Ask a Biologist Vol 005 (Guest Cheryl Nickerson)

## Bugs in Space -

Blast off with microbiologist Cheryl Nickerson and her high flying experiments on board the space shuttles. Learn how microbes grow in space and how this research will help not only astronauts, but also you and I on planet Earth. Did we mention race cars too?

## Transcript

**Dr. Biology**: This is Ask a Biologist, a program about the living world, and I'm Dr. Biology. Now, hold onto your seat and prepare yourself for a show that I promise will be out of this world.

**Man 1**: 10, 9, 8, 7, 6, 5, [rocket engine starts] three main engines up and burning, 2, 1, and liftoff of Space Shuttle Atlantis opening a new chapter in the completion of the International Space Station for the collaboration of nations in space.

[loud rocket engines]

**Man 2**: Roger go Atlantis.

**Dr. Biology**: In case you're wondering, we just blasted off the Space Shuttle Atlantis. On board are six astronauts and several new parts for the International Space Station. Also, on this mission are some very tiny passengers. They're sealed inside a special container and part of the research of microbiologist Cheryl Nickerson.

Dr. Nickerson is our guest scientist today. She is an Associate Professor in the School of Life Sciences and a researcher in the Center for Infectious Diseases and Vaccinology in the Biodesign Institute at Arizona State University.

You also learn that she's part of a team of scientists that have been able to catch a ride on the Space Shuttle for some of their research experiments. Well, to be accurate, her experiments caught the ride. She didn't get to go. Welcome to the show, Professor Nickerson.

**Cheryl Nickerson**: Thank you very much. Glad to be here.

**Dr. Biology**: OK, let's jump right in. What are the tiny passengers that blasted off with the crew of the Space Shuttle Atlantis at the beginning of the show that we just heard?

**Cheryl**: So, what we sent up in flight were some very small single cells called microorganisms. And these microorganisms, in fact, are so small that you can't see them with the naked eye. You have to have a microscope to actually see them.

But what I want everyone to understand is just because they're small it doesn't mean they're not important because there are more microorganisms on the Earth than there are any other life form. And they're found everywhere. They can survive under very extreme conditions--on the bottom of the ocean, in the Antarctic glaciers. They're very important for our life and our survival. In fact, life as we know it would not exist without them.

And while most of these microorganisms are very helpful to us, some are not. Some harm us. You might know those as germs. And germs are a special kind of microorganism that cause us to get sick and cause infections. And that was the whole purpose of this experiment--to look at the effect of space flight to change the disease causing ability of these microorganisms in flight, for two reasons.

Number one, we want to keep those astronauts safe, and healthy, and not have them get sick so they can do their important jobs. But the other important reason is because what the lessons we learned from space flight about these microorganisms, we can apply to us right here on the ground. Us normal humans here walking on the Earth to help keep us healthy and prevent us from getting sick from these infection causing germs as well.

**Dr. Biology**:  OK. Let me go on a little bit more, you've been able to fly more than once on the space shuttles. How many times have you been able to get an experiment to go up on a space shuttle?

**Cheryl**:  We have been lucky enough to fly in space three different times. Two of those times were onboard a space shuttle and one of those times was onboard the International Space Station.

So, we have been very lucky because it doesn't happen a lot--that you get to fly experiments that much. It's very expensive. And it takes a long time and a lot of hard work to do the research on the ground which qualifies you to fly your experiment. But we've been very excited each time and we're hopeful there'll be another chance for us in the future to fly.

**Dr. Biology**:  OK, so, it's difficult to get there, to say the least. How expensive is it?

**Cheryl**:  It's so expensive even I, as the lead investigator on this experiment, don't actually know the final cost. What I can tell you is that for each pound your experiment weighs, that you want to fly, it costs $10,000 to fly it. So, for example, our last experiment weighed 30 pounds. So that was $300,000 just to fly it.

**Dr. Biology**:  Wow.

**Cheryl**:  But that does not take into account the five years of hard work of our entire team, which collectively consisted of several hundred people that it took across the country to get us ready to fly. It's a very astronomical, and I kind of pardon the pun there associated with spaceflight, but it's a very large amount of work and it's very expensive to do it.

But it's very meaningful to our health to be able to understand and provide answers to these kinds of important questions.

