Ask A Biologist Vol 093 (Guest Athena Aktipis)

Are Your Cells Cooperating or Cheating?

Cooperation is something that humans and animals are known to do. It turns out that the 30 trillion cells in our body also need to cooperate. Like some humans, there are also cells that are cheaters when it comes to cooperation. They do not do their share of the work and cause a lot of other problems. These are cancer cells. Cooperation theorist Athena Aktipis talks with Dr. Biology about her research and how it is helping us learn more about cancer cells.

Transcript

Dr. Biology: This is Ask A Biologist. A program about the living world and I'm Dr. Biology.

Let me ask you this? When was the last time you cooperated with someone? And when you require a rating did you expect to get something out of it? Maybe you help her friend study for math exam and they helped you edit your English paper. In this case you cooperated with your friend and both of you got something out of it.

Now can you think of a time you cooperated with someone? When there was no expectation of a benefit or pay back. These are just a few of the examples or scenarios my guest has been studying.

And it turns out that cooperation is not just for humans or animals. Cooperation can also be found in our cells.

My guest today is Athena Aktipis a professor in the Department of Psychology and a researcher and Biodesign Institute at Arizona State University. She's also the co-director of the Human Generosity Project.

For today's program, we're going to take you on a journey from the Great Rift Valley in East Africa to the inner world of your body and its 30 trillion cells. Along the way we're going to learn about cooperation and cheating and how they play a role in the study of cancer.

Welcome to show Athena.

Athena: Thank you so much for having me.

Dr. Biology: Alright we have had an evolutionary biologist. We've had ecologists on this program. You are my first cooperation theorist.

Athena: Well I'm excited to be the first cooperation theorist on the show thanks.

Dr. Biology: What is a cooperation theorist?

Athena: Cooperation theory is really about how do things cooperate with each other? What makes it possible for them to cooperate? What maintains that cooperation? What keeps it stable? What keeps cheating from taking over and it turns out that a lot of those principles that apply to say human cooperation also apply to looking at how cells cooperate in our body and sometimes outside

of our body, too.

But basically the same ideas apply across all these systems and so cooperation theory is about connecting those principles across the system so that you can gain new insights into the nature of cooperation and cheating and hopefully have a positive impact on things like how people interact with each other and when it comes to this cooperation of cells that has potential impact for understanding human health and wellbeing.

Dr. Biology: Ah - well since we're humans and we're going to relate too what humans do or don't do. Let's start with your work and a topic around the Maasai and their form of cooperation called osotua (o-so-twah).

Athena: So the Maasai live in East Africa and they are herders so they have cows that they take around the landscape and have them eat grass and then the Maasai will eat the meat from the cows and drink the milk, and I know it's kind of gross, but they also drink the blood if they don't want to slaughter a cow and they need some protein.

So they're basically depending on these cows for their day-to-day survival because they can't just go to the grocery store and get some food there living in really, really rural areas and they still have their traditional way of Life, which is called pastoralism, in the sort of technical anthropological terms, and that means that they have these livestock cows and they also have some goats and some other animals and basically the animals go around and eat grass and turn that grass into food that humans can eat.

And that allows them to make a living on this really, really sort of spread out land where there aren't a lot of resources concentrated in one place so they kind of use the animals to like collect up the resources and store them and then they when they need to.

And so a typical Maasai family - they will need to have a heard that has about 60 or 70 cows in it to be able to survive. Now you can imagine, though that living in those kinds of circumstances, you know sometimes that might be a really good rain and they'll be a lot of grass and sometimes there's not.

You might have a big heard one year and not as many the other year, or maybe there's a disease and a few of your cows die or get sick, or maybe even a neighboring tribe comes and steal some. That used to happen a lot. It doesn't happen that much anymore because there's a lot more security in the area, but those are the kinds of risks that the Maasai face on day-to-day, month to month, year to year, basis in terms of what their depending on for their food supply. Their cows are kind of like their food supply and their bank account at the same time, so they need to have 60 or 70 cows to be okay.

But sometimes something will happen that may be totally out of their personal control that will make it so they go below that threshold for how many cows they need to support their family. And so this is where osotua comes in.

The Maasai have this cultural idea, which is kind of like a social and emotional bond with another person called osotua, and what osotua means, literally what it actually means, is umbilical cord.

And an umbilical cord, if you remember your basic anatomy, is what connects the baby to the mom inside the mom's body. Right? And the umbilical is what transfers the resources from the mom to the baby. So even though word for this, osotua, umbilical cord, it is about giving, right, and it's about giving from one individual who cares about another individual right. The parent cares about the child. And importantly that giving is unidirectional it's from the parent to the child. So the

whole metaphor of the umbilical cord captures a lot of things that are actually really important about osotua and what it means?

