Ask a Biologist vol 026 Topic: Seeing inside cells Guest: Carolyn Larabell

Cell CAT Scans -

Dr. Biology travels to the National Center for X-ray Tomography in Berkeley California to learn about a new microscope being built by cell biologist Carolyn Larabell and a team of scientists that provides a new way to look inside cells. Using a building sized instrument called a synchrotron for its light source the XM2, as it is called, uses X-rays to look inside cells - in fact it is so new it is the only one of its kind in the world!

Transcript

Dr. Biology: This is "Ask-a-Biologist," a program about the living world, and I'm Dr. Biology. Today, we're in for a real treat, because we're going to be learning about a very special microscope. It's special because it uses x-rays to look inside of cells instead of the typical light or electrons biologists have used in the past. And it doesn't use just any old x-ray light that you might find in a hospital or a dentist's office. This microscope gets its x-ray light from a special device called a synchrotron.

If you're like me, you might have said, "Synchro what?" Well, that's one of the things I hope we learn about today. As a matter of fact, we're driving up University Drive in Berkley, California, and I can see the building that houses the synchrotron. It's a very, very large domed building on the side of the hill.

Computerized Voice: In 0.1 miles, we are right on Synchrotron Road.

Dr. Biology: Well, that was my electronic navigator. Don't know if you ever had a GPS system, but they're great; and it's pointed out we're getting really close to the building, and our guest scientist, Dr. Carolyn Larabell, the director of the National Center for X-ray Tomography. She'll be talking to us about the new microscope called the X1. And I also hope she'll take us on a journey inside a cell; so we can learn a little bit more about these small units of life.

Computerized Voice: Synchrotron Road on right.

Dr. Biology: Well, I can see we're at the gate. Let's check in with the guard.

Hi, I'm Dr. Biology. I'm here to meet with Dr. Carolyn Larabell.

Guard: Yeah. I need picture ID. This is a parking pass, goes on the dashboard of your vehicle at all times. You are right here. Go up this hill about 200 yards to a stop sign. Turn right at the stop sign, follow this road. This is building 6, the big round monster. You'll see it. Park in the N2 lot.

Dr. Biology: Thank you.

Guard: Welcome.

Dr. Biology: OK. We've made it past security, and we're heading up the twisty roads to the Synchrotron, or as the guard said, the big round monster.

After just a few wrong turns, I was able to find our parking spot. Now we're walking inside the big monster. It's definitely round and that's one good thing because no matter where we go, sooner or later we should find Dr. Larabell's office. And yep, sure enough, right around the corner looks like I can see the name on her door. Let's peek in. [Knocks on door] Oh, you're here.

Carolyn Larabell: Hi. Good morning, we're here.

Dr. Biology: I'm so glad you could meet with us today. This is so great. I love this facility. It's probably the only domed facility, as far as a laboratory, I've ever been in.

Carolyn: It's very fun working in a dome. You never have to worry about getting lost or losing people.

Dr. Biology: What we're going to do today is we're going to be talking about your really cool microscope. Is it called the X1?

Carolyn: That's the microscope that we use to collect our preliminary data.

Dr. Biology: Oh, so, are we building the X2?

Carolyn: We're building the XM2.

Dr. Biology: The XM2. Sounds like some kind of a high-tech plane that you'd be flying off into space.

Carolyn: It's very simple, though. It stands for x-ray, microscope, second one.

Dr. Biology: Oh, it does make sense. And talking about going off into space, a lot of people think about astronauts; and that's really rather romantic to think about going off into space, and quite frankly, you and I, because I also am a microscopist, we actually explore inner space. So, I consider ourselves micronauts, not that we're not tiny little people, it's just that we get to explore inner space. We get to go look inside cells, which is one of the things we're going to be doing with your microscope later on.

But before we go there, I thought, you know, we should talk about what's inside of the cell and what people would see if they could go in there. If you love science fiction, you might have watched the movie called "Fantastic Voyage." And this is where you have these scientists that get in this special submarine that's then miniaturized and they inject it inside the human body.

