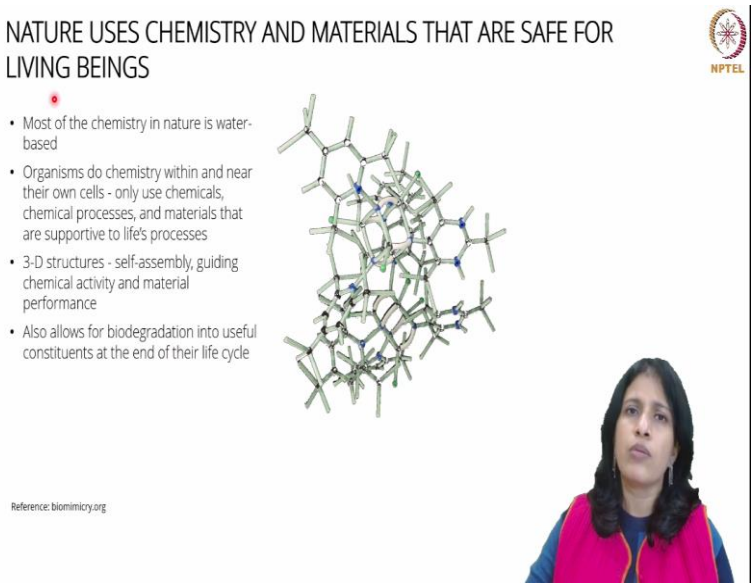

Next, let us look at nature uses chemistry and materials that are safe for living beings. Now, all of nature's chemistry is water based not based on any other compound or chemical it is all water-based and the key reason for that is all of the life processes, happen within or near the cells of the organism. So, therefore it makes sense that the organism ensures that the chemicals that are used, the processes that are used, and the materials that are used are all conducive to life.

It makes sense right otherwise it is going to be toxic; it is going to be something that is not going to create conditions conducive to life. So, therefore most of nature's chemistry is water-based and how that is accomplished is through chemicals that have very precise 3D

structures and what this ensures is that they are easily able to create these building blocks that can assemble on their own.

And they are able to guide chemical activity that is required for life processes and also the performance of these materials is enhanced because of the specific 3D structures that happened in nature. The best part is also because of these 3D structures what happens when once the job is done, once these chemicals have accomplished what they need to do, they are also degraded harmlessly without creating any sort of toxic waste which is harmful to the organism or its cells or other parts of the environment.

And that is what nature does in terms of the chemicals that it uses and the processes that it uses. Clearly, this is a very important lesson for human solutions and human processes because whether it is growing materials or sourcing materials or transporting materials, or manufacturing materials we clearly need to take this lesson from nature and use chemistry and materials that are safe for life because right now we know that we are struggling with toxic, non-biodegradable materials that are creating more problems when they solve and this is a lesson that can help us overcome that.

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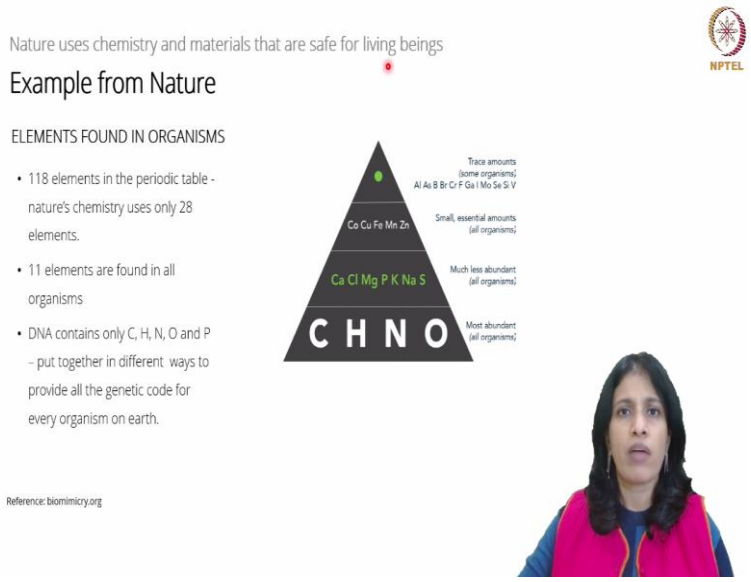

An example of nature using safe chemistry from nature would be the 118 elements in the periodic tables and this pyramid here actually shows how many of those are found in all livings systems and in all organisms, of all these 118 elements only 28 are found in nature's chemistry and of those 28, 11 are only found in all organisms. 4 of those 11 are carbon, hydrogen, nitrogen, and oxygen are the most abundant elements on Earth.