Now let's go back to our scenario. Say I have a pretty good heard of you know 75 cows, but then a drought hits me and I lose 25 of them and you're my osotua partner and you live a couple of miles away. Maybe you're a little higher altitude and so you had more rain and your cows are doing fine, you've got 100. I could come to you if you're my also taught partner and say, Hey, I'm below the number of cows that I need to support my family would you help me out? And given that you have plenty, and I'm in need you would help me. You would give me enough cows, so that I could get up to the threshold that I would need to support my family.

You might wonder well what if you also had a drought and you had maybe just enough to take care of your family. What would you? And with osotua you wouldn't be expected to help me if you didn't have enough to help me without going below what you needed.

So also osotua is sort of different from just pulling all your resources. It's not like Oh, you know, we have all these cows. Let's all share them, and distribute them equally. It is based on first you take care of yourself and then if you have enough to help someone else who is in genuine need, and they ask you for help. Then you help them.

Dr. Biology: And this is your osotua partner.

Athena: Yes, exactly.

Dr. Biology: Right and I think the other part of it that I found interesting is that you only ask for help when you need it.

Athena: Exactly

Dr. Biology: It's not like you're not going to say here take your 70 you like you know, I'd like to have 90.
Go ask my partner for 20 more.

Athena: Exactly. Yeah, an interesting the Maasai they have simultaneously, two different sort of systems of rules for transferring resources. They have the osotua system and then they have a debt and credit system, which is the one that maybe we're little more familiar with, where I might say, "Hey can I borrow 20 cows?" I want to have a big party and I need to, you know feed 300 people. Then I might borrow them from you, and if I borrow them from you then I'm expected to give them back.

And the circumstances that you might ask to borrow cows are a lot more varied. But if you're asking within the context of osotua it has to be because you're genuinely and need, not because you want to do something frivolous or you just think it would be cool if you had more cows.

Dr. Biology: Alright so we now know a bit about cooperation. You made the leap and I don't even know that it's a leap, but you made the transition from studying humans and animals because it's not just humans that do this sort of thing.

Athena: That's right.

Dr. Biology: Is there a good example of an animal that does this as well.

Athena: Yeah, in fact, there are 2 cases that I really like. One is the classic vampire bat, which is sort of known in evolutionary biology and cooperation theory as an example of reciprocity.

So vampire bats, they are kind of like the Maasai herders in some way. They also eat blood and they basically can't go more than two nights without feeding. And now in addition to feeding by eating blood of livestock they also can get nutrition from having a fellow bat regurgitate the blood for them.

So they can share with each other. So there was a study done that found that one of the biggest predictors of the bats helping each other was that the other bat had previously helped them. And so this was taken as oh, they're doing account keeping kind of reciprocity.

It turns out when you go back and look at the data that the biggest predictor of helping was actually have how little the bat weighed, who was in need. And so another interpretation of what's going on is that these bats are helping based on need perhaps with preferred partners.

[laughter]

But, they might not be a paragon of account keeping reciprocity. So I love the Vampire Bat example because it also shows that sometimes it can be hard to sort of peace apart, which explanation really fits the data best. But if you look at the question is the giving happening conditional on the need of the recipient and the answer seems to be yes, and then at least it's partially a need-based transfer system, I would say.

Then there are social insects in particular ants that do something called trophallaxis, which is some of the ants that stay in the nest will get hungry' because they're staying in the nest, and there doing jobs in the nest while other answer go out foraging and so when an ant that has been successful foraging comes back to the nest sometimes the hungry ant will literally come up to the ant that just forage and tap its antenna.

And the aunt that foraged if it has, you know, excess resources from foraging well at that point regurgitate some of the food for the hungry ant and I love that example because there's a very clear request. The little antenna tap is like "may I please have some? I'm hungry."

So yeah, vampire bats and trophallaxis in ants I think are really cool examples from the animal world of need-based transfer system.

Dr. Biology: How did you go from animals to cells?

Athena: When I finished my PhD I had the chance to work in a postdoc with someone who is a cooperation theorist, he was in ecology evolutionary biology. His name is John Pepper and he worked and still does work on cooperation theory. When is cooperation stable? When is it not? What kind of dynamics lead cooperation to be more stable? So I went and I started working with him and he exposed me to the new work that was happening on applying evolutionary biology to cancer.

And at first, it was just, oh this is a cool thing that you can apply evolutionary biology to, to understand it better.

And then, at some point when we were chatting I said, well you know a lot of the things that we're studying just in general in cooperation theory. They actually apply to try and understand how cells evolve in the body and how the cooperation can breakdown. I wouldn't say it's an all ha moment, because it was process that maybe took, you know, a couple weeks or a couple of months, but then,

when it finally gelled and I realized, yeah, well fundamentally cancer is a problem of cheating in the body.