Well, we actually have to go much smaller, because we actually go inside a cell. And with Dr. Larabell, with her very cool microscope and all the time she spent looking inside cells, we're going to take a tour.

So, here we are, we're shrinking down. You can imagine the special effects in the background. And we're going to start from what, the outside?

Carolyn: We'll start from the outside and work in, and look at the cellular universe.

Dr. Biology: Great. So, what are we going to be approaching here?

Carolyn: We start by looking at the outside, and that's called the plasma membrane. It's a very nice structure that separates the cell, protects the inside, separates it from the outside, keeps those things inside that should be inside, but prevents things that shouldn't be in there from getting in.

Dr. Biology: Well, it doesn't look solid to me though. When I look around here, I see these, they look like openings there, and some things are getting through and some things aren't. What's going on here?

Carolyn: Yes, they have specialized regions in the membrane that allow signals to get into the cell, ions, hormones, allows those things to signal the cell in a very specific fashion.

Dr. Biology: Oh, so, this is kind of the doorways, but they're not just a doorway that anything can go in and come out. They're specialized doorways.

Carolyn: That's right. They have special codes that allow certain things to get in.

Dr. Biology: All right. Now you and I, let's zip in through one of these channels here, and see what's inside. You can go right through this passage, it's like a little tunnel here. What do we see?

Carolyn: We're now in what's called the cytoplasm. It's sort of a gooey fluid composed of water, salts and organic molecules. And inside that gooey fluid, there's a number of individual organelles.

Dr. Biology: Oh, yeah, those organelles. I always think of... well, maybe, a lot of people think about cells as being just a bag of goo, as you said, but I see things in here that almost looks like a highway.

Carolyn: Yes, that's part of the cytoskeleton. The cytoskeleton is both a structural component as well as a freeway system. It keeps all of the organelles in the places they should be kept, and then it moves specific proteins and organelles around the cell on a little freeway using little motors and cargo that delivers it to the proper spot.

Dr. Biology: Ah, that's pretty cool. And you call those what, microtubules?

Carolyn: Microtubules, yes.

Dr. Biology: Let's journey a little bit further in. What are we seeing next?

Carolyn: The biggest organelle inside of the cell is the nucleus, and that's the control center of the cell. It contains the code that tells the cell what to make, how to make, and how much of it to make.

Dr. Biology: Yeah, we talked about this before. We've talked about DNA quite often, and that's where all that information is stored. And it's pretty impressive because every cell you're going to have to have this with just a few exceptions. For example, mature human red blood cells, they don't have a nucleus. So, I won't say every cell has a nucleus, but almost all of them do.

Carolyn: That's right. And we have many different types of cells in the body - cells that make up your skin, cells that make up your lungs, your heart, your stomach. They all have specialized structures but many features in common.

Dr. Biology: All right. So, we've ventured in, we got the nucleus, it's big. You know what? It looks like it has little openings as well.

Carolyn: It does. It has nuclear pores. They're little doors that allow proteins and RNA to get into and out of the nucleus.

Dr. Biology: Oh, OK. So, there's a little bit of this traffic going in and out of the nucleus. And I do see things coming out and they're going off to another area. What's going on here?

Carolyn: They have to go to what's known as the endoplasmic reticulum.

Dr. Biology: What are these things?

Carolyn: This is messenger RNA. The code in the DNA has been turned into another signal, a message that the protein factory can understand. That process is called transcription, and it's now made what's known as messenger RNA.

Dr. Biology: Oh, OK. So, now this is going to go into did you say the endoplasmic reticulum?

Carolyn: That's right. It goes to the endoplasmic reticulum, or the ER, where it's translated into a protein. It does that by first going to ribosomes. The ribosomes are on the surface of the endoplasmic reticulum. The messenger RNA is traveling through the ribosome, where it's turned into a protein, and then it goes inside of the endoplasmic reticulum. And that's where it's folded. The proteins have to be folded properly in order to function.

