Ask a Biologist vol 030   Topic: Math Biology   Guests: Cassie Pawling & Genevieve Toutain

Math Biology -

Dr. Biology visits with two young mathematicians that also have a love for biology. Cassie Pawling and Genevieve Toutain talk about how their passion for numbers have blended with biology as well as how they have gotten where they are and future plans. Be sure to listen in if for no other reason than to learn some great math tricks you can use to impress friends and family including some mind boggling mind reading?

Transcript

Dr. Biology: This is "Ask a Biologist," a program about the living world, and I'm Dr. Biology. How about we start out today with a pop quiz? Now, before I hear the cries of "Oh, no!" and the click of the dial, let me tell you we won't be grading you on this, so you can relax.

OK, ready? What's four plus seven? Next multiply 45 times 45. Finally, what's the square root of 25? So how did you do?

If you're like a lot of people, you probably felt a slight panic right after I asked what's 45 times 45. It's kind of like when the teacher asks you to go to the chalkboard to solve one of your math homework problems that you didn't do.

It's also common for people to have a fear of math. We even have a name for the fear, "Mathphobia." Now you might be thinking, hey, this show is supposed to be about Biology. Why are we having a math quiz?

It turns out, we get a lot of questions sent to our website from students wanting to know how much math they will need to become a biologist. And well, the answer is, it depends on the type of biologist you become.

To be sure though, no matter what kind of biologist you become, you will need to use math. In fact, mathematics is one of the best skills a biologist can master and also a very powerful tool to answer complex biology questions.

Today we're going to talk about biology, mathematics, and some of the ways biologists use math in their research. Our guests are two young mathematicians that are studying both mathematics and biology.

Cassandra Pawling or Cassie, as she likes to be called, is an undergraduate student in the Department of Mathematics and Statistics at Arizona State University. And Genevieve Toutain is a graduate student also in the Department of Mathematics and Statistics at ASU.

Together, we are going to talk about mathematics, biology, and the paths they are paving in school, and maybe their thoughts of a career in science.

We're also going to share some cool math tricks that you can use to impress your friends, family, and maybe even your math teacher, including a simple way to solve the 45 times 45 problem that was part of your pop quiz.

In fact, before we started the show, I overheard Genevieve say something about using math to read my mind? Which has me very curious to find out how she can do that. Thanks for being on the show and welcome Cassie.

Cassie Pawling: Hi, Dr. Biology.

Dr. Biology: ...and Genevieve.

Genevieve Toutain: It's good to be here.

Dr. Biology: All right, why are two young mathematicians getting involved in biology and well, maybe you didn't even start out with mathematics? Genevieve, what got you started?

Genevieve: So I actually started in biology. My undergraduate degree was in biology, and from there I decided that I needed to know some math in order to do biology better. So, I'm doing a math degree now.

Dr. Biology: And what was the biology degree in?

Genevieve: I did Limnology actually, which is a freshwater ecosystem.

Dr. Biology: Limnology, we often think about oceanographers but we don't think of people that are inland, the ones that deal with lakes and streams. We actually have a Limnologist, Jim Elser. He's one of our faculty in the School of Life Sciences. We had him on an earlier show where we went out into the field.

It was called a "Walk on the Wild Side." Jim talked about what you could find in a drop of water, which was pretty impressive. And so, I'm hoping to get him back on the show. All right, Cassie, what got you started in mathematics and biology?

Cassie Pawling: I just started my undergraduate degree a couple of years ago. When I came in to college, I thought math was neat so I chose it as my major. My first math class that I went to, my adviser signed me up for the wrong class.

It was really terrifying. I got called on within the first two minutes to answer a question. I had no idea what was going on. But my teacher pulled me aside after class and when he saw how interested I was in math and excited about school, he introduced me to his adviser, Carlos Castillo-Chavez. Ever since, I've been involved with math biology.

Dr. Biology: OK, I can tell, you both got hooked on math at different times. Genevieve actually started out in biology and Cassie, seem like you just started right out in math.

But you're both getting this blend of biology and mathematics, what kind of courses had you been taking or plan to take? Can you help us out there, Genevieve?

