Ask A Biologist Vol 103 (Guest: Fiona Naughton)

Explained by Cats

What can our furry feline animals teach us about how science works? Beyond the millions of viral cat videos and cute pictures of our feline friends that span all the social media channels these four-legged animals might just help us understand science. My guest certainly has given them the freedom teach us about the world of bile acids, digestion, cholesterol, and drug therapies. Fiona Naughton is computational biochemist at Arizona State University. Her work goes beyond the lab and incorporates some fun and instructive insights via her clever cat illustrations.

Transcript

Dr. Biology:

This is Ask A Biologist and program about the living world. And I'm Doctor Biology. Now before we get started, you might notice the show sounds a bit different from our other studio episodes. The reason is, well, we're in day 55 of our stay at home mandate. And to record the show, we're using Zoom. I'm actually in my closet in my house recording on Zoom.

Okay, now that we've got that out of the way, if I asked you to pick some images from the world of biology, you might fill it with pictures of white lab coats, beakers, test tubes, test tubes filled with unknown liquids. Or maybe you're really in love with the ocean and have visions of being a marine biologist. So, you could see yourself swimming through a kelp forest, or diving into the depths of the ocean to discover deep sea creatures. I even bet there are those of you that thought about microscopic images of cells. And in today's current environment, even viruses. One picture I doubt you had was a Well.... [cat meows three times]

Dr. Biology:

Yes, cats. But for my guest today, cats have found their way into the world of biology. Not in the way you might think, not in the laboratory, not even studied in the wild. The cats in my guest's story first crept into her work in a creative way, and then expanded into a role where they help explain some complex biology. Fiona Naughton is currently working in the laboratory of Oliver Beckstein, and Associate Professor in the Department of Physics, Center for Biological Physics at Arizona State University. Her research blends physics and biochemistry with a dash of cats. You'll get a better idea of what might be in store for this show by Fiona's Twitter handle @explainedbycats. Welcome to Ask a biologist Fiona.

Fiona:

Thank you for having me.

Dr. Biology:

I hope that we've teased some people to think about what on Earth would cats and science and how they're going together other than do cats lick milk up with their tongue in a certain way? And what's the physics of a cat when they drop? Do they always land on their feet? Explained by cats from you, is a little bit different.

Fiona:

Yes, so what I've been doing is, instead of explaining some of the work I do through the same old set of boring science equations or images, replacing some of those things with cats. And explaining my work instead of looking at these complicated molecules. What of these behave like cats? And how would I explain the things they do if they had a tail and four paws?

Dr. Biology:

Did your cats start to explain your science all at once? Or did they start slowly to creep into your science?

Fiona:

Yeah, it started slowly, really. So, the first cats that started appearing were, you know, sort of unrelated cats peeking in the background of my slides just to sort of break up the otherwise science, science, science, oh like a cat science. But then as I got further along, I thought, well, why not actually make these cats sort of a relevant part of what I'm talking about, instead of just hiding off in the corner there. So, over the years they have started to work their way in.

Dr. Biology:

Let's talk about yourself. Because I'm actually going to say it in the traditional science terminology. And then I'm going to challenge you to use your cats to talk a little bit about this. And let's explain it in a more, what would I say, broader terms so that everybody can, and in your case digest. [laughter] and I hope some people will catch on to that what you do. So, Fiona studies, bile acid transporters, which are proteins in the lining of the intestine, that transport and recycled bile acids. Basically, molecules synthesized from cholesterol in the liver for use in digestion and absorption in the intestines. If I go and I talked to my next-door neighbor, or I talked to my mother or my kids, and I said, Oh, yes, I'm going to have a nice chat with Fiona Naughton. We're going to talk about bile acid transporters. I'll bet you I've lost them [laughter] by the time I end up with transporters. So, I'm going to challenge you. Let's bring our cats in. Let's talk a little bit.