**Dr. Biology**:  And actually, that's one of the things that you talk about before, during, and after. I mean, we get the intrigue of seeing the shuttle come up and come back down, but you're prepping before hand, you're monitoring it while it's in space, and when it comes down you're analyzing the data. The last launch was in September. I believe you're still analyzing data, aren't you?

**Cheryl**: We're still analyzing data and we will be doing so for several more months. We already have some very exciting results back from this data. But, no, we're not finished. And so we have several more months' worth of work to do.

**Dr. Biology**: OK. And then if we're going to go into space, and it costs so much, why do we go there?

**Cheryl**: Well, there are a couple of important reasons for that. Number one, we go there because we can and we have to. We're explorers by nature. Human begins have always wanted to discover and understand. Christopher Columbus came to America for that purpose. If he hadn't wanted to discover, would we have America?

Science has always been driven by people who are curious and wanted to discover. By that very nature we are driven to study, and explore, and understand universes that are outside of our own.

The second important reason is that spaceflight already has provided very, very important products to us on a daily basis since the very first man flew.

And a lot of our listeners may not know that because I know they're a little younger, but for example, if they get up in the morning and they like to turn on the TV and hear the weather. Or their parents tell them the weather. The reason that they know what the weather is, is because NASA (National Aeronautics and Space Administration), which is the United States space agency that flies these experiments, they have put special mechanical machines in flight called satellites, that their goal is to monitor the weather around the globe and report back to us and let us know what it's going to be.

And a lot of your listeners also have flat panel TVs in their home. Or their parents have cell phones, I think they might be a little young themselves to have a cell phone, but I don't know. They have sunglasses. These are all examples of just some of the many hundreds of technologies that the manned spaceflight program and NASA has given back to us.

So if we wanted to be able to advance human health, which we have to do, we always have to improve the condition of people here on Earth. Spaceflight offers us a very unique chance to do that because, again what we learn in flight we already have been able to bring right back down here on Earth to hundreds of products to improve our daily lives. And we anticipate doing the same thing for the infectious disease work we're doing.

**Dr. Biology**: So, is there something in particular that when we go in space that we have that we don't have on Earth?

**Cheryl**: Yes and no. There's certainly a common thing that both spaceflight and the ground have in common that allows cells to change the way they do. But, what we have in space that we don't have on the ground is when cells are grown in space they float because there's no gravity to pull them down. So, they don't sense that gravity force and so they kind of just float in their culture media. They just float--very gentle kind of growth conditions.

Now, here on the ground is there a way to model culturing cells under a way that's similar to what you have in flight during spaceflight, and the answer is yes. One thing I want to make sure that our listeners know is that what you can and can't do on the ground.

So right here on Earth we cannot change the gravity force. We cannot culture cells on the ground under reduced gravity, it's not possible. But there are certain conditions that come along with culturing cells in flight under this reduced gravity that we can model on Earth.

And, for example, when you culture cells and they float, and I should mention tha that NASA scientists have developed these very new and exciting, what we call "bioreactors." What a bioreactor is, is really a culture chamber, OK. It is a chamber that these NASA scientists built as a way to grow cells on the ground right here on Earth, under conditions which are like space flight.

So while you don't change the gravity in these vessels, the cells do float in them; so you get a very similar environment. It appears that when these cells float there is a change in the fluid motion that goes over their cell surface; and it appears that that fluid motion in these special culture chambers and what the cells experience when they are cultured in space is almost identical. So that appears to be what the cells are responding to, or changing their properties.

**Dr. Biology**: The way the fluid actually intermixes with the cells themselves.

**Cheryl**: Yes.

**Dr. Biology**: You know, an interesting thing is "bioreactor," it sounds like a really cool instrument, right? And it might even sound like something really big.

**Cheryl**: It's not. Well, it can be. The ones that we have are not. You could have one of these bioreactors, or again, just a chamber to culture cells; you could make it as big as you wanted to.

**Dr. Biology**: Tabletop?

**Cheryl**: Tabletop, or as big as the room, OK, in some companies--and commercial companies have bioreactors that would barely fit inside this room because they have to make a lot of products that we use on a daily basis. But for the work that we need to do, our bioreactor culture chambers are very small--they probably are about eight inches long and eight inches wide and ten inches tall. So, they're small, and therefore that lets us have a lot of them, and we can do a lot of experiments in the laboratory. They are not too big, and they work very well in the lab, and they are very easy to work with.