And they are found in all organisms. So, these elements are found in slightly lesser amounts and progressively in lower amounts in not all organism. So, nature chemistry is based on elements that are found abundantly, elements that are safe and these are the elements that are used in all of nature's chemistry. The fascinating fact here is the DNA. Now DNA as you know is the genetic blueprint for all of life on earth.

DNA contains only 5 elements carbon, hydrogen, nitrogen, oxygen and phosphorus and these 5 atoms come together in unique ways and are structurally arranged in unique ways in order to encode all life forms on earth. Think about how stupendous that is as an achievement and that is what the lesson is that nature accomplishes stupendous things, wonderful things, and still uses chemistry and materials that are safe for living beings.

Unlike human solutions which tend to be toxic and non-biodegradable and we think that we are doing it because we need to accomplish something very important or very difficult. Nature does the same thing without having any toxicity involved and that is the lesson we need to take here.

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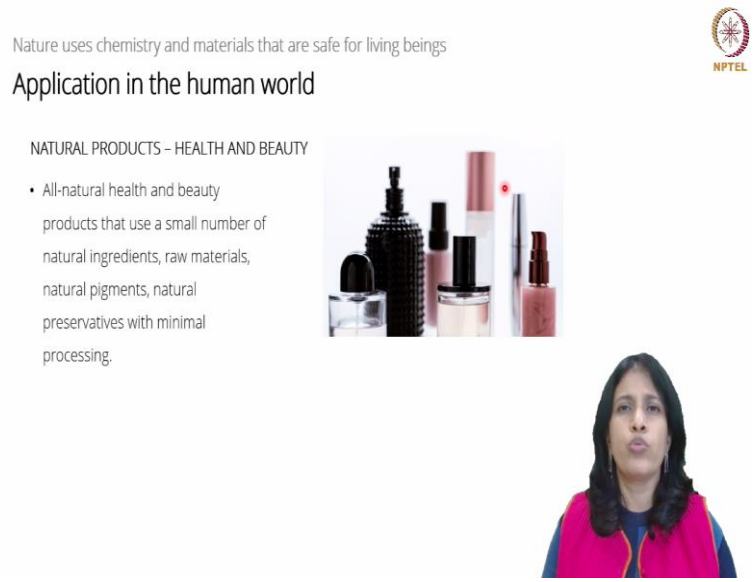

An application in the human world of using safe chemistry would be natural products. Now, natural products I mean products here that are genuinely natural products because there are several products that have just a label that says they are natural, all-natural, herbal etcetera. We are not talking about those products. We are talking about products that are genuinely natural which means what do they do.

They use a small number of natural ingredients just like what nature does. They use natural raw materials and pigments with minimal processing and that is how they become safe for living beings. Therefore, they are also biodegradable, they are non-toxic etcetera because they try to mimic what nature does in terms of chemistry, in terms of processing and that is how they end up being equally safe if not more for human beings as well.

So, that is an example from the human world of using safe chemistry. Again, you must start seeing clear connections between this pattern and other patterns that you already looked at and the patterns that we are going to look at. We urge you to start looking at those connections as well because that will be key for you to understand these patterns better, and find out how you can use them in the work that you do in the solutions that you create.

