OK, so finishing up predation. We ran out of time last time. We talked about predation, and let me give you the big overarching context here. We've been talking about interactions between organisms. We talked about competition between organisms and how this shapes community structure and drives evolution. And then we moved onto predation, the interaction where one of the organism's fitness is increased and the other one's fitness has decreased. And that this, too, shapes community structure, and in many different ways. One way we talked about was keystone predators and how when you remove a predator from the system it can completely change the competitive interactions of the organisms in that ecosystem.

That was the starfish example. And we also started talking about predation as an evolutionary agent, as a selective force.

And I started showing you just some pictures. Some of the best evidence for that is what we see in the characteristics of prey populations.

So just very quickly going back here. The evolution of defense mechanisms like these spines on the cactus that wards of predation, spines on a porcupine that ward of predation. Here's another defense mechanism of an octopus, when disturbed puts out that big ink cloud. And here are some caterpillars that look very much like snakes that are more threatening to a predator than a caterpillar but they are still caterpillars. An alarm.

Many snakes have coloration on their tails to attract the predator to their tail rather than their head if they're going to be attacked.

And this is one of my favorite bugs. This is its tail versus its head.

And then we talked about alarm, you like that one? So do I. I don't know why. It's so silly. And then we talked about eyes or things that look like eyes, that we assume are also what attract a predator to the wings here rather than the head.

And then this system, which can develop into having these eyes or not, depending on the substrate.

So here we are. This is some form of caterpillar.

This is what's called cryptic coloration. In other words, it blends into the leaf of the plant that it lives on.

And if it develops during this time of year it looks like a leaf.

If it develops during the time of year when the plant is making these catkins, these flowers, it actually looks like the reproductive part of the plant. So it has developmental mechanisms, a developmental switch in the same species that can make it look one way or another, depending on what the plant looks like that it is living on. And, again, as we talk about these I hope you will constantly remember all of the molecular biology that you learned from Professor Walker.

Now that's a very good question. The question was does it actually change the phenotype while it's developing or do both phenotypes develop and one gets selected out depending on what the background is?

And I don't know the answer but that's an excellent question.

And I will see if I can find out the answer, but a very good question. And it would be interesting either way. Well, I think it would be more interesting if it actually changed the development, because figuring out what the cues were at the molecular level would be interesting. Here's one, a leafhopper that resembles the leaf that it lived on.

A cryptic coloration. . This is an insect looking very much like the leaf that lives there.

I think we'll see one of those in the clip. Here is another.

This is a praying matis. There is his head. There are his legs sitting in with the flower pedal. Butterflies. Here's a slug on a leaf. Here's a flounder blending into the sand on the bottom.

And there's another one which you can barely see. There are his eyes. And in this way avoiding predators.

And the amazing thing about these flounders is they can change their color very rapidly. And they can match the substrate.

And this one is trying to look like checkerboard which it would never encounter in nature, but you can see these checkerboard patterns on it. So how they do this, you know, the actual mechanisms for this are probably not that well understood. But it's pretty convincing.

Here is a toad blending into its substrate. Another toad.

Look, you can barely see it on this rock. Some more insects that are looking like spines on a leaf. And here's a moth that looks very much like a twig that it's on. And then there are these alarms.

This guy is trying to say, you know, don't come near me.

I look bigger than I really am by putting out these.

And then there are frogs that use a different strategy that draw attention to themselves, but they have a good reason to do that because they have a poison. So they're saying to the predator, you know, move onto some other frog because if you attack me I'm going to taste bad. And then there are chemical defenses.

This is a bombardier beetle being pinched by somebody's forceps here.

And it's spraying this very nasty substance on the predator.

And you can see it can direct it in any direction.

And there is a wonderful story about this beetle that was studied extensively by scientists at Cornell University. There's a whole field called Chemical Ecology where people actually study the chemistry.

This would be a great MIT problem because there's a really interesting chemical reaction in the system here that creates this explosive force.

They put two things together and create this force here.

And this is a very acidic solution. And these scientists were out in the field in the middle of the desert studying these guys.

And they needed an acid to develop some chromatography reaction so they had the beetles spray on it. And they made the beetle a co-author on the paper and it got by the editors. That's an interesting story. So there's a paper out there with the beetle's Latin name as a co-author on the paper.

Just a little story. And here's another beetle that doesn't have that defense, but it mimics the posture. So a predator comes up, and this gets into this whole area of mimicry that we're going to talk about, where there are a lot of systems where you have a defense mechanism and then another organism evolves to mimic that defense even though it doesn't have the real thing.