**Dr. Biology**: If that's the case, you still go into space? I'm assuming they get close but they are not quite the real thing.

**Cheryl**: That's exactly right.

**Dr. Biology**: So, there are a couple questions. What I'm leading into is, one is, how is this slightly different? And one of the things I don't want to forget to talk about is there is also an interest about how these microbes grow in space, and particularly the bad ones; we want to talk about those germs. And also thinking about going off to other planets and humans, and there is also another issue with the humans themselves, what happens when they are in space? And I know you have the story for us.

**Cheryl**: I have a portion of the story from the bioreactor chambers that we did here on the ground, and I have the beginnings of the story from our space flight work. What I can tell you, and I would like to answer and go back to your first question first, "Do those special bioreactor culture chambers on the ground duplicate all the effects that we see on cells during space flight?" and they do not; they certainly mimic some of them and they can model many of the things that cells do in flight.

But if you want to know the true effect that space flight has--for example, on cells; in our case, to change their disease causing potential, their bad properties-- you really have to fly them. And that is very important to make certain that the astronauts don't get sick when they are traveling, because if the astronauts get sick in space flight they can't do their jobs.

**Dr. Biology**: Right.

**Cheryl**: If they can't do their jobs, that has a very, very huge impact in a bad way on not only the space flight program but us here on Earth, because we lose knowledge, we lose the ability to transfer some of what we learned in flight back here on Earth and keep us healthy. And as I mentioned, there is a lot of cost and time associated with this too, so you want to make sure they can do their jobs well.

We have found when we put these germs in our bioreactors on the ground and culture them under conditions which are like space flight--not exactly identical to it but like it--that these germs, some of them become more harmful.

**Dr. Biology**: Super-bugs.

**Cheryl**: Well, maybe not super-bugs, but they become better able to cause disease. Now, these are only for the germs we've looked at, and one cannot say that this is true for every microorganism or germ you would put in the bioreactor, but for the germ that we looked at, culturing it in that bioreactor on the ground under conditions which were like space flight made it more harmful. It was better able to cause disease, and it was better able to keep from being killed by important cells in your body, which are called immune cells.

Your immune cells help fight infection. If you have a healthy immune system you stay healthy but if your immune cells aren't so healthy then you can get sick. Their entire job is to go around the body and look for things that aren't supposed to be there--like germs--and get rid of them.

Culturing some of these germs in the bioreactor allows them to better escape, or better keep from being killed by your immune cells as quickly.

**Dr. Biology**: Right.

**Cheryl**: So, that's important for us here on the ground because that information that we get from that study can lead to new drugs and new ways to treat, and keep us from getting sick here on the ground, which we are doing right now. It also is important for the astronauts, because we already know their immune systems don't function so well when they fly.

**Dr. Biology**: Which is interesting. I did not know that until I was reading some of the work that you have been doing, and that's something that even anybody else out there may not know.

**Cheryl**: Their immune systems work, I don't want to let our listeners think that they don't work at all, but they don't work as well as they do when they are right here on the ground. And you might ask if astronauts have ever gotten sick when they are flying, have they gotten infected with these germs; and the answer is yes, they have; and it's not uncommon for that to happen.

But we need to make very certain when we start getting the astronauts further and further and further away from Earth and they go into space for three years to get to Mars and back--they don't have a way to get back quickly if they get sick--so we need to do our homework now and make sure that if they can get sicker when they are traveling, we have the right drugs or the right vaccines to treat them; and send that with them so they won't get sick.

**Dr. Biology**: Exactly, and just to be really clear for everyone, the packages you send up, the experimental packages that go up, they are very well sealed and they are very well protected, so we are actually not sending up anything that the astronauts are going to come in contact with. And not only that, when you've designed these, one of the things we talked about, the cost, which is pretty clear; but the design and the creative part is, how do you make something that can go up there that doesn't take a lot of time for the astronauts?