Genevieve: I had been taking math courses that are applied to biology. This semester I'm actually taking a course called "Macroparasites," where we study mathematically how parasites can get into different populations. I've also done some courses in "Mathematical Epidemiology," which is the math of how diseases spread.

And I also did some "Mathematical Neurobiology," which is how nerves work and the brain and that kind of thing.

Dr. Biology: Excellent! And when we talk about epidemiology, you could have a career with the CDC, the Center for Disease Control. When someone might ask, what do you do with the degree in mathematics and biology? That would be one of them, right?

Genevieve: Yes, and there's also the NIH, which is the National Institute of Health. They also have positions for people with degrees in math and biology.

Dr. Biology: Perfect! Now, Cassie, you're just starting out with your academic career, what does it look like for you? What kind of classes are you planning on taking or have taken?

Cassie: Well, I'm still exploring what I am going to do in math. I just finished a couple of classes. One of them was abstract algebra. I just took another class, which was statistics. In that class, there are tons of things that you can do with statistics.

We looked at some examples with some health issues, different disease statistics, and finding out if the stats are significant or not, if they really generalize for a whole population.

Dr. Biology: Before we move on, Cassie, you used a really interesting word and it's one that gets used in different ways and means different things depending on who's using it. And that's the word "significant."

In most cases, in everyday use, I would have to say, significant means something that's notable. For example, even in science you might say that there was a significant increase or decrease in the number of Monarch butterflies wintering in Mexico.

However, when you use the word "significant" in statistics, it has a much more precise and a different meaning. Statistically significant means that it's unlikely that something has happened by chance.

And this becomes very important when you're doing studies -say in medicine. You want to make sure that a drug is working because of the way it's designed. And if there wasn't some outcome that was just by chance.

So, because we use it differently, I just thought it would be worthwhile talking about it because it also gets misused or misunderstood sometimes.

Cassie: Right.

Dr. Biology: So let's continue on. You're beginning to show how math fits with biology and where biology fits with math. It all depends on your perspective. For yours with your math background; you'll probably approach biology from a mathematical point of view.

As a pure biologist, I typically use math when I need to. For example, if I'm calculating some kind of magnification on a micrograph, which is a picture of some kind of a cell. That's where I would be using some math.

And I also have to say that the Ask-a-Biologist website gets a lot of questions from teachers and students. And they want to know how much biology do I need to know. In other words, what kind of math will I need to take to become biologist?

And of course, the answer varies depending on the type of biology you plan to be involved with.

Between the two of you, I was hoping we'd be able to list and talk about the different ways that math is used in biology. Or as I said, how biologists use math. Genevieve, how about starting out?

Genevieve: Oh, there's lots. Like I already mentioned, there's disease spread and neurons and parts of the brain. There's also...you can do modeling at the cellular level. There's lots of math that goes into how to sequence DNA.

Dr. Biology: Like the human genome?

Genevieve: The human genome project is very math intensive. You can do math of populations and how...migration patterns of different birds is another math problem.

Cassie: You find math a lot with airports, with the flight patterns that you see that there. And also traffic, okay this is not biology.

Dr. Biology: Actually those two things, especially traffic patterns and the movement of materials or people, has a very interesting link to biology. We talked about ants and ant algorithms in an earlier show. We were able to sit down with Steven Pratt from ASU. He's also in the school of Life Sciences to learn how ants are helping computer scientists answer complex problems like traffic patterns and the movement of materials.

I also want to say, you gave me a great transition to the next topic and that's nature. To the casual observer, nature and mathematics may not have anything to do with each other, but it turns out Mother Nature may have been one of the first great mathematicians. I was hoping the two of you could talk about the close ties that nature does have with mathematics. Cassie does anything come to mind?

Cassie: There's one area of math called fractal geometry, That's a study of things in nature that have these type of what we call fractals, which is a splitting off. So if you think about a tree branch and all the different branches. There's a lot of symmetry that goes on in that tree branch.

Dr. Biology: Can either of you think of other examples of symmetry?

Genevieve: You can also see math in seashells or snail shells, where you can see that you have a pattern that continues to repeat and in each year as they grow their shell a little longer you see the same kind of pattern just stretched out a little more.