Dr. Biology: Oh, OK. This is where when we're building them, where actually the shape makes a difference in how they will work. And while we're talking about the endoplasmic reticulum, the ER, I see that where the ribosomes have been sticking to it, it looks really bumpy, and that's actually called something else when it's in that form; right?

Carolyn: That's called the rough endoplasmic reticulum, or rough ER, as opposed to smooth endoplasmic reticulum, which doesn't have ribosomes.

Dr. Biology: All right. So, let's build this protein. We're going to go in, we can watch this folding of the proteins. It's quite an amazing process. And there are, man, how many different proteins are there? I mean, do we even know?

Carolyn: No, we don't know. We still don't really even know how many genes there are. But, however, many genes there are, there's a lot more proteins.

Dr. Biology: So, we've got these proteins being built, and they're going along this almost like a conveyor belt type area. By the way, we're talking about these organelles, which are inside the cell, and that literally means 'tiny organs'. So, you can imagine you and I walk around and we've got organs like hearts and lungs and livers, and those are the organs. Well, the cells have these little, tiny organs, and that's what's doing a lot of this work. And we're talking a little bit about what they're doing.

All right. We're moving out of the ER here, and what's up next?

Carolyn: Now, we go to what's called the Golgi. It's another sheet or stack of membrane-bound structures. It's the post office of the cell. It packages all of those folded proteins and packages lipids, and puts the address on that package that sends it to the proper destination.

Dr. Biology: OK. Not just a matter of making the proteins, we got to tell the proteins where to go. And some of them stay in the cell and actually, some of them go outside the cell.

Carolyn: That's right. Some of them go outside to signal yet another cell for it to perform its function.

Dr. Biology: Oh, OK. Well, inside the cell, there's an awful lot going on. How does it keep it going? I mean, where does it get the energy?

Carolyn: There are specialized little organelles called mitochondria. And that's the powerhouse of the cell. It makes all of the energy. And it's a very recyclable energy. It's called ATP, adenosine triphosphate.

Dr. Biology: Oh, OK. Now, that's going to be anybody goes into biology, especially any kind of cell biology, they'll be talking a lot about ATP and how it is recycled. It's really pretty impressive because that's again something that's going on all the time in our cells. We're constantly making ATP, it's getting used, and then it has to be regenerated.

Carolyn: That's right. Inside of each cell is very busy, and then they have to talk to other cells in the body to make the tissue in the whole body function.

Dr. Biology: Oh. And when you think about it, we have 60 to 90 trillion cells. Even when we're sleeping, we must be awfully busy.

Carolyn: No rest for the cells. They work even as we sleep.

Dr. Biology: Now, while we're talking about these organelles, the interesting thing is none of them are actually capitalized with the exception of Golgi. That has a capital G. And that's because it's named after the person who discovered the Golgi apparatus. And his name was actually Camillo Golgi. And he was a physician, an Italian physician.

All right. We've got this stuff, that's all put together. Does it just travel on its own, or does it sometimes have to be transported in like little trucks or something?

Carolyn: We have little packages of proteins that are being delivered to the cell surface, for example, or to other sites in the cell. You can package up a large number of proteins and deliver them to their destination along that freeway system with a single motor protein or several motor proteins.

Dr. Biology: And what do we call these?

Carolyn: These little packages are frequently called vesicles.

Dr. Biology: All right. Well that pretty much takes us through a tour of the cell. And I wanted to do that because we're actually going to go and look at a wonderful microscope that you have, and if we don't know what's important, what's the point of actually going out there and learning about the microscope?

To do this, I think, we'll just walk down the hallway here, and it's round; so we'll get to some destination, of course. Where are we going to stop first?

Carolyn: Let's go to this lookout station here, where we can look over the whole synchrotron and get a global view of what we see down there.

Dr. Biology: Oh, right. Oh my heavens, look at this. I can't believe it. It is really big and it is really full of stuff, as my kids would say. It's the dream of any mad scientist, probably, and I see lots of people down here. Matter of fact, how many people work at this synchrotron?