Fiona:

Okay, so perhaps one way we could consider it is we have our house and we have a wall that separates the inside of the house from the outside of the house. That would be the cell wall, and this case, which is lining the intestine. And we have our cats, which are our bile acids. So, they're currently sitting outside, but we want our cats to come back inside. So, what we do is we build a special trapdoor in our wall that our cats can get through. But because we don't want just everything that's outside getting into our house, that's why it's a special trapdoor so that it only lets the cats through, and it only lets them inside the house and not sort of back outside to escape again.

Dr. Biology:

Any cats?

Fiona:

I guess you could say that it will recognize cats but not dogs or something like that.

Dr. Biology:

Is it just one door? A lot of doors?

Fiona:

Yeah, you would end up with a lot of different doors. And so well, I look at the door that lets cats in, they might be some doors that let dogs in, or perhaps the doors that would let the dogs out or perhaps then letting birds in or trying to get insects out of your house, and so on.

Dr. Biology:

But did we miss anything?

Fiona:

Well, as anyone who owns a cat might know that it it's one thing to build a cat door to ask your cat to come inside, but it's quite another to actually convince the cat that it wants to come inside. So more or less what we do is rather than having outdoor, just move the cat inside, we also build it in such a way that say we've got these little butterflies that will come along. And the cat will sort of, when it sees that there's these butterflies sitting on this trapdoor, the cats more likely to come and sit on this door and then they all move inside together. Whereas in our actual bodies, this cat represents these bile acids. These butterflies are sodium ions. So, we encourage the lessons to move inside the cell, which they otherwise wouldn't necessarily want to do by coupling the transport with sodium ions, which do want to move inside the cell.

Dr. Biology:

Now, this is amazing. So, this is fun. So, we have bile acids, we have transporters, sodium ions, and we can do it all and explain all about it by cats.

Fiona:

Yes. [laughter]

Dr. Biology:

And a butterfly in this case, yes.

Dr. Biology:

Okay, so, we've been talking about cats and dogs, which is quite interesting for a show on biology, certainly something that we would talk about, [laughter] not necessarily in this context, but in reality, we're talking, in this case about bile acid transporters. Let's get back to a little bit closer to the science. What are we doing with these transporters? And what are you interested in learning about?

Fiona:

So basically while we know the general idea that we have a special door that lets these cats in without letting other creatures in, and without sort of letting them back out, we don't really know sort of the exact details of well, how exactly does it only let certain cats in and why is it not letting them back out? So, what I do in my work is more or less run simulations. So, we have sort of other people in biochemistry, using various techniques can get a picture, a snapshot of perhaps what this door with a cat sitting on it looks like,

at a given point in time. But that doesn't tell us sort of how it moves. So, I run these simulations that kind of tell us well, perhaps How does this cat interact with the door? How does this door kind of swivel to go from facing the outside to the inside to let the cat inside and what's preventing it from sort of, instead letting all the cats outside?

Dr. Biology:

So, we're talking about simulations.

Fiona:

Yes

Dr. Biology:

In this case, we're probably talking, in your case in particular, we're talking about computers, right?

Fiona:

Yes.

Dr. Biology:

Okay. And so, your background, would you consider yourself more of a physicist more of a biochemist, a modeling scientist? Or have you decided that you're all of those?

Fiona:

In a lot of ways, all of them. My undergraduate degree was in biochemistry and physics. My final undergraduate project was physics. And then my PhD is biochemistry. And now I'm back working in a physics department. So, I usually go with the term computational biochemist to kind of wrap all of them together. But it does have Yes, as you said, sort of bits of the major fields working together.

Dr. Biology:

So, I wouldn't say find you in a typical laboratory that where somebody would think about a biology laboratory with a bench and, and doing experiments? I'd find you in front of a computer screen, right?

Fiona:

Yes.

Dr. Biology:

So, if we talk a little bit more about bio acid transporters. What do they do for us?

Fiona:

So basically, the idea is that they recycle bile acids from our digestive system. So, if bile acids aid digestion, and rather than if we just sort of leave them to be expelled from the body, then the body has to synthesize new ones. So, the idea is that after they've been useful in digesting your food, let's reabsorb them into the body so that we can send them back up and start again without having to waste energy making new ones.