Dr. Biology: And staying in the ocean there's another animal, a sea star. Some people call them starfish. They have a really neat pattern or radial symmetry. Any other animals or place in nature that math is seen?

Genevive: Tigers and leopards, their striping and spotted patterns. You can model that mathematically. You can actually write down equations that describe where the spots will end up and where the strips will end up.

Dr. Biology: Really? I didn't know that. Now earlier we were talking about math in biology. I think it was Genevieve that said that there was a way of modeling say, for example, how cells work. We're not actually talking when we say modeling about fashion models or creating the latest car model.

When we talk about modeling we're talking about creating a simulation, an artificial environment, usually on a computer, that helps us learn how living things work. Have either one of you done any computer modeling?

Genevive: I did some cell biology modeling with nucleus zone positioning so I.... DNA knots itself that way it can fit inside a cell better and so I did some modeling research, looking at where the DNA can find space to knot itself.

Dr. Biology: That's very cool. We actually talk about DNA on this show all time and how virtually every living thing has cells inside them that have a tiny area called the nucleus. Inside the nucleus is this DNA. And the DNA is the blueprint that tells the cell how to build things or how to do things. What kind of function it has to have. So it becomes really important. And you've been working on how it knots itself or sometimes we say folds into this really teeny, tiny shape.

Now to give you an idea of how important those folds are and the packaging of DNA, if you actually took the DNA out of a human cell and you were able to stretch it out into a long line, you'd be able to stretch it out to almost three meters, which is just about ten feet. This is pretty impressive. So those folds and/or knots are very important.

Now Cassie we've talked about your career path before. And even though you love math and biology, you may not be heading towards a career in biological math or computational biology. In fact, you have an interest in teaching math and you're working on a book for teaching math in high school. Right?

Cassie: Correct.

Dr. Biology: Well, tell us a little about the book.

Cassie: Well originally this book started off for the students. I'm part of a program over the summer. Genevieve and I we did it over this past summer. It's for students in high school. They take some college level courses and they learn the basics of mathematical modeling.

But I'd like to generalize the techniques that we taught them and put them in a book for teachers. We see that a lot of the techniques use a lot of the concepts that are taught in high school.

So through the book, we want to be able to show teachers that we can use these real life applications and this real life type of mathematical modeling. It's really used to teach the same type of concepts that are already taught in high school. It gives students a little more meaning to what they're learning.

Dr. Biology: It sounds like a great way to introduce mathematics to students. Actually, one that I would really be fond of, if I was a student because I really enjoy using math when it helps solve a problem or answer a question that I'm interested in.

What if I asked you to share one or two of your examples from your book on our companion website? Would you be willing to have us create a companion article that we could link to this show?

Cassie: Absolutely. We have tons of examples that we could put up there.

Dr. Biology: Excellent. Well, that's just what we'll do. We'll arrange to have a companion article written that will link to this podcast.

Genevieve, you're about to finish up your Masters, if you get all your classes completed and your exams, correct?

Genevieve: Yep. I'll be done in May.

Dr. Biology: You'll be done in May? So are you going to go out and get a job? Are your parents pushing for that or do you plan to continue on and get your Ph.D.?

Genevieve: Well it's looking right now that I'm going to pursue a Ph.D. I haven't decided yet if I want to be in a math department or a biology department, but I'm in the process of applying to Ph.D. programs right now.

Dr. Biology: This brings up another question that we get sent in from students to the "Ask-a-Biologist" website. They often ask what they should do to prepare themselves to go to college. Then what they might need to take in college to become a biologist.

Of course, we do advise them and there are variations depending on what kind of biologist you want to be. But since I have the two of you here I thought it would be great

to hear from you. It would be nice to get a viewpoint from someone who is actually doing it right now.

And you're relatively fresh out of high school, so you've got some more real world experience. For example, do you have to make up your mind in high school about what you want to do for a career? When you get to college can you change your mind? If you decide you don't want to be a mathematician and you want to be a biologist, or you don't want to be a biologist and you want to be a mathematician, can you make those changes?