Carolyn: Well, there's a difference between how many people work here and how many people are actually employed here. The number of employees is probably only about 150, but we get thousands of visitors coming to do many types of experiments here.

Dr. Biology: It's round. Is there a reason why the building's round?

Carolyn: It's round because we inject electrons and they travel around and around in a circle at faster and faster speeds. And I think you're going to talk to Dr. McDermott a little later to describe how the synchrotron actually works. But, let me just say that you get the electrons accelerated very, very fast, close to the speed of light, and then they're deflected into this outer ring here, where they turn into x-rays. And we use those x-rays for many different types of experiments.

Dr. Biology: I do want to mention one thing about x-rays before we go down there. X-rays are basically light, because a lot of people think, "Oh, I know what an x-ray is" because they've seen an x-ray when they go to the doctor; or when they go to say the dentist and they have an x-ray of their teeth. You're seeing a picture, it's almost a silhouette of different parts of your body, and in particular the bones are a common thing, because they're so dense, they're so thick that the x-ray light can't pass through it.

In other places it can, and so that's where you get that really interesting image. You're using x-rays in a slightly different way with your microscope; right?

Carolyn: That's right. We use a different energy of x-rays. The type of x-rays that people are most accustomed to are those that you have a picture of their lungs or their chest in a doctor's office; they have much higher energy than the x-rays that we use. We use what's called soft x-rays. They have less energy, they can't penetrate as thick of an object, but they're very good for looking at cells because they can see the natural components of the cells without the need to do any labeling of those structures.

Dr. Biology: Oh, labeling. So, they don't have to put anything on them so that they can be viewed, or actually seen. And if you think about a light microscope, a lot of people have seen things where they're red and they're blue and they're purple, and that's because they have a stain on them. Without the stains you wouldn't be able to see them, because cells really are pretty much transparent.

Carolyn: That's right. They are quite transparent, and so with most microscopes you have to use dyes or labels to see all of the structures. But, we can look at the natural components of those proteins, the most prominent of which is known as carbon. And our microscope sees that just very naturally.

Dr. Biology: Cool. I take it that you're down in one of these labs down here. Let's just go down and take a tour of the facility.

All right. Now, we're walking down on the first floor. We had to go down the steps here and there are a lot of different groups here. It's pretty amazing. And wow, I don't think I've seen as many cables, as many wires and as many blinking things in my life.

Carolyn: It's quite fascinating; isn't it? It looks probably more fantastic than a science fiction movie.

Dr. Biology: Yes, I'd have to say that fact is actually better than fiction in this case. Although I have to say, out of all this fancy stuff here, I see an awful lot of what I would consider pretty mundane aluminum foil.

Carolyn: That’s the first thing that everybody notices when they enter the synchrotron is the amount of aluminum foil wrapping around these tubes. A lot of pipes in here and all of the pipes are under what's known as a vacuum, where you take all of the air out of the inside of them. And one of the best ways to make sure you get all of the air and dirt out is to heat them to very high temperatures. And the aluminum foil helps hold all that heat inside of the pipes.

Dr. Biology: By the way, the vacuum is really important because if you're moving these little tiny subatomic particles around, if you have air, well, that's a particle. And it would start to collide with it, and it would be bouncing all over the place, and you couldn't get what we'll be able to talk about a little bit later - a nice, clean, straight beam; right?

Carolyn: That's right.

Dr. Biology: OK. Well, we've turned the corner and there it is. National Center for X-ray Tomography. We've talked a little bit about x-rays; so, people know that's a form of light. What's tomography?

Carolyn: Tomography is the name for the approach used to get a three-dimensional image from a large number of very two-dimensional images. A two-dimensional image is what you get when you take a picture with your camera of any scene, any person. And you see what looks like a flat person. But, the person isn't flat. And if you take pictures from multiple different angles, as you walk around the person, and then reconstruct those images using some math - I know most people are afraid of math, but it's very important. You use those mathematical, what's called algorithms, you can turn all of those individual two-dimensional images into a very three-dimensional image.