Dr. Biology:

From a practical standpoint, what would this lead to?

Fiona:

So, the bile acids when they are synthesized, those are made from cholesterol. We know that sort of high Cholesterol has been an increasing problem in sort of today's age. So if we can, in fact, block these transporters from recycling the bile acid and force the body to make new ones, then we're using up that sort of extra supply of cholesterol to make these new bile acids, which perhaps the way sort of things originally involved was not the ideal way. But today if this is a possible way, we can look into treating high cholesterol.

Dr. Biology:

Ah, I see. And then I think I saw something when I was doing some reading about you also about some drug delivery. This is something that we've been talking about, because typically you have certain ways of taking drugs, right? You can get a shot, intravenous, which is still with a needle, and then you can take either a liquid or pill form type of medicine. But often when you take the ones that you take through the mouth, there are some issues. So, let's talk a little bit about some of those issues.

Fiona:

Well, first of all, you're kind of relying on the body and sort of absorbing everything that you know, sort of delivering in your pill, which, you know, is not always the case, obviously, not everything you put into your mouth stays in your body. So, you have to play around a lot with - well, how much of this medicine do I give you in a pill format? Knowing that, well, not all of it may be absorbed, but you also have to consider well, but what of all of it does get absorbed when too much of a particular medicine is not always a good thing? So, it can be kind of quite hard to figure out exactly. You know, what dosage do you put in a pill to ensure that sort of enough gets into the body but not too much?

Dr. Biology:

Right, because we're not all the same.

Fiona:

Yeah, exactly.

Dr. Biology:

Okay, so we can help treat for possibly high cholesterol. We're talking about helping us with drug delivery. And when we talk about drug delivery, we're talking about the fact that we're not all the same. And so that when we take some drugs, especially through the mouth, that we don't always absorb them the same way. And so, with your work, what is the goal ultimately, to get to? What would you be pleased to see?

Fiona:

I think particularly how this transporter sort of recognizes these bile acids, because we can then both start considering then well, if I know how it recognizes this bile acid, how can I sort of put a block in so that it will stop absorbing the bile acids? And then we can sort of consider that so the high cholesterol treatment. But then also a drug delivery, if I know going back to our cat and the dog analogy, if I know that this door recognizes I

have a cat because oh, it's got two ears and a tail. Then I can say, Well, I have this drug I want to deliver, can I put two ears and a tail on it and trick the transporter into thinking, oh, here's a cat, I can absorb it. And then sort of through the simulations, if we know sort of, you know how fast it's likely to do that that will help us sort of better understand how we might get those drugs delivered to the body.

Dr. Biology:

I'm glad you brought us back to the cats. [laughter] I meant to ask; do you have a background in art?

Fiona:

No, not sort of a formal background.

Dr. Biology:

I also thought it was interesting because I read that some of your inspiration for doing this came from David Goodsell.

Fiona:

Oh yes.

Dr. Biology:

And I recommend and what we'll do, Fiona, if it's okay with you, I am going to take and put your illustration If Proteins Were Cats on the podcast here, so people can come and see it. And we'll link off to David Goodsell's site as well, because he has some really exquisite works dealing with cellular imagery that he's done through watercolors. I just think it's wonderful to explore this space, because, quite honestly, we get to see them on a regular basis. And it's kind of like living someplace that is beautiful. And no matter how beautiful it is, if you're there long enough, you forget how cool and wonderful it is, because it's just right outside your door.

Fiona:

[laughter] Yes.

Dr. Biology:

And so this is a nice way for people and for us to revisit these things and say, you know, this really is cool stuff. I really do get to see some amazing things every day. And I forget about it. And there truly are a lot of people that are artists and scientists, and they got some formal training. In your case, you basically just started teaching yourself to draw.