Genevieve: You always have flexibility to decide, you're never stuck. Once you get into school, there are all kinds of departments you can take classes in. It's all about finding a professor that you can work with. If you can find someone you like working with, and work on something that you like to do, then you're going to keep doing it, as long as you like what you're doing.

Dr. Biology: Now Cassie, you did jump right into math as a major in college.

Cassie: I did, but more, out of anything, on a whim. I didn't want to be undecided, or undeclared, so I just chose math because I thought math was like a puzzle and it was fun. And it just happened to luckily be my passion.

Dr. Biology: Genevieve, you talked about finding a professor that you like to work with. Cassie, you said, I think the word was 'advisor', and in either case, we often call these people 'mentors.' Cassie, how important are mentors, especially if you think you're going to get involved in research, or some kind of a scientific career?

Cassie: I found that your teachers are your most invaluable resource. Like I said before, the whole reason that I got into math and mathematical biology was because of my teacher. They know people. If you're a good student and if you show some enthusiasm, they will introduce you. They will put you down the right path, because somebody was there for them at some point to do it for them.

Genevieve: I think it's really important to have a mentor that you can talk to about things that are not only academic, but beyond that - candidly, Going to college is a big transition; you're moving out of your house, taking different courses, it's a completely different time schedule, and it's important to have someone that you can talk to, who you can run decisions past. If they happen to be very handy at getting you a job someday too, not a bad plan.

Dr. Biology: Not a bad plan at all. How hard is it to find a mentor?

Cassie: It's a little intimidating at first. It means that you have to go up to your teachers, you might have to send emails; you kind of have to put yourself out there. But I've always found that teachers are always more than willing to help out their students, so just as long as you talk to your teachers.

Dr. Biology: How long did it take you to find one, Genevieve?

Genevieve: It took me about a semester before I found somebody that I could really connect with, but I just kept going to teachers, and kept taking to people until....

When you find a mentor, you sort of click with them, and when you find somebody you can sit down with and have a banter with, you can talk back and forth about things. Then once you find someone you're comfortable with, you know you've found a good mentor.

Dr. Biology: Who's your mentor?

Genevieve: My mentor is Sharon Crook. She's actually in the School of Life Sciences and the Department of Mathematics. She's joint appointed and she's who I do research with right now.

Dr. Biology: And that just reinforces the point that there's a very strong link between math and biology. To help these two areas connect, we're seeing more and more joint appointments for new professors between biology and math, or biology and say, computer science.

It also shows how mixing these two disciplines is very important so that we can solve some of the more complex problems and answer some of the more difficult questions about our living world.

Getting back to mathematics, and my promise at the beginning of the show, to share some fun tricks that you can use to show off to your friends and family, and/or maybe a teacher, even a math teacher.

I'm going to ask Cassie and Genevieve to think about something they could share, and while they're doing that, I'm going to start with one that I like.

If you're somewhere where you have a pencil and paper handy, you may want to grab them, but don't worry, a lot of these thing you can do in your head.

For my math trick, all you need to know are your times tables. What we're going to do, are multiply large numbers that end in five, to themselves. And that's actually one of the quiz questions at the beginning. It was 45 times 45.

Well, in this example I'm going to say, let's multiply 25 times 25. All you need to do is take the digit that's to the left of the five - in this case it's the number two - and multiply it by one number larger, which in this case is the number three. So you multiply two times three and you get six. Now all you have to do is take the number six, and on the end, place the number 25. So you now have six two five, or, 625.

And this holds up all the way through the multiplication tables. So, if I picked the example of 45 times 45, I would take the next higher number from four, which is five, and multiply four times five, which is?

Cassie: 20.

Dr. Biology: And if I put 25 on the end of it, I get?

Genevieve: 2,025.

Dr. Biology: Excellent, and this holds up all the way through the multiplication tables. As long as you multiply the same number that ends in five, by itself, you can do this trick.

Now how about you two? Genevieve, do you have a math tip you can share?

Genevieve: I do. So, we know the tens rule - so if I'm multiplying a number by ten - so if I have something like five times ten - then I just add a zero onto the end, so if I multiply five times ten, it's going to be 50. Well what a lot of people don't know is that there's a similar rule for 11.