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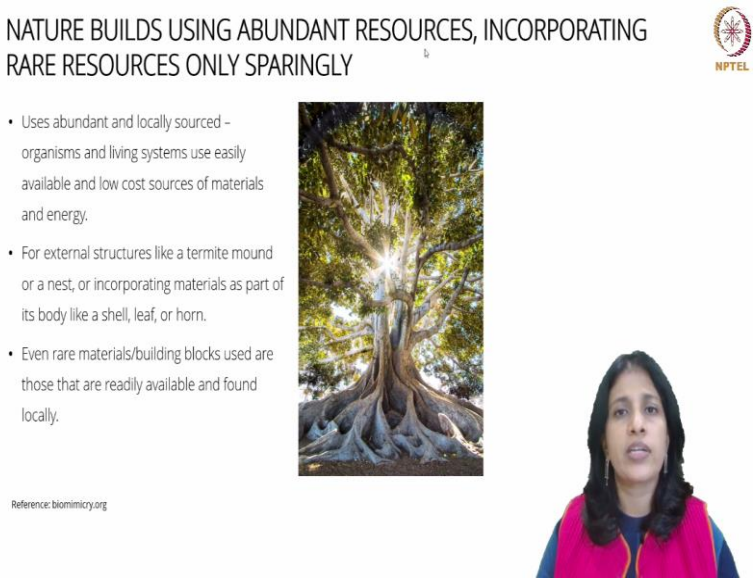

Next, let's look at this pattern of nature building, using abundant resources and incorporating rare resources only sparingly. What this pattern implies is that all living systems, all organisms look only for widely available and easily available resources in order to build things. Now whether it is building something that is external to the organism like the nest, like the termite mounds or the nest, or any sort of home that they build or incorporating materials as part of their own body.

All organisms will look only for widely available materials and even those widely available materials are those that are abundantly available on earth. We already saw in the safe chemistry pattern, carbon, hydrogen, nitrogen, and oxygen are the most abundantly available

elements on earth and organism use these abundant materials fully. See in the natural world what is abundant is considered gold.

And therefore used to the fullest extent possible whereas it is only in the human solutions and in the human world that we do not consider what is abundant as gold. We consider what is rare as gold and go after that. Nowhere will you find in the natural world that an organism travels millions of kilometers in order to source things like marble and granite and build their own house only humans do that.

Whereas organisms in living systems they use only abundant resources and even rate resources are those which are readily available in the local environment, not travelling millions of miles in order to procure it or shipping it or extracting it from the earth. That does not happen in nature.

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An example of this in the natural world would be the caddisfly. Now, the caddisfly is an insect that lives in the water and the larvae of the caddisfly builds these casings in which it lives to protect itself from creditors. So, this casing I mean you do not even know that this is a caddisfly it just looks like a piece of rock. So, it builds this casing using small pebbles, pieces of rock and shells and twigs etcetera.

And it extracts a type of silk to hold all of it together. There is a video that you can watch to see how this actually happens, how the caddisfly actually does it. The link to this video is actually posted below this recording as well. So, this is what the caddisfly does. It does not

start looking for materials that are not available to itself, it does not spend energy looking for materials that are rare.

It looks for materials that are available in its local environment because it lives in the water, it looks for materials that are available easily in the flowing water and creates this casing out of it to protect itself and because it is made of local materials it also blends in completely and it protects itself from predators as well. So, that is what the caddisfly does an excellent example of using resources that are abundantly available, readily available in its own environment, and not looking for rare resources.

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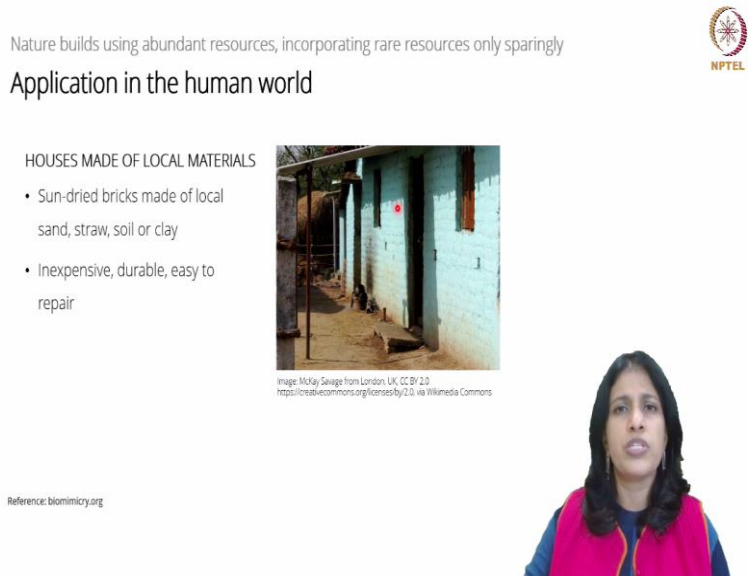

An example from the human world for this would be these homes that you see mostly in rural areas. So, they use sun-dried bricks that are made of local sands, straw, clay etcetera. Now these do not require a whole lot of sand to be mind from river quarries etcetera. So, using abundant resources is a lesson that these homes readily take and the best part is that these homes are inexpensive.