Fiona:

Yeah. So, I guess I've been sort of creative in a way and I guess had a passing interest in sort of artistic things. But never quite, I guess, had is the natural talent especially that I saw a lot of my friends did so kind of stuck to my science. But now that I sort of started wanting to include cats and things, the first couple of sort of cats I drew were, you know, not very good, but I suppose it's as long as it's got, you know, is in wishes people could usually tell it was a cat. But then just sort of trial and error over a couple of years, I've figured out sort of the particular style that works for me. That's something that that I can do and be proud of, rather than the sort of messy kind of circles I started off with.

Dr. Biology:

It certainly has progressed because you actually ended up at the Biophysical Society meeting and They have this art of science image contest. And your illustration called If Proteins Were Cats won first place.

Fiona:

Yeah, that was sort of very exciting to get so that that recognition of, yes, I can do this, and you know, people like it.

Dr. Biology:

Is this kind of relaxing? Is this a way to escape a bit as well?

Fiona:

Yeah, I think so. It's sort of a good way to kind of still be thinking about the science and you know, the work I'm trying to do, but without getting too caught up in sort of all the details and sort of stressing too much about, oh, you know, this graph doesn't show exactly what I thought it might or how do I explain this in sort of the proper science terminology. It can be nice to sort of just spend some time sort of doodling and just, you know, how would I do this if this was a cat, instead of the bile acid transporter.

Dr. Biology:

So, I can see why the general public would love learning about biology through your illustrations. [laughter] What about scientists?

Fiona:

Most people have generally sort of quite liked them. Well, that I've heard of. Certainly I did sort of struggle with it first, when I was starting out with how much other people would appreciate having these cats to sort of break up the usual and how much they might think it was sort of irrelevant or detract from the actual science. But I've had sort of a lot of good positive feedback. [What] was really good, especially about this five physics conference that I had a lot of people seek me out at the conference and come up to me and say, oh, was that your cat image in the image contest? And then that told me, you know, they really enjoyed it and that it was, yeah, something really different. A lot of my fellow scientists definitely would like something different every so often.

Dr. Biology:

We talked about our cat doors, our dog doors. Your drawing, it's not the same thing. So, let's talk a little bit about the drawing that you did that won first place.

Fiona:

Yeah. So, in that first analogy, we had the cats were our bile acids that we were trying to get inside. And the transporter was the door that lets us do that, in this drawing, the cats are our door here or sort of our door guards that are deciding, you know, what can get in or not. And our bile acid is this little toy mouse that we're trying to get inside. So instead of just one cat, we have two cats. And we could consider that rather than just having sort of one wall. We have sort of two walls and that each cat is in charge of sort of, you know what goes through sort of one particular wall. So, it's cat's face opposite directions. And there's two, sort of two ways that each cat can sort of sit one where his tail is kind of blocking his particular wall, or one where his tail sort of, you know out so that his wall is

open. So, when say the cat that's kind of facing outside, his tail will sort of be open, but the other cat facing the inside, he'll have sort of his tail so that his wall is blocked. And then the toy mouth starts off outside, but it can sort of get past that first cat to sort of sit with these cats sort of between these two walls. And then the two cats kind of swap the way they're sitting so the one facing outside now has his tail blocking the wall to the outside, and the one facing inside now sort of opens his side of the wall. So, our toy mouse can now get properly inside the cell.

Dr. Biology:

Got it. So basically, the mouse that's outside the cell that you have the cat tail is in a position and allows it to sneak in kind of behind in the tail. And, and it's gotten in between these two walls that are basically aligned with each other. And then the cats for whatever reason, they swap the, you know, like, there must be a mouse here. And they, they swap positions, because the mouse couldn't get all the way through because the other cat the tail is blocking it.

Fiona:

Yeah.

Dr. Biology:

Right. And so now this mouse is in there and the other cat switches. And so now the tail is opening up the other wall, which is facing inside the cell. And so now that mouse can scurry on into the cell.

Fiona:

Yeah, that's correct. Yeah.

Dr. Biology:

Cool.

Fiona:

Yeah. So this is, I guess, this particular way of working where you've got say two cats who kind of change tails tail position like this comes up in quite a few other systems for forgetting things inside ourselves, not just for tally marks or mice as we're talking about here.

