PROFESSOR: OK, I hope you all got the message I just sent. I finally found the meerkat videos on YouTube. They weren't coming up in the searches, especially Part Two. But once you realize they're on YouTube, they're easier to find, and I posted the links to both of them. So if you missed that last time, you can watch it or you can watch it again.

We were talking about communication involved in sexual selection, and I just wanted to point out here that it's led to a sexual dimorphism in some species that's so extreme-- like in these little Anolis lizards-- that the differences are greater between male and female than they are between some of the species in that genus. So it's a major factor affecting evolution, and we should get a chance at the end of the class to show some are examples of that.

But let's deal with some other questions first. One is, the evolution of ritualized fighting behavior. Why do so many species engage in ritual fighting, instead of real fighting, in order to, for example, decide on relative dominance of the males? This has been studied by Scott. He's done specific studies of the blue tits, and he has a discussion that's particularly telling of these beautiful birds called the lorikeets. A guy named James Serpell did the studies. These are what they look like. This is a small one. Here's another small one, and here's a very large one. And note the enormous beak on this one.

Well, when Serpell looked at the fighting behavior of these various types of lorikeets, he found that the large ones, like this one, engage in the most ritualized fighting, whereas the small ones were much more likely to engage in real fights. There's an obvious reason. The big ones are capable of doing a lot more damage, so the individual, his chance of getting injured in a fight, are much greater. These little birds aren't as capable of hurting each other. So that's why it appears that the bigger birds have engaged in more ritualized fighting.

Later we'll get a chance to see some studies of domestic cats, and you will see the ritualized way that male cats often settle their differences. They don't always. Sometimes they really fight, and they can badly damage each other. But usually, it's done by ritual. And also, they remember. So if they did have a real fight, it will usually only be one with the same animal. They will remember the outcome, and everything else is settled by this posturing.

Let's talk about a few other forms of communication , like auditory communication. So what's the big advantage of auditory communication in animals like whales, songbirds, marmoset monkeys. What do those such disparate animals have in common, whales, songbirds, and marmoset monkeys? They all engage in a lot of auditory communication.

Think of the difficulty of visual communication. Whales, because they live in water, how far can they see in the ocean? And they're swimming large distances from each other. Auditory communication works very well over very long distances, and they say the effective range of whale calls is they think more than 100 kilometers. It seems hard to believe.

For songbirds, of course they live in forests, there's so much foliage, they have difficulty seeing each other. Not for real close range, of course, like you would find in courtship behavior, but other kinds of communication, like response to alarm calls. They're often far apart, and they're not going to be able to see each other.

Marmoset monkeys, similar. Dense foliage. They need their calls, auditory communication, just to be in touch with each other. So I'm asking for distinct functions of birdsong. This is part of that, of course, very important in auditory communication in birds. What are the different kinds of functions of birdsong? Why do they sing? can anybody suggest even one? Yes.

AUDIENCE: Mating.

PROFESSOR: How would it function in mating?

AUDIENCE: If you could say you're ready for a mate, and trying to give off a more verbose call.

PROFESSOR: Could be advertising. OK. So advertising is important. Not only that, they want to advertise more than just the fact they're ready to mate. "I'm a male and I'm ready to mate." No. They want to be, "I'm a really fit male, and you should mate with me rather than that other guy over there, because my song is better. I have a larger repertoire," and so forth.

So these are males attracting females I have put as number one here. The second would be females judging males for purposes of mate selection. Another is territorial advertisement. This it has to do with male-male interactions. They occupy distinct areas where they establish their nest in the center of the area where they're foraging. They each have a home range. And many animals do this, they establish very clear territories. Many hunting animals have distinct territories. In some of them, they're overlapping, in some of them they are not. But in birds, birdsong plays a very important role in that.

The other that many people are not aware of, is in some species it's part of pair bonding, where they sing. And what sounds like a single song-- and you'll hear their singing in the forest, and you'll swear it's only one bird singing when it's actually two-- it's a duet. And they recorded these.

It was the British ethologist and ornithologist Thorpe who first described it, and recordings were made by him and his students, where they were able to separate the songs, the contributions of the male and female. And they're perfectly-- they interleave their notes and phrases of the song. So this duet is a major part of their bonding. And you can find some interesting things online about that. I've noted one of them here. But if you do a search on that, duets in birdsong, you will find pretty interesting studies.

