Course Name: I Think Biology

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W4L18_Our Favourite Cells - Part I

Hello, in the previous lecture, you would have heard about cells, the cell theory, and you would have gotten a picture of how cells actually are not at all static and have really extremely interesting functions. And there are actually lots of things happening inside a cell, right? That it's it's a very dynamic system in which waste is being produced, energy is being taken in, there are all kinds of chemical reactions, and within the cell itself, there are many specialized organelles that have specific functions, right? You also heard in the very beginning of the course about the cell theory, talking about how cells are the fundamental unit of all life, and they are sort of the building blocks through which multicellular organisms are made. So in today's lecture, we have something special lined up for you, which is where we will tell you about our favorite cells. So cells come in a huge variety of shapes and forms. And of course, there are unicellular organisms, multicellular organisms. So each of us instructors in this NPTEL course will be describing to you our favorite cells.

So this is not just a fun exercise to talk about the variety of cells that there are that exist in nature. But it's also an exercise for us to view the diversity and how to actually put this in the context of evolution, right? The fact that there are cells that have so many different kinds of functions that they can survive in such different kinds of environments, that cells actually cooperate with each other in different kinds of ways, or not just cooperate, but you know, can cause harm to other cells or organisms as well. So looking at the variety also tells us that why we learn theories, right? so for example, cell theory, we like to categorize knowledge, but often, it's also important for us to see that there are exceptions to everything, every sort of, say, theory or every sort of dogma that we try to put in place. And that's actually what makes biology a really interesting subject.

So I'll start off by talking about one really interesting cell, which is Toxoplasma gondii. And this is a type of parasite. Yeah, this is the cell as a schematic of the cell that you see here. And it has many of the typical organs that we that you would have heard about in the previous session, right? So there is a nucleus with the DNA. It has mitochondria, it has an endoplasmic reticulum, and it also has other organisms that sorry, organelles that are specific to its parasitic life form.

So I want to point out that this single-celled parasite, a unicellular parasite, has a very complex life cycle. And that's what's pictured here. And what you can see is, if you look on the right hand side, what you see is actually that the main definitive hosts are felids. So any kinds of cats, right?, ranging from the domestic cat, your pet cat, stray cats, all the way to tigers and lions, right?. And it's really interesting that it's only felids that are the definitive host.

So it's it's a mammal, not just any mammal, but it only can be felids that the Toxoplasma gondii can actually, what it does is it enters the intestine of the of the cat. And as it does this, the parasite is able within the gut of the of the cat, it is able to differentiate and form gametocytes. And this allows it to actually reproduce sexually. And this sexual reproduction only occurs in the definitive host, which is the cat, right?. Once it does this, the gametocytes fuse and form a zygote.

And this matures into what is called an oocyst. Right?. So the cyst is what is eventually released from cat faeces. And these cat faeces then are basically a way for the parasite to get transmitted to other intermediate hosts. So such as birds or other or rodents.

And when the cysts are released, they now release bradyzoites, which are, which can only reproduce asexually within this intermediate host, right? And they, while they do this in the intermediate host, so they can also of course infect humans, not just rodents or birds. Of course, they cause illness in the intermediate host. In the cats, in the definitive host, they don't cause disease at all. So this is a really interesting example of coevolution.

Because on the one hand, cats don't get any illness from being infected by these toxoplasma. But they provide the parasite, a host, an environment in which they can differentiate sexually. And in turn, it is thought that whenever I say a rodent is infected with, with the parasite, it induces behavioral changes, such that rodents don't have an aversion to say things like cat urine, right? And so the rodents can become prey for the cat. So it's this very complex and surprising sort of relationship that cats have with the parasite.

On the one hand, cats are influencing, sorry, are allowing the parasite to reproduce asexually. And the parasite in turn, much further down in its lifecycle, is helping the cats provide more prey. So this is what happens in rodents. But when animals, sorry, when humans are infected, it becomes the story is really even more fascinating. It turns out that latent infection of toxoplasma gondii can also influence our behavior.

And it has been actually associated with many neuropsychiatric disorders. And so for me, it's really fascinating that a unicellular parasite that's as small as one micrometer can influence host and host behaviors that are as and hosts that are as large as human beings.