Dr. Biology: Oh, I see. It's kind of like a deck of cards. Each individual card is the 2D image, and when you put them all back together, all 52 cards, you end up with a three-dimensional object that you could rotate.

Can you give me an example of how tomography is being used today?

Carolyn: This is something that many people are familiar with from visiting the doctor, where you've had a picture of an inside part of your body taken, perhaps the head or the knee or an abdomen. And the patient is inside of a large machine, and a form of camera is going around that body and taking multiple different images. And then the doctor turns it into what's called a CT scan or a CAT scan.

Dr. Biology: A CAT scan, huh? We're not talking about the furry creatures, are we?

Carolyn: No, that's 'computerized axial tomography.' And now they just call it CT, 'computerized tomography.'

Dr. Biology: OK. Well, let's go into the lab. By the way, I notice everybody else seems to have their labs in open space. You actually have a room here.

Carolyn: Yes, we've enclosed our microscope inside of a room. We have a number of reasons for doing that. We can keep the room quiet and clean and it gives the biologist a room to do some experiments with another form of microscope, watch the cells growing in a dish, and then put them inside of our microscope to get higher magnification views of the inside of the cell.

Dr. Biology: So, in essence, with this microscope, you just talked about CAT scan, so you're doing a CAT scan of a cell?

Carolyn: We are doing CAT scans of single cells, yes.

Dr. Biology: OK. Now I'm looking at this microscope. It doesn't look like any microscope I have ever seen. Matter of fact, if you didn't tell me it was a microscope, I wouldn't even know. How long is this?

Carolyn: The microscope is about 72 feet long. I think, the average light microscope is probably only about a foot high. Our microscope, you might notice, is oriented differently than most microscopes. In most microscopes, the specimen is sitting very horizontal, parallel to the ground, and the microscope is vertical. Ours is oriented in the other direction, and that's because we're using the synchrotron beam and it's flying around in a circle parallel to the floor. So, the whole microscope has to be parallel to the floor.

Dr. Biology: I'm looking at this and you said it's 72 feet long. Where does the specimen go?

Carolyn: The specimen fits right in here between these two cones.

Dr. Biology: Oh. So, you take the cells and you put them right between... they look like two little silver cones, but one of them looks like the tip's cut off; right?

Carolyn: That's right. One is just a little bit flat, and the other one has more of a point to it.

Dr. Biology: Do you just take any cells, can we just cut something off of me and throw it in there?

Carolyn: No. The cells have to be treated very specially. They have to be frozen before we can put them into the microscope to look at them.

Dr. Biology: Frozen? I'm just going to toss them into the refrigerator? Why am I going to freeze them?

Carolyn: No, we have to use very special freezers. We do what's called rapid freezing to get the water turned into ice as fast as possible.

Dr. Biology: Why would we want to do that? Ice is ice; right?

Carolyn: Not really. When water turns into ice, it expands. If it expands in an uncontrolled fashion it forms ice crystals that crystallize into bigger ice crystals and breaks the membranes of the cell.

Dr. Biology: Oh, so by freezing the ice, it expands, which a lot of people have done. Matter of fact, if you ever put something in the freezer, like a can of soda or something, it always looks a lot bigger and sometimes it explodes inside the freezer once it freezes.

So, that's what the cells would do if we just froze them very slow. So how fast do you freeze cells?

Carolyn: We freeze them in fractions of a second.

Dr. Biology: OK. Again, a great microscope, although it doesn't look like one. I have not seen a picture, or a cell since we've been here. Can you show us something here?

Carolyn: Let's go over here to the computer. And we have some images on the computer, I can show you.

Dr. Biology: All right. We'll turn around, yep. And you guys love big monitor screens; don't you?

Carolyn: Oh, yes. We have to have lots of room to display both the control panels and the images.

Dr. Biology: Well, here we are, pulling it up. Oh, and so we've got these cells on here, and it looks like it's being built right before my eyes. And sure enough, as it's getting built it's rotating. Wow, that's very cool.

Describe a little bit what's going on here.