Now I mentioned here one that we don't have direct experience of it all: communication by electrical signals. So when would that really be important? It's done in animals living in water. And water, where visual communication is difficult, but rather than using auditory, a number of fish species use electrical communication, and they use it for other means, too. Especially these two groups: the mormyrid in Africa and the South American gymnotids. And they have corresponding development of specialized receptors, specialized secondary sensory neuron groups in the brain, and specialized regions for analyzing that electrical information.

So they're in murky waters, and they have these receptors all along the lateral line along the side of their body. It's innervated by cranial nerves that are not found in mammals at all. We always say we have 12 cranial nerves, but those are sort of the standard way of enumerating them. If you look throughout vertebrate species there's at least 25 cranial nerves, and six of those in some fish are cranial nerves devoted to electrosensory functions.

So these are pictures of a couple of mormyrid fish, and recordings of the electrical pulses they emit. So they're not just responding to electrical pulse or detecting it. They also emit electrical pulses. Now, a few of them, like some electric eels, are capable of producing such a strong electrical pulse in the water that they can actually based on smaller prey animals, and so they use it in prey catching. But these animals aren't using it for that. This is a form of communication and of sensory detection.

So in this diagram, you see field lines of an electric field generated around these animals. They usually have electric generator area cells towards the tail region. They generate this field around their body, and their lateral line receptors all along the side of the body respond to that field. And any animal that enters the field distorts it, and they detect that distortion, and they compute exactly where the disturbance was in the field. They're very good at it. It's a very good means of communication. So they have specialized emitters emitting the electrical pulses. They have specialized receptors along the side of their body that all come-- governed by hindbrain mechanisms, as I've indicated here.

Now there's other sensory means, too. One that you're probably more familiar with is the catfish. They have very specialized taste systems. This is a picture, it's actually from my 914 class, it shows a drawing of a catfish. Bullheads are examples of catfish. This is not a Bullhead, but it's similar. And what they're showing here is one cranial nerve, the seventh, which is the facial nerve. But look at it in this animal. It innervates the entire body surface, and it innervates these little barblets. What are they doing with those? Well, it's important in their feeding. Remember, they live in very muddy water. They literally go along the bottom, dragging these things along the water, and tasting what's there, so that can detect when they're near food.

And I point out here that this catfish that you see in the picture and the other catfish, too, they've developed specialized cell groups that respond to that input. So, the seventh nerve nuclei in the hindbrain develop very large size. So much that these animals, the side of their hindbrain bulges out in that region.

There's one fish, the buffalo fish, that it's not just the seventh cranial nerve, but the ninth and tenth that innervates the throat. And the reason is, they have specialized taste receptors. It's a specialized palatal organ that, again, most animals don't have. But they filter water, passing through their mouths and out their gills, they pass it over this region . Again, it's used in detecting tiny particles of food. And many of them have a motor side, too, that will trap the particles. It's a particular way of feeding.

And of course, these animals, all of them have specialized fixed action patterns, part of their foraging and feeding that have developed centered around these specialized sensory abilities. Either taste or, of course in the case of the electric organs, the gymnotids and these fish that we just looked at here, mormyrids and gymnotids.

Now what about olfaction? What are the advantages and disadvantages of olfactory communication? This is a particularly interesting one for mammals, because it appears to be of such major importance in the early mammalian evolution. We've detected fossils of mammals from the time of the early dinosaurs. They were apparently nocturnal animals living on the forest floor, and they had a big problem.

How do you avoid these very visual predators roaming the earth?

At that time, the dominant species were the lizards. And they developed specialized olfactory abilities. It functions in complete darkness. It functions as a distance sense. They don't have to be sniffing something right under their noses. They can detect through the air. Some of the scents linger. It varies, but many of them linger for some time, so it gives some information about things that happened in the recent past.

When your dog enters a room, he doesn't just smell food in the room. He smells who was there recently, and who's there now, who was there minutes ago, who was there 10 minutes ago? Because the odors linger. This is something animals can do with olfaction that they can't do with the other senses.

Also, there's evidence that in these very early mammals, they evolved out of a group called mammal-like reptiles. And there was a regression, according to the skull evidence that we have, of regression of the visual sense, reduced bones around the eye, and so forth.

And we should, of course, add that the audition developed in a special way, too, in the mammals. Mammals evolved specialized little bones. Formed the middle ear. There was only one bone in the reptiles, equivalent to the stapes, but the other small bones developed. That was very important, because it allowed impedance matching between air pressure level changes in the air, and in the fluids of the inner ear. And that evolution was also very important in mammals.