Dr. Biology:

Right? These are very selective doorways into the cell for different kinds of mice or different kinds of dogs or cats. Oh, well, I love it though. I mean, I love the colors, and I love the cats.

Dr. Biology:

Before my scientists get the leave, I always ask three questions. Okay, now you're ready.

Fiona:

Yep.

Dr. Biology:

Okay, the first one is... When did you first know that you wanted to be a scientist? And I always say, the aha moment. Was there such a thing for you?

Fiona:

Well, ooh, certainly I know in primary school. So, when I was about 10, I discovered genetics, or the idea of genetics and thought that was super cool. I then had a brief foray, sort of until late high school, I thought I wanted to be an engineer instead. But yeah, my final year of high school, I participated in the International Physics Olympiad and sort of discovered through that science was something that, yeah, I really did like and that I was good at. That was like, okay, sorry, engineering, but I'm a scientist now.

Dr. Biology:

[laughter]

Dr. Biology:

Okay, so you're just starting out. You're a young scientist. But I'm going to take it all away from you on this next question. And so, you can't be a scientist and so I'm going to take away your engineering. You already let me know that you thought you might be an engineer. [laughter] I'm going to take away anything to do with biology. And you might even have gotten the teaching bug. So, I'm going to take that away. And this is a question where you get to expand, what would you do? Or what would you be if you could do anything or be anyone?

Fiona:

Oh, I'm probably gonna answer and then go to sleep at night and think, Oh, I should have said this instead. Let's see. So, this is something I've kind of only dabbled with occasionally. But I do quite like cake decorating. I wouldn't say I am very good at it yet. But yeah, it is kind of a nice hobby to keep up. And I guess if I had more time to put into that and learning kind of, you know, the proper techniques as it were, that could be something that could be quite fun.

Dr. Biology:

It's interesting because I was being really nice to you because I didn't take away from you the drawing part. [laughter] And then You're going to say, I'm going to be an artist. Did you think I took that away from you?

Fiona:

I think, I guess it's I feel that I do like the drawing, but I don't think I could do it full time. I like just having it as an on the side, occasional thing.

Dr. Biology:

Fair enough.

Dr. Biology:

All right. So, we have one last question.

Fiona:

Okay.

Dr. Biology:

What advice would you have for a young scientist, or perhaps, in this day and age, you can have multiple careers in your life. And so, there might be someone who got it into one career and always wanted to be a scientist. And so now they're ready to switch. So, what advice would you have?

Fiona:

I guess, yeah, it's sort of that science kind of has the two parts to it that you can sort of read things out of a textbook, but it's always really good to sort of be able to do experiments yourself and kind of see things working in practice. And obviously, there's a lot of things that, you know, you can't just do at home. But there is also a surprising amount of things that, you know, simple home experiments you can do that actually kind of connect to sort of deeper science concepts. Well, at least I've always found it really cool to be able to link things like that, you know, the things that you read in a textbook to something that you can sort of see with your own eyes.

Dr. Biology:

So, the experience of actually doing rather than just reading and watching,

Fiona:

Yeah,

Dr. Biology:

Okay. Well, Fiona Naughton I have to thank you again for taking some time out and joining me via Zoom on Ask A Biologist.

Fiona:

Yeah, it's been great fun.

Dr. Biology:

You've been listening to Ask A Biologist to my guest has been Fiona Naughton, a researcher working in the laboratory of Oliver Beckstein, an Associate Professor in the Department of Physics Center for Biological Physics at Arizona State University. Now if we you have grabbed your attention with this podcast, you definitely want to go over to the website and see the illustration that Fiona created that won her first place in the Biophysical Society's Art of Science Image contest.

Dr. Biology:

The Ask A Biologist podcast is produced on the campus of Arizona State University, and is recorded - Well, usually recorded in the grassroots studio, housed in the School of Life Sciences, which is an academic unit in The College of Liberal Arts and Sciences. And as always, remember, even though our program is not broadcast live, you can still send us your questions about biology using our companion website, the addresses, askabiologist@asu.edu or you can just Google the words. Ask A Biologist. I'm Dr. Biology.