Carolyn: What we've done is color code all of those individual organelles that we talked about earlier, so that you can easily recognize what they are and where they are in cells.

Dr. Biology: And yes, that's exactly right. They look like they're yellow, they're red, they're blue, they're green, they're black, quite an array.

Carolyn: Yes. You can see the nucleus is the largest one here. And we've color coded it gold. And then the small ones you see over here, the red ones, those are the most dense organelles. What we've done is color code them, first of all, just based on their density. And these red ones are the most dense, which are the lipid droplets of cells.

Dr. Biology: All right. Well, you know, it begins to look like, what's that candy?

Carolyn: Skittles. These are what we call skittle yeast.

Dr. Biology: Oh, skittle yeast. That is amazing. All right. I really do feel like I can look inside a cell now. It's almost as if I have the ultimate computer game for cell animation and cell imaging.

What are we going to be to do with these wonderfully cool images of cells?

Carolyn: We can now start asking questions that would help to understand human diseases. We can ask whether or not this particular disease is missing an organelle or has too many organelles, has the wrong types of organelles, wrong types of proteins, or proteins in the wrong places. We can also do things like study drug trafficking.

Dr. Biology: Drug trafficking? OK, now that sounds like a bad thing.

Carolyn: [laughs] In this case it's a good thing. When pharmaceutical companies are trying to develop drugs to treat diseases, they need to know if that drug is going in the right place in the cell to be able to act on that disease. So, we can look at drugs that have been tagged and see where in the cell they go.

Dr. Biology: All right. So, that means we can look at these before we actually test them out on, well, on me?

Carolyn: That's right. We don't want to test on humans. We first start by testing in cells.

Dr. Biology: What else can we do?

Carolyn: We can also look at the cells and how they respond to various drug treatments, things that are used for chemotherapy.

Dr. Biology: Ah, cancer treatment.

Carolyn: That's right. And this, too, you want to first test in cells. You place the cells in these drugs, let them sit for a while, then look at the cells and see what has happened to those cells. Sometimes you want them to die, and so you can see if they are dying, or if they're not dying, or if they're just sick.

Dr. Biology: I have to say I am very jealous. It looks like quite the amazing experiment in progress. Now, did you build this all yourself?

Carolyn: No, of course not. We have a very large team of experts in many different areas. We have physicists, we have mathematicians, we have computer scientists, chemists, cell biologists, molecular biologists, a large group of people. It was designed by the physicist in our group, that's Mark LeGrow. And then he sent all of the designs to various engineers to actually build the microscope.

Dr. Biology: Oh, actually that brings up one question. How long did it take to build this?

Carolyn: It took about three years to build it.

Dr. Biology: And how much does it cost?

Carolyn: It was about 2.5 million dollars.

Dr. Biology: Two and a half million dollars, wow. So, I take it we can't find these on every street corner?

Carolyn: No, in fact this is the only microscope like it in the world. There are some similar microscopes that we based our design on, but ours is very unique and designed for studying cells.

Dr. Biology: Wow. There's only one of these in the entire world?

Carolyn: Only one in the world.

Dr. Biology: I have to give a little more of a description of it. You mentioned it's 72 feet long. And parts of it are covered with Plexiglas and another part looks like it's open at the moment, and I can see what looks like the ultimate electronic gizmo. And then to the right of that I see where the specimen goes in.

How does someone go through the process of actually making such a microscope?

Carolyn: Oh, we build on many years of expertise and how these sorts of instruments work. And it was done pretty much on the computer using a special drawing program that put all the parts in the right places, but it took a lot of thought about how to get it to perform as we need it to perform.

What you're looking at there is the control center. All of those wires and all of those little circuit boards you see are the control mechanisms that tell how the computer to function and when to function.

Dr. Biology: We haven't mentioned that actually you got your doctorate at Arizona State University and you and I actually worked in the same laboratory.

Carolyn: That's right. Just a few years ago.