Back to auditory . Alarm calls. I'm asking about two functions of alarm calls. One's obvious, the other's not so obvious. Well, the first one, of course, is warning other animals of the same species of danger. That's important for an individual, because if he can do it, other animals in the group can do it. So if they all do it, they're all benefiting. But the second function is that it signals the predator. "You've been detected, and we're watching you. It's useless for you to continue trying to catch us, because we run very fast and we can already see you. You'll never catch us." So animals actually go out of their way to display to predators.

Remember the mobbing response in the geese and in the jackdaws? We saw it in the video of the geese. They're not just responding to predators by running away. They form in a group and they mob them.

Why do foraging birds sometimes emit at a fake alarm call? Why would they do it? Well, maybe because they see food and they want to get rid of the competition. So they can get the other animals to run away, then they can get the food.

The problem is, these animals remember. And if he emits fake alarm calls a couple of times, the other birds learn who it is doing that, and they learn that those calls are unreliable. So individual recognition by their cognitive abilities, very important. So if too many animals did that, of course, the alarm calls would lose their usefulness. But it doesn't function very long, so in fact, it doesn't happen often enough to lead to a loss of alarm calls in evolution.

Now, of course, many other animals besides birds do this. I'm asking here about ground squirrels and vervet monkeys. They convey specific information about predators when they give alarm calls, and this is my summary of that. The ground squirrels respond to threats from the air or from terrestrial predators. The ones from the air, from raptors, mean very high risk. They can be much more easily caught by a raptor than they can by a ground predator. So they emit these short, shrill whistles. If it's lower risk, a ground predator, they have a trill and a chatter, which always indicates threat from ground predators. So the other members of their species can tell what kind of predator they should watch out for when an animal emits these calls.

In vervet monkeys, it's even a little more complex. [INAUDIBLE] threats from the air, they make a coughing noise. If it's a leopard, they emit a bark. And for snakes, they make a chattering noise. So it's very easy to tell which kind of predator they should watch out for. And that information is very important for these animals in avoiding those predators .

And, of course, they learn that some animals more reliable than others, not just because they emit fake alarm calls, but they sometimes jump the gun too quickly, they emit alarm calls too often. And also, they discriminate young and old. They learn that young animals are less reliable. They're likely to start chattering alarm calls when there's no real threat from the predator. It doesn't mean they didn't detect one, but he may be too far away to be emitting an alarm call. So they depend mostly on the older animals that are more reliable.

So we just talked about a function of individual recognition. What other functions of individual recognition are there, besides this, remembering about reliability of alarm calls? An animal can remember previous encounters with the individual. I mentioned that when we talked about ritualized fighting and real fighting. It's very important that they remember the results of fights, because it saves a lot of injury and energy later.

So just to remember their place in the hierarchy of animals in their species, individual recognition's very important. What other functions are there? Well, they can recognize members of their closely related animals, their young, their mate, so forth.

Did you know that there's other species besides humans that have names for other individuals? One we know about the most is the dolphin. They have what's called a signature whistle. The data on other species is not as reliable, but we know the elephants, for example, seem to be able to convey something specific to an individual. We know less about the language they're using. It's been studied a little more intensively in dolphins. This is an area that a lot more study could be done.

Now, there's two videos that I would like to see. I'm not going to show this one initially, because it's available easily online. And I've asked some questions about it, and it only lasts about 10 minutes. It's very easy to get online. We can watch part of it if you want, but I have video clips illustrating sexual selection. It's from another nature program , called *What Females Want and Males Will Do*, and it's quite fascinating.

If I can get these in control of it. When I started today I couldn't, but I think I figured out what I was doing on wrong. The only player I can get to do this right is WinDVD, because then I can go to go to the parts that I'm interested in. All the same birds, emitting all of it.

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PROFESSOR: All of that has evolved because of sexual selection. You see the gradual changes that you can trace closely related species, and you see all kinds of variations of these elaborate calls and dances. You find it throughout nature. And, of course, I pointed out last time that humans have developed various ways, of course, some of which are instinctive, but a lot of these are modified by learning. But most of what you saw today was all instinctive. Every member of the species does something very similar. But, of course, that first one you saw, the animal that could imitate the lyre bird, could imitate anything. It's an incredible amount of learning. And how many different things he could remember, and the elaborateness of what he remembers, that's what impresses the females.

All right, so that's all for today. So remember to watch the horse video yourself, OK?