It's cheap to build, they are durable, they last in the environment that they are built for and also in many cases, they are energy efficient as well because if they are built with materials that are from the local environment. So, that is an example of using abundant resources in the human world.

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Next, let us look at a pattern that states that nature is locally attuned and responsive. Now, again I am going to reiterate that you must try and look for the connections between this pattern and the other patterns that you have seen. I am not going to spend too much time on that, but I am going to urge you to start looking at that on your own. What is this pattern imply?

The pattern implies that any living system there are a few conditions that enhance its chances of survival and what are these conditions. One is when they are good at recognizing local conditions and opportunities. Another is when they looked good at locating and managing available resources and the third is responding appropriately to information that comes from the local environment.

Clearly, you can see the connection between nature using energy, nature using resources, and nature running on information. So, these are essential conditions for survival and these come together in order to create this very important principle of being locally attuned and responsive. In any location in nature, you will find that living systems and the organisms that inhabit that have evolved based on the local environmental conditions.

Some of these conditions may be cyclical in nature, for example, tides or the seasons etcetera. So, what these organisms do is they take advantage of those cycles and accordingly tune their life processes to that. So, you have an organism that live in high moisture areas, they thrive in those high moisture areas whenever the tides come in and out they live in those regions. Also there could be some slower changes that happen.

And at the same time, organisms adapt to those slower changes as well. So, that is nature being locally attuned and responsive and this is kind of an aggregation of some of the other patterns that you have seen earlier.

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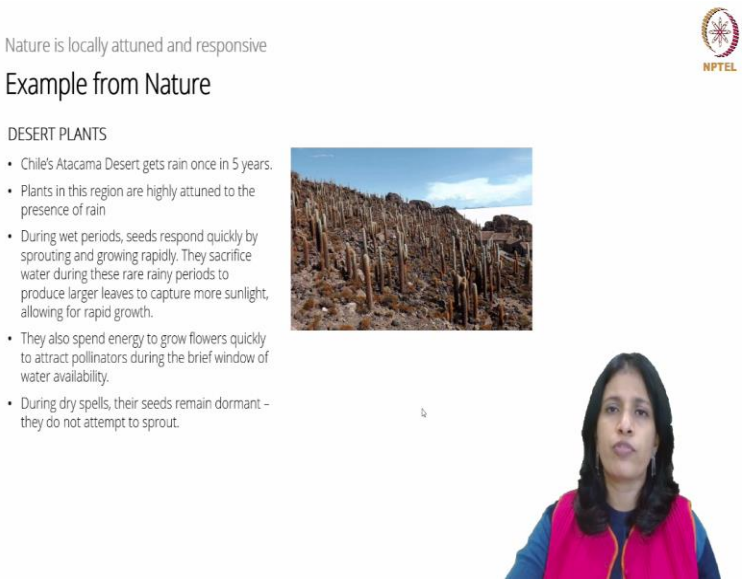

An example of nature being locally attuned would be the plants that you see in the deserts especially in Chile's Atacama Desert. Now, you have these plants that do not have very great water conservation strategies, but when it rains and it rains once in 5 years imagine they go through a long period of drought, but when it rains these plants ensure that they respond quickly. What do they do?

They sacrifice water during these periods to produce large leaves that capture more sunlight so that they can grow rapidly and they can grow flowers quickly so that this can help them reproduce, this can help them spread as well. So, in the brief window of water availability they ensure that all of their reproduction is actually happening and during the dry spells they do not attempt to do anything at all.

The seeds do not attempt to sprout they just remain dormant. So, they do not spend unnecessary energy in trying to sprout during the dry spells and that is an example of being locally attuned and responsive.