Dr. Biology: [laughs] Ah, we're lying just a little bit on that. And we've both been interested in cell biology for quite some time. You've really taken off. This is amazing. And I love the idea that you've been working with a lot of different kinds of scientists. A lot of people might think that biologists all live with biologists and the physicists are only with the physicists and chemists are off with the chemists, but more and more we realize that we have to interact and we have to use the strengths of each one to answer a lot of the questions that are out there now.

Carolyn: That's right. It's something we've started realizing over the last couple of years that to make such large projects work, it takes a multidisciplinary group of people.

Dr. Biology: Have you really enjoyed this process? And of course, I'm setting you up here. Would you do it all over again?

Carolyn: I would do it all over again, and I actually have enjoyed it more than I thought I would. I think, it has allowed the physicist within me to come out, the chemist within me to come out. Usually you're sort of forced into a box to do your specialized area of research. And for those of us who like to do many different things, this is a perfect way to do it.

Dr. Biology: One of the favorite parts of this show is asking all of my scientists three questions. The first question I have for you is, when did you know you wanted to be a biologist or a scientist? Where was that spark in life?

Carolyn: It actually took longer than it takes most people. I got my first degree in business administration. And it wasn't until I started working in a hospital, in fact, in the administration office, where I got exposed to science in the form of medical science. And I started learning more and more about what different tests that people received to diagnose diseases were all about. So, I went back and got a second degree and went into science.

Dr. Biology: That is different. A lot of people start out younger, although we've had a few of our guests that also did the same thing as you, they came to science a little bit later. And I think, that's really great because you don't have to be stuck in one career. If you've really loved this sort of thing, you get to do it.

Carolyn: That's right. Never give up. Always do what you love to do.

Dr. Biology: All right. Now, I'm going to take it all away from you. This is the other question. I'm going to take your biology and your science away and now you pick another career. What would you be if you couldn't be a biologist or a scientist?

Carolyn: I'd be a wildlife photographer. And that really shouldn't be too surprising. I'm now doing photography of cells, so I would do photography of wildlife. I've always loved the out of doors and that would allow me to do that.

Dr. Biology: You're right. We're looking at this giant microscope right here, humming in the background, and it is just a giant camera, 72 feet long, that allows us to look at this really, really tiny world. Pretty cool.

All right. The last question: what advice do you have for someone that would like to become a scientist? And in your case, it could be someone that says, "Hey, you know, I don't like this job I've been doing for ten or fifteen years. I want to switch."

Carolyn: I would encourage people to consider the switch very strongly. You have to do what you love to do in life. I love science and sometimes you don't figure out what that is for a while, but keep asking questions, keep investigating and you'll find what you love to do.

Dr. Biology: Some people might be a little bit afraid of going back to school, especially after being out for a few years here, and they have to go back and work on their math and their genetics. You're kind of an expert in that, so I want to ask you; did you find that really difficult and was there any advice for when you returned to school?

Carolyn: I didn't at all find it difficult. I found it very easy. So, explore, never stop learning. I think that's actually the secret, never stop learning. Continue to ask questions and explore all possible fields of research.

Dr. Biology: Well, Dr. Larabell, I really want to thank you for letting us come up to the Lawrence Berkley Laboratories here. We're at the synchrotron, and it's a giant domed building. If you're ever in Berkley and you look up on the hillside, you can probably see it there. And for us to be able to see this new x-ray microscope, it's really quite a treat considering it's the only one in the world.

Carolyn: My pleasure.

Dr. Biology: You've been listening to "Ask-a-Biologist" and my guest has been Dr. Carolyn Larabell, the director of the National Center for X-ray Tomography. We've had a chance to see her very cool microscope and tour her laboratory. In fact, we've been able to tour the inside of a cell. The "Ask-a-Biologist" program is usually produced on the campus of Arizona State University. Today, we traveled to Berkley, California to the synchrotron, where the XM2 microscope is being built.

And even though we don't broadcast our shows live, you can still send us your questions using our companion website. The address is www.askabiologist.asu.edu or you can just Google the words "ask a biologist." I'm Dr. Biology.