Then I was like I couldn't turn back from that, because it was number one so fascinating, number two, there so few people working on it that it was just this wide open field to explore and try to understand how we can apply these concepts. And number three it has such important implications for human health.

Dr. Biology: So let's talk a little bit about cellular cooperation. So inside our bodies, we have lots of different kinds of cells, and they have to cooperate with each other because they don't all do the same thing. They rely on each other. So this is back to your cooperation within the cells.

And then when you get into the cheating. I think you said multi cellular cheating.

So, cancer cells are multi cellular cheaters.

Athena: That's one way to think about them.

Dr. Biology: How are they cheating? What are they doing that's different?

Athena: Yeah, that's a great question. So, we've got all these cooperative things that we do as multi cellular bodies automatically without realizing it and what happens in cancer is that the genes that make those cooperative things happen without us even knowing it they can get mutated, or broken in other ways. The environment around the cancer cells can also get messed up which can make them express the wrong jeans at the wrong time, and basically what happens is these foundations of multi cellular cooperation get messed up. So rather than cells restraining their proliferation, they'll proliferate too much. Rather than them controlling their cell death, they'll keep surviving even though they're messed up.

Instead of passing resources along and the way they should, or refraining from using resources, cancer cells will use a lot of resources. And then they'll create a bunch of waste. So instead of maintaining this environment around them, they are destroying it.

And cancer cells also kind of stopped doing the job that there supposed to do. They're like you know these shirkers. They're just sitting around doing their own thing instead of contributing to the wellbeing of the multi-cellular body.

Dr. Biology: Now with your work, you mentioned that you're in an area that not a lot of people have been doing this.
So would you say you're a disruptor in the study of cancer?

Athena: I'm not as much of a disruptor is cancer is. You know, that the good thing is that in cancer biology there's actually a lot of receptivity to the evolutionary approach to the ecological approach, because evolution and ecology bring all of these methods and tools that can actually be used to analyze a bunch of the huge datasets we now have access to in terms of you genomics. In terms of what is going on inside tumors so you can take pathology slides, where you kind of get a slice of the tumor and analyze that based on ecology. Like what is happening in the ecosystem of the tumor.

So there's a lot of receptivity to evolution and ecology in cancer biology and more and more so I think receptivity too cooperation theory is well. There are a number of researchers, not just me, who are looking at how cancer is a breakdown of multi-cellular cooperation and even how cancer cells evolved to cooperate inside the tumor.

Sometimes, in a way that is really bad for us, because once they can start to organize themselves, they can exploit us even more effectively, which is kind of scary.

Dr. Biology: Right. so I guess we could say we have a cooperation of scientists around cooperation thing like that? Yeah.

[laughter]

Athena: Something like that, yeah.

Dr. Biology: Well, Athena:. I cannot let you get out of here without asking three questions I ask all my scientists. So let me start. The very first one is - when did you first know you wanted to be a scientist?

Athena: Hum, I think it was when I was about three and a half and I had a little brother. He was a year old and my mom was holding him and he had this toy. He was dropping it and then my mom and hand it to him and he would drop it again. And I said to my mom, I think he's testing gravity.

[laughter]

So, I've always been interested in the world. Searching for you know regularities and patterns and for a really long time I actually wanted to be a theoretical astrophysicist, because I thought, Ah the mysteries of the universe. You know, I really want to understand how the universe started and our place in it, and at some point I think it was in the middle of high school I realize that understanding social behavior, and understanding the human mind, and understanding how we interact with each other, and what the principles are underlying that that, that is a frontier of our knowledge that sort of right here in front of us. And it's as deep of a mystery as sort of understanding the structure of the universe.

And so, yeah, so really I think since high school, I wanted to focus on evolution and behavior as my scientific specialty.

Dr. Biology: So since the age of three and a half and then more focused in high school.

Athena: Yeah.

Dr. Biology: But my next question is, I'm going to take it all away from you.

Athena: Okay

Dr. Biology: So you're an accomplished scientist you're not going to be a teacher. I know you're an author. I'm going to take that away because I really want you to stretch okay. What would you do if you could do anything?

Athena: Well, I don't know if this is cheating or not - cheating, but I would probably go back to teaching dance professionally.

Dr. Biology: Teaching dance professionally!

Athena: Yes, yeah, I taught salsa dancing throughout college and in graduate school I actually had my own dance studio. So I was doing that, while doing my PhD, which on one hand was, you know, a challenge, but it was also really fun. And dancing is a great way to connect with people and to also get exercise without even realizing you're getting exercise. And it's also just a really

interesting thing in terms of like why do humans do it? Why do we dance? So yeah I would probably go back to teaching dance and I might explore some of the mysteries of why humans dance and create music, but as a dance instructor instead of as an academic.