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An example of nature being locally attuned and responsive using the lesson of that in the human world would be this project called Jeevan Bindi or the life-saving dot. The bindi of course is this small little dot that most Indian women place on their foreheads. It is generally used to enhance appearance. Now, the background to this project is that iodine deficiency is a widespread problem among women in India especially rural women.

And these rural women can also not afford iodine supplements and because of that the deficiency of iodine causes lot of medical issues for these women. The local health sectors and doctors do give them supplements to take in oral form, but these women are not used to taking these supplements and therefore it does not really have much of an effect. So, there was this agency, there was this organization that looked at this problem.

They also found out that iodine can be absorbed through the skin. Therefore, they created the iodine patch, but instead of a patch that can just replace anywhere on the skin. They created it in the form of this bindi. It is an iodine patch which is also a bindi and they distributed it to all rural women across the country, in many parts of the country in India and this was able to solve the problem of iodine deficiency among many women because they got the required dosage of iodine through this bindi that they wear.

A clear example of understanding the local conditions and taking the lesson of being locally attuned and responsive to local conditions.

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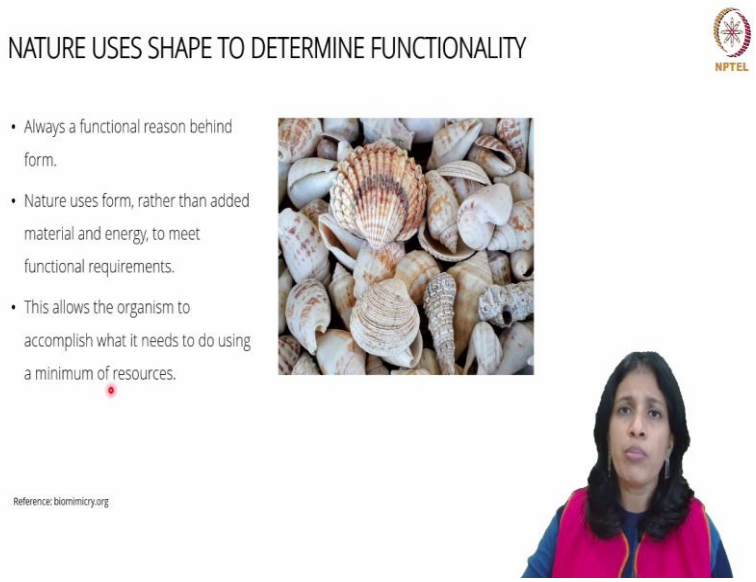

This brings us to the last pattern on this list which is nature uses shape to determine functionality. This pattern implies that any shape in nature there is always a functional reason behind it. Nature is not using materials, it is not using energy to come to a shape nearly because it can. The reason that it is doing it is because it uses the form as a reason to accomplish a function.

So, instead of just adding energy and materials in order to meet a functional requirement in nature you will see that it uses form to meet the functional requirement and this is quite a contrast to many human solutions right. We keep adding additional materials, additional energy just because we can in order to accomplish a function, but that is not what nature does.

And the benefit of doing this for nature is that a minimum amount of resources are actually used in order to accomplish that function. So, nature using form in order to determine function is an important lesson that human solutions can also take because this ensures that the usage of resources has actually optimized.

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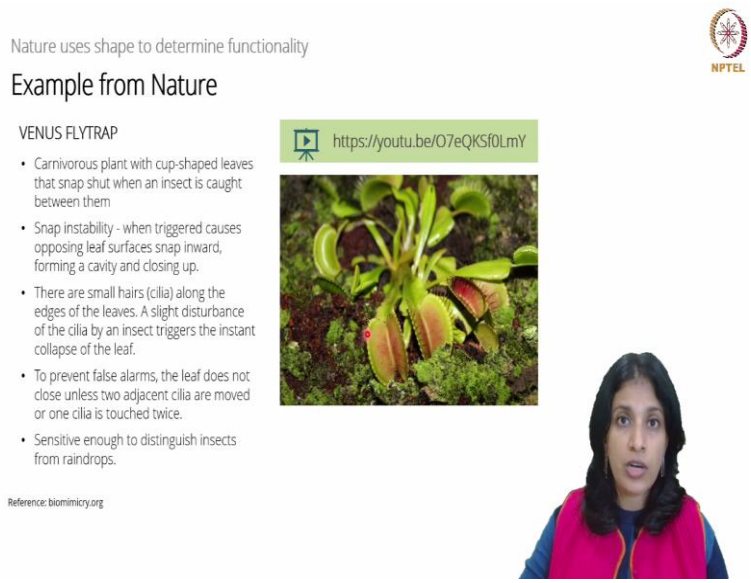