So if I want to multiply a two-digit number by 11, I can just take the two-digit number and I'm going to split it up, that way I have a space in the middle.

And then, so if I'm going to do 32 times 11, I'm going to break it up so I have a space in the middle, and I'm going to add those two numbers together. So I'm going to take three plus two, which is five. So I'm going to take the first number which is three, then I'm going to tack on the sum of them, which is five, then I put the ones in, which is two, so 32 times 11 is 352.

Dr. Biology: Excellent. Can you do one more example?

Genevieve: So how about 45 times 11? Four plus five is nine, so 45 times 11 is four, nine, five, just 495.

Dr. Biology: That's so cool. You know, I just love these things, because it lets us have fun with math, even if someone is not hooked on numbers.

How about you Cassie? You want to share one?

Cassie: So here's an interesting one. If we take one times one, we know that equals one, correct. So let's do 11 times 11. We added another one to the one we had before, so not adding, but actually putting digits next to each other, so one one times one one, and we get 121 - the middle number is now two. Well we'll start seeing a pattern after a little while.

If we out another one digit in front of eleven, we have 111 times 111, and that multiplied is 12,321. So our middle digits, it goes one, two, three, two, one.

Dr. Biology: Mm-hmm.

Cassie: Are you guys catching on?

Dr. Biology: Yes, I am catching on, but then again, I am using a piece of paper and a pencil, so it's much easier for me to see this pattern forming.

Cassie: All right, lets try 1,111 times 1,111. We'll get 1,234,321.

Dr Biology: Now just remember, if you got confused on any of these tips or tricks, what you can do is just sit down, listen to this recording, and write it on a piece of paper. It's real easy to see what's happening.

I also remember that before we started recording, I overheard Genevieve say something about reading my mind, using math. What's that about?

Genevieve: We can use math to read people's minds.

Dr. Biology: OK, you've got my interest. How are you going to do that?

Genevieve: OK, so pick any two-digit number.

Dr. Biology: OK.

Genevieve: Now, I want you to take it and add those two digits together.

Dr. Biology: All right, that's done.

Genevieve: Now, take that and subtract it from what your original number was.

Dr. Biology: All right.

Genevieve: OK, and I want you to take the digits that you have now and I want you to add them together. So you only have one digit left.

Dr. Biology: All right, one digit.

Genevieve: And now, I am going to read your mind and I bet your number is nine.

Dr. Biology: No way! How did you do that? That's so cool! It is nine. I have to say it is a bit scary and so looks like I'd better be careful what I'm thinking while you're here today.

All right, since people could not see what I was writing down on the paper, let me go through the steps I went through. Just so you can visualize what is happening. I picked 23, so I wrote down 23 on a piece of paper. Then I went ahead and added two plus three and I ended up with five.

Next, I subtracted the number five from the first number, which is 23, and I ended up with 18. And then finally, Genevieve had me add, one plus eight, which was nine. That's just amazing! And it is actually fun, so you could do this thing with your friends or your class or hey, try it out on your math teacher.

Let's shift to one of the favorite parts of the show. I like to ask all my visiting scientists three questions. And this is going to be interesting with you two, because you are young and you are coming through this from a math perspective.

So, Cassie, can you remember the first time that you wanted to be a mathematician or a scientist?

Cassie: I knew that I had a special love for math in high school. My junior and senior year, I had the same teacher for calculus. I don't know what it was. It's not something I can describe very easily but I knew that I loved math. I loved the puzzles of math. I loved working with numbers. It's just how my mind worked and that's how I figured it out.

Dr. Biology: Hmm. Now, Genevieve, you already told us that you started out in biology. And then you switched to math. Now you are blending the two, so now, I am going to ask you when did you first want to be a biologist?

Genevieve: I first knew I wanted to be a biologist, though I probably did not know what a biologist was, when I was little. I was probably in second or third grade. We found an earthworm that had been cut in a half by someone on the playground. And both sides of the earthworm were still wriggling about and seemed to be doing just fine.