Hello, everybody. My name is Divya. I'm a biology faculty at Azim Premji University.

Today I'm going to be talking about my favorite cell. Can you guess these are my favorite cells? These are known as diatoms. They come in various shapes and forms and

colors. And because they look so beautiful, I like them. I'll tell you a little bit more about diatoms.

These are microalgae. These are single-celled protists. And these almost look very colorful. And because they look colorful, they almost look kaleidoscopic. And a person, a scientist known as Claus Kemp, he perfected the diatom art.

He invented his own glue to kind of nicely very detailly glue different kinds of diatoms and he created art out of it. And I'm going to send you a link, which you can see after this video about, you know, various kinds of diatom art. Now let's look at in detail about what are diatoms. So diatoms are single-celled protists. They are actually eukaryotes.

That means they have their own nucleus and many other cell organelles. But they are single-celled, they are microscopic, they are protists. If you look at where are protists here under eukaryotes, they come under here. This is a phylogenetic tree, which has bacteria, archaea, and eukaryotes. So diatoms are, they're not plants, fungi or animals, but they're protists and they fall somewhere here.

And these are, you can call them as microalgae, because they're very tiny and microscopic, but they're extremely diverse. They can go from anywhere between 20,000 to 2 million species on earth. They're also photosynthetic. And that's a very, very important function of diatoms. And they are present in various kinds of water, freshwater, marine ecosystems, in even in ditches and saw, you know, even in wetlands there, these diatoms are present.

Diatoms get their very glassy, colorful appearance because of a, because in their cell wall, they have silica or silicon dioxide, which makes them, you know, reflect light. And that's why because of that, they are so very colorful and have different patterns. Why do they have them? These silicon silica cases or well, it is known as frustule and they give them protection because they the whole cell is enclosed by this silica valve and it offers protection from predators. Diatoms can be free-floating, they are, they can be attached to other organisms or even benthic that means they're under water's surface. And they can reproduce really fast, they can double within a day and they reproduce by fission and that's asexual reproduction, and with adequate nutrition, they can basically form algal blooms.

You would have heard about this. Basically, the entire area would be taken up by these diatoms because they reproduce so fast and their metabolic rates are also very high. In fact, you can see from the satellite images taken of the sea, of the earth and sea, you can see various colors, blue or green colors formed by these microalgae. So, though you can't

see them when you are actually in the water, you can, through satellite imagery, you can see, you know, how these diatoms are really widespread in oceans. Now, why are diatoms so important? Of course, they are pretty looking, but diatoms are also extremely important because they since they photosynthesize, they are primarily food source for many, many invertebrates, protists, and other invertebrates and also vertebrates such as fishes.

Diatoms also are important for, because they are they are responsible for 20% of the oxygen on planets because they photosynthesize and they take up, you know, atmosphere has lot of carbon dioxide, right? And they, and ocean takes up a lot of the carbon dioxide as dissolved carbon dioxide is in the waters and diatoms can actually, with the help of sunlight and this carbon dioxide in the water, they can produce photosynthate, that is sugar and also oxygen. So, they are really important because it contributes to a great extent of oxygen present in the planet. So, it is not just plants which are responsible for the oxygen, but also microalgae such as diatoms. And diatoms are really important for one more reason because climate change also affects the diatoms. So, because of anthropogenic, you know, increase in carbon dioxide levels that also affects oceans ability to act as carbon sink.

So, the oceans take up greater amount of carbon dioxide because of which the dissolved carbon dioxide because of which the pH levels of ocean go down decreases and that affects the cell wall of these diatoms and it decreases diatoms and thereby drastically altering lot of other processes downstream. So, though diatoms are very tiny and microscopic, their significance is, I mean, of a global nature, right?. So, it is extremely important to acknowledge that we have to conserve lot of marine creatures or lot of aquatic organisms like diatoms in order for us to kind of protect the, protect earth and other organisms on earth. Diatoms are also useful for other various applications.

Diatoms preserve well as fossils. When diatoms die, they are ground up and formed into white powdery substance known as diatomaceous earth and this can be used for various things such as filters because they have good absorbent property. They can also, they are also used in cat litter and in toothpaste and also as insecticide. In fact, you can buy diatomaceous powder and you can spray them, you can spread them in different places, and use them as insecticide. So, for all these reasons, protecting diatoms are really important and I hope you like them too as they are my favorite organisms. Thank you.