So this beetle just assumes the posture and some of the predators think, oh, I better avoid that one. Fireflies have a particular flash that attracts. The females have a flash that attracts the mates of their particular species.

Some of them have learned to mimic the flash of other species.

And when the male is drawn into that flash they actually eat them.

Another evolutionary function of the predatory force.

And then there are many examples of this mimicry. These are two butterflies of different species. One of which is toxic or very unpalatable to prey species. And the other is not unpalatable but because it looks like that one is less likely to be preyed upon.

And people have done experiments to test hypotheses about these and shown how that works. And there are lots of also fly species that have evolved to look like these species for the same reason. So there are several of these mimetic systems.

So we're going to move on them to mutualism. So we've talked about minus-minus interactions, competition, minus-plus interactions, which was predation, and mutualism is plus-plus, win-win. Both organisms benefit from being in contact with the other organisms. And several of the clips I'm going to show you have to do with mutualism. So I'm going to go through this rather quickly. And these examples, for the most part, are from your book. I'm showing this example because it also has an experiment that goes with it in your book.

These are treehoppers, like insects that suck on the sugar solutions from the tree. And they squirt out the sugar for the ants that they're symbiotic with. They feed the ants because the ants, in turn, protect them from spider predators.

And there are many systems like this. And I show you this one because they did experiments. And you can do them easily.

Here's a study plot. These are the plants that have the ants on them.

And these are plants. You can remove the plants and then measure whether the plants have an effect on treehopper survival.

And so this is the average number of young treehoppers per plant with the ants, without the ants. So with the ants there are more.

And they also showed in this study, though, that if you, in years where the predators of the treehoppers, the spiders were less abundant, the symbiosis loosens up. There's no point in feeding the ants if you don't need them to protect you. So these are dynamic systems. So treehopper survivorship increased by the present of ants.

Another system just like this is where ants live in these thorns in acacia plants. These are hollowed out thorns that provide a habitat for the ants, but when the plant is vulnerable to herbivore grazers the ants all come out in force and scare off the herbivore. This is my absolute favorite, one of my favorite biological systems of all times. And we're going to show a clip of this. These are tree cutter ants that go out and get pieces of leafs and bring them back to the nest, chew them up, and they farm this fungus on the leaf chewate or whatever you want to call them.

They pulverize the leaf. And they actually farm a fungus.

And then they eat the fungus. That's their food. So there's this mutualistic interaction between the ants and the fungus.

And there's even a really interesting complexity here that you'll see in the clip where the ants actually also carry a bacterium on their chest that makes an antibiotic that keeps the fungus farm free of infection by other fungi that might take it over.

So it's this beautiful, beautiful co-evolutionary system that predates human beings many, many, many millions and millions of years of agriculture. I mean the ants are literally farming and of natural antibiotic. So I'll stop talking so we can get to the clip. Another example of mutualism that is one of my favorites are cleaner fish. In coral reef ecosystems there are cleaning stations where these little cleaner fish, here is one, which hang out in these giant fish. And turtles and other organisms in the ecosystem come to these stations, and these cleaner fish pick of little ectoparasites from these giant fish. So the fish get cleaned and these guys get fed. There's a moray eel being cleaned by one of these fish. I mean that could wipe that guy out in two seconds if it wanted to make a meal out of it, but it's not worth it to get a meal because it's better to get parasite-free. However, whenever you have mutualism you also have cheaters. And so this is an example of, and I love this picture because it kind of has the cheater smiling, you see? And this is a fish that has evolved to look just like this cleaner fish. But it's not a cleaner.

And it comes into these cleaning stations, and it dashes in and just takes a chunk out of the skin of one of these fish because they're off guard, you know, they're not on guard for fish that look like this. And you can get into beautiful, beautiful population analyses and game theory analyses of these systems, because the presence of these cheaters actually strengthens the mutualistic bond between the cleaner fish and the host.

Because if the fish that's being cleaned is more fit, the better it can recognize, tell the difference between these two, right? And the better it is at recognizing the real cleaner fish the more fit it's going to be, and that tightens that relationship.

So it's a really interesting dance. And you can do game theory analyses.

OK, more mutualisms. These are all from your text.

Those are my cats cleaning each other. I thought you should meet my cats. They clean each other and then they fight.

OK, so enough from me. Let me show you some clips, if I can make this thing work right.

OK, so the first one, well, I'll just start playing it.

So your challenge is to figure out what these are about.