An example from nature of using shape for functionality is the Venus flytrap. Now, this video actually explains how the venus flytrap uses the shape to determine functionality. The link is posted below the recording so you can pause it and actually look at it. Now, the venus flytrap feeds on small insects and flies and how it does that is through the shape of the leaves that you see.

It is very unusual shape and this unusual shape is not there just for aesthetic reasons. Now, what happens is this shape is very sensitive. So, when an insect comes and sits on it, it actually snap shut and capture the insect inside this cup cavity. At the same time it is extremely sensitive as well because even if it knows how to distinguish between an insect and any other thing like a raindrop.

And these little hairs that you see along the sides of the leaf are sensitive to pressure. So, when an insect comes and disturbs it, it waits to see whether it is actually an insect or something else and based on that it snap shut and captures the insect within the cavity. So, do watch this video you will be able to see how exactly this mechanism works and how the plant has been able to use shape to determine functionality.

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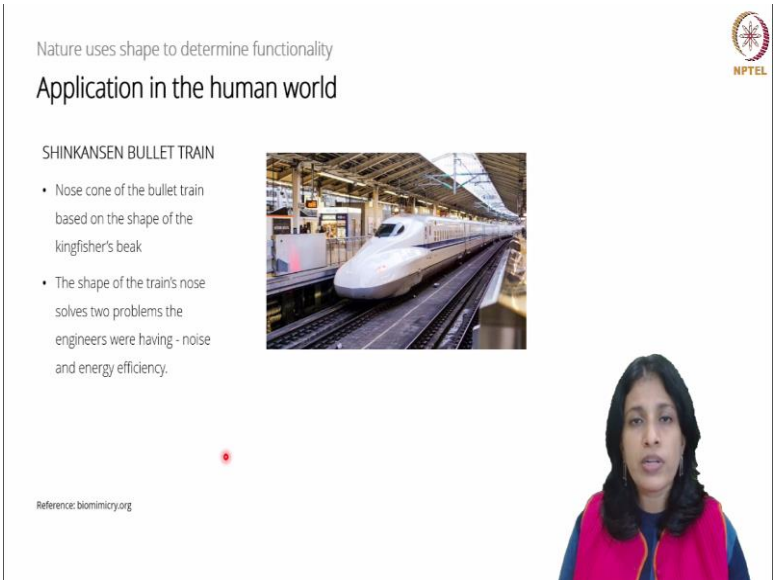

An example of the same thing in the human world is of course Shinkansen bullet train. You have been introduced to this example earlier as well. The nose cone of the bullet train is actually modeled on the kingfisher's beak. So, this bullet train earlier used to have a more rounded shape which is why it was called the bullet train, and unfortunately when it was passing through tunnels and exiting tunnels it used to create this huge booming sound which was causing a lot of noise pollution.

People living next to the train tracks used to complain about the noise. Therefore, the engineers looked to nature and found that the Kingfisher, the Kingfisher when it dives into the water to catch fish it does not make a splash at all. So, they used the small principle of moving from one medium to another without creating too much disturbance for the purposes of the bullet train as well and modeled the front of the bullet train, modeled the nose cone of the bullet train after the shape of the Kingfisher's beak.

Thereby taking the lesson of nature that shape is used to determine functionality. So, these are the 10 unifying patterns of nature that we have looked at. All of them fascinating in their own right, all of them giving us valuable lessons and how we can incorporate them in our life and in our work and also all of them connected to each other in many ways because by doing one pattern you can actually bring in aspects of anther pattern as well.

So, please do look at these patterns holistically, look at the interconnections and the relationships between the patterns of how one pattern can actually help you accomplish other

aspects of other patterns as well and try and see how you can imbibe them in your solutions, how you can imbibe them in your work.