Hello, my name is Kaustubh Rau and here I am to tell you about my favorite cell. My favorite cell is called Mixotricha paradoxa. And before you say mixo what, let me assure you that once you know a little bit more about this cell, you are going to agree with me

and say yes, this is indeed a most interesting cell. Mixotricha paradoxa perfectly embodies this poem.

Great fleas have little fleas upon their backs to bite them,

And little fleas have lesser fleas and so ad infinitum.

So let's see how this holds. So, M. paradoxa is a protozoan and it's found in the gut of termites. It's pear-shaped and it's a fairly large single cell about half a millimeter in length and about a quarter millimeter in breadth. And as I said before, it has a symbiotic relationship with a termite, where the termite offers its safety and protection in its gut, and in return, M. paradoxa digests wood and makes the products of digestion available to the termite. So this is a very nice relationship that we have and if and that would be interesting in and of itself.

But if we go down a little bit further, we find that M. paradoxa has its own symbionts and it forms a symbiosis with not one, but not two, not three, but four different creatures. Yes, M. paradoxa has four bacterial species that are symbionts of it. And if that is not amazing, I don't know what is.

Here's the termite, which is the host for M. paradoxa. It is called Mastotermes darwiniensis. It is found in Australia, where it has now become a major agricultural pest, but it is also considered interesting because of its evolutionary relationships with cockroaches and it's being studied in that regard.

But back to M. paradoxa. Here is an image of this protozoan. Seen in the front is the mouth or what's called as the ingestive zone. And then you have this pear-shaped body, which tapers to a blunt end at the back. And as you can see, it's covered with very fine hair. So the biologist who discovered this organism first, her name is Jean Sutherland, she also thought that these were hair, but then later on discovered that they were not really hair, but a species of bacteria called spirochetes.

And that's the reason for the name of this genus Mixotricha, which means the animal with mixed-up hair. And these spirochetes actually act like flagella for the M. paradoxa. And somehow it is able to control them and move them in synchrony such that they act like flagella, allowing this animal to move.

Here is a closer look at M. paradoxa. So on the left, we see a cross-section of the animal, allowing us to see its insides. And on the right? we see the outermost surface of this animal. And just to orient ourselves, at the bottom, you have the mouth or the ingestive zone, which is labeled as i. And then at the top, it has these four cilia. And these were

thought to be able to help the animal to move in the beginning.

But now it is known that they serve the purpose of a rudder and allow itself to steer in the gut of the termite. Then looking at the outside in more detail, if you look at the part labeled n, it has these hook-like microstructures on its outermost covering. And then along associated with these hooks is a rod-shaped bacterial species, which is labeled as b. And after that, you have another species of bacteria called spirochetes, which are shown as fine hair. So basically every hook will have this rod-shaped bacterium whose purpose is yet not known.

And then you have these spirochetes, which act like the flagella of this creature. And then if you look on the inside of the creature, you have two bacterial species. One takes up the job of the mitochondrion of M. paradoxa, which has ditched its own mitochondria and allowed this bacteria to take over that function. And then finally, you have one more bacterial species and that serves to break down cellulose and lignin, which are the major constituents of wood.

And then it makes the products of this digestion available to the M. paradoxa, which in turn makes it available to the termite, building up this beautiful chain or trophic levels as it were. And so we have to think about the fact that where do we consider as this animal ending and its symbionts beginning, or are they all mixed up together? And that's the reason why it is known as a superorganism with five genomes. And it has been labeled so by a famous evolutionary biologist, Lynn Margulis. So Mixotricha paradoxa to me is a reminder that nature is always interesting.

And every time we think we have found a pattern, we always find an exception to that pattern. And sometimes the exception is so outrageous that it's completely outside the framework of this pattern, reminding ourselves that there are always more and newer and more interesting things to be found. So now it's time to modify our little poem and say,

Great protists have little protists upon their backs to guide ’em,

And inside they have more protists and so ad infinitum.

I hope you've had some fun learning about my favorite cell. Bye.