And I wanted to know why that happened. And so, my mom took me down to the library. We looked up and found out that earthworms have many hearts and that if you cut them in half, then, both halves can still live. And I knew right then that I wanted to find out about living things.

Dr. Biology: I think I had a similar experience with an earthworm when I was younger. Obviously, becoming a biologist stuck. But I am going to take that away from you. You can't be a biologist and I'm not going to let you be a mathematician, what would you be?

Genevieve: I think I would want to be a pilot.

Dr. Biology: A pilot!

Genevieve: A pilot.

Dr. Biology: Now you are going to be an airline pilot or a fighter pilot?

Genevieve: I would like to be an airline pilot. I think it would be fun to fly a plane around. Then you get to land on all kinds of cities and you could see the world and it would be your job to fly around and see all different places in the world.

Dr. Biology: Do you like to travel?

Genevieve: I do like to travel.

Dr. Biology: That's a common thing with our biologists. It is something you can do as a biologist, you can travel. All right, Cassie, I am going to take away your math. You can't be a mathematician and you can't be a biologist. What are you going to be?

Cassie: A wedding planner.

Dr. Biology: A wedding planner!

Cassie: Yes!

Dr. Biology: Really!

Cassie: Yeah!

Dr. Biology: Well, I would have to say that's a first Ask-a-Biologist for someone switching from a biology career to a wedding planning career. However, I have a sneaking suspicion that you would still need some skills that would include mathematics and biology. If not biology certainly psychology if you are going to be a wedding planner.

Cassie: You said anything.

Dr. Biology: Yes, I did say anything. Quite frankly, I love this question because it's very illuminating. We've get to find out what someone would do if they really had to do all over again or they could pick any thing they could do as a career. And it's fun to see what people would do.

All right, one last question. And this one has to do with the kind of advice that you would give someone if they wanted to become a scientist. And since you are both very young, and you are actually doing it and you are not reflecting on it. You are actually experiencing it right now, I thought it may be fun and actually may be more instructional for some of our listeners to hear what you would say.

Cassie: I'm going to be cheesy but I'm going to say, just follow your heart. If you feel like you really just love a school, take your way to that school. If you find that your passion is biology or is math, or something else, just follow that passion and things will work out for the best.

Dr. Biology: How about some words of experience from you, Genevieve?

Genevieve: I would say the best advice I can give is, to just go with the flow. And if you like to do something then find a way to do it because where there's a will, there's a way. And if you can make sure that you are doing something that you like to do, it's the only way to be happy.

Dr. Biology: You have both given some very good general advice. But I want to get down to the details. Let us get in to maybe classes and advisers, and even going off and picking a college. Tell us some of the things that you did or some advice you would have.

Cassie: I took a trip with my mom to different colleges. And when on campus, I got a feel for which campuses I really liked. I talked to students if students were on campus during that time. That was a really good way for me to get a feel if they like their university and what area they were in.

I talked to counselors. I tried to talk to older siblings of my friends and that was my way of getting a good idea of what university I should choose.

Dr. Biology: How about you, Genevieve?

Genevieve: Another thing that is good to do is make sure to get involve in extra-curricular activities. That way you can make sure that you are well rounded which will be something that will be helpful for getting you into college.

Make sure to do well in your classes, senior year. Everybody get senior-itis really tempting to not want to do your work. But stick with it; it will be worth it in the end. And make sure to make good relationships with your teachers. Make sure to have a teacher or two who knows you really well, that you have taken classes with, and make sure that you get good recommendation letters.

Dr. Biology: Well, I want to thank you both for being in the show, Cassie...

Cassie: Thank you.

Dr. Biology: ...and Genevieve.

Genevieve: I've enjoyed it.

Dr. Biology: My guests today on Ask-a-Biologist had been two young mathematicians, Cassie Pawling and Genevieve Toutain from the Arizona State University, Department of Mathematics and Statistics.

They have been really wonderful to have on the show. We have learned about how mathematics and biology are entwined. The Ask-a-Biologist podcast is produced on the campus of Arizona State University.

And even though our show is not broadcast live, you can still send us your questions using our companion website. The web address is askabiologist.asu.edu or you can just Google the words Ask-a-Biologist. I'm Dr. Biology.