Dr. Biology: Do you go dance some place now?

Athena: Yes, I try to dance one or two, maybe three nights a week, if I can.

Dr. Biology: Very good. The last question. What advice would you have for a young scientist, or perhaps the dance instructor out there that's always wanted to be a scientist and wants to shift their career?

Athena: Well. My favorite piece of advice that I've ever gotten, which I'll share is to be careful what advice you take. To me what this really means is that there are a lot of people out there who are very well meaning and they have a certain understanding of the world and how you succeed in the world.

But, that does not necessarily mean that only those things are possible, right? So, if you're getting advice that doesn't feel like it fits you, or maybe you have a different kind of ambition, or you want to study something that nobody has studied before in the way that you want to study it.

I would take with a grain of salt advice that tries to steer you just in a conventional direction. That doesn't mean that you should be completely unconventional and throw out everything that's ever been done before, because there's a huge amount of work that of a really high value that you can learn about that can help inform what you're going to study or do. But in order to do something truly new you have to be willing to imagine the world in a way that it isn't now. And you have to be willing to take some risks. That's not always encouraged in academia, but I think that that really is the way forward for all of us as humans if we want to understand the world and do something that we can in our little corner of it to make the world a better place.

Dr. Biology: Well before I let you go there is one other question I have for you and that's about Zombie Apocalypse Medicine meeting. What's that all about?

Athena: Yeah, what is that? An academic conference about zombies is that for real? Yes, it's for real.

[laughter]

So me and a few of my colleagues. We came up with this idea a few years ago to use the idea of zombies and the apocalypse to talk about a bunch of really cool scientific findings that are coming out about how our health and wellbeing is really tied in with these kinds of dynamics of one thing controlling another or co-opting another.

So, parasites are sort of the classic example of this, where they can hijack their host behavior sometimes in ways that are really not in the host's interest. But are in the interest of the parasite that they complete the parasites life cycle, or allow it to transmit to other hosts. and so one of the very central things for this conference is that just the basic principles of evolutionary biology mean that you're going to have parasites that can manipulate hosts in these really wild ways, but it's not just parasites that do this kind of thing.

We as humans, we manipulate each other. We co-opt each other. Sometimes we exploit each other. There's all sorts of ways that humans do that. So you could think of con artists and cheaters and exploiters as zombifying people to a certain extent. And then there's technology, which to me is a

really exciting new area of understanding human interaction.

But one of the things that happen with technology like can take our smartphones for example. I mean how many people do you know, and maybe you're one of them, you can't not pick up your phone and see if you have notifications every 30 seconds.

Because the algorithms in your phone have really been you know designed to keep your attention and get your attention as much as possible.

Dr. Biology: Well, the same thing if you go out and you watch the behavior of humans. If you watch someone pick up their phone. Check their phone. If there in a group it won't be long before they all do the same thing. It's almost like then there queued as well.

Athena: Yeah, so talk about a zombie horde right, I mean, you've got everyone like crossing the street while you are on your phone. I mean you look a little bit like a zombie when you're doing that. Just for your information in case you do that. You do look like a zombie when you're walking across the street while checking your phone and you might also get hit by a car, because you're not paying attention.

So all of these things with technology zombifying us I think they also captured this same kind of fundamental dynamic of when do you have one entity that is fully or partially controlling the behavior of another entity. So a lot of what the zombie apocalypse, Medicine meeting is about is looking at all of those kinds of phenomena through this lens of evolutionary biology and really of cooperation theory also, because this coercion, and control and exploitation it's kind of the other side of cooperation.

Dr. Biology: How often do you have the meeting?

Athena: This is our first one, it's happening October 18 through the 21st? And will have the next one in two years. So it'll be every other year.

Dr. Biology: Athena, thank you so much for joining me on Ask A Biologist.

Athena: Thank you so much for having me.

Dr. Biology: You been listening to ask a biologist and my guess is been Athena Aktipis, Professor in the Department of Psychology and a researcher at the Biodesign Institute at Arizona State University. She's also the co-director of the Human Generosity Project.

You can read more about her in our story Cooperation or Conflict On the ask a biologist website. There's also a new book, coming out by Professor Aktipis from Princeton University Press titled, Evolution of the Flesh: Cancer and the transformation of life.

The ask a biologist podcast is produced on the campus of Arizona State University and is recorded in the Grassroots Studio housed in the School of Life Sciences, which is an academic unit of the College of Liberal Arts and Sciences.

And remember; even though our program is not broadcast live, you can still send us your questions about biology using our companion website, the address is ask abiologist.asu.edu.
Or you can just Google, the words 'Ask A Biologist'.

I'm Dr. Biology.