**Cheryl**: And that's another important question, because the astronauts don't have a lot of time to do scientific experiments; their main job in going up in the shuttle is to bring up parts to keep building the International Space Station; there is very little room to carry anything else, so your experiment must be very small. And the astronauts work about 18 hours of every 24-hour day. If you do the math, that gives you six hours to sleep.

**Dr. Biology**: Right.

**Cheryl**: There is not a lot of extra time in there for them to do experiments, so the experiments that you send up have to be small. They would prefer that these experiments not use crew time to do them--so that a machine could perform those experiments. We were very lucky that we actually got a little bit of crew time to do our last experiment. And of course, expense is a big problem because the more it weighs the more expensive it is.

I also wanted to highlight or mention one other point that you made which is very important. You were correct; anything that has any chemical or any cell or anything that has the potential to cause harm to the astronauts, before it can even fly has to be cleared by so many different committees of people. It takes, really, years to get full clearance, and when you do get full clearance there are hundreds of people in place in that team to make sure everything is singly and doubly and triply sealed so there is no chance whatsoever that if something breaks the astronauts could get infected. So that is very well taken care of.

**Dr. Biology**: Very, very good. So then when I plan my trip into space I'll know if you have an experiment riding along I'll be safe when I go with it. How did you get involved with NASA and the bioreactor technology and flight?

**Cheryl**: I got involved with NASA when I was getting my doctoral degree because another of my colleagues or associates at the same time was also getting his doctoral degree with me at the same program; and he was an engineer. After we both got our doctoral degrees he went to NASA and became employed by NASA and I went to a medical school and became employed by a medical school to do my research.

It was through this individual, when I asked if NASA would be interested in looking at the effect of space flight on the disease-causing potential of our microorganisms, he said they would be, and put me in touch with the right people.

He is the one who first showed me how to use the bioreactors. We work with this individual almost every single day. He's at the Johnson Space Center in Houston.

**Dr. Biology**: Oh, OK.

**Cheryl**: He is an author on almost all of our papers and all of the grants, which is how we get funding for all of this research that we write. He's a very, very smart scientist at NASA.

That's how we got started in working with him.

**Dr. Biology**: You actually mentioned something that comes up in just about every show we've done, and that's writing. Not everybody likes to write. Some people do, some people don't, but this is a way of life in science.

You're either writing grants to be able to do the experiments you want to do, or you do the experiments, analyze the data, and then you have to report the results. There's a lot of writing.

One of the questions I have: I rarely hear of anybody liking to write grants. What about the process of writing those papers? Do you find that a really rewarding process?

**Cheryl**: I absolutely do, and I'm going to be one of those people who is different, because I love to write grants, too. I find it makes me think more carefully as a scientist, plan my experiments more carefully as a scientist, and think about the data that we have already discovered from our experiments that we're writing up.

I very much enjoy the process of grant writing. Of course, that means that I also very much enjoy the process of writing the papers. Writing the papers is how we tell the public what we've found, and more importantly, why it's important to them. The public needs to know why the dollars that they've invested in this work is important for them.

This research lets us do that, and it says, "Look what your money has gone to fund." It's gone to fund research that's going to, maybe, lead to a treatment, or perhaps to a cure (although that's very long away) for some very important diseases that cause a lot of human suffering here on Earth.

**Dr. Biology**: I can see it. Well, actually, I can feel it and enjoy what you're saying...the enthusiasm from looking at your face. When I actually do my writing, it's interesting to me, because it is a fun part. Not necessarily grant writing, but writing the papers.

It's interesting also in the sense that, it's almost like the story comes full circle. Even I don't know the whole story until I put it down on paper.

I think that's one of the things that our young scientists out there need to know. Communicating, either verbally or written, is as important as those math or other science skills. I always like to mention that a little bit.

**Cheryl**: It's an important point to mention.

**Dr. Biology**: One of the fun things about this program, also, is learning about how you get started in science. I like to call it "the spark." So what was the spark? What got you started in science?

**Cheryl**: I was born knowing that I would go into science. My father is a very, very famous scientist, and he actually got his Doctoral degree here at ASU. I was born here. We moved when I was small. He is one of the world's leading scientists in venom research.

I just grew up in my parents' home reading his science books, rather than the kinds of books most children probably look at. Now, when I was young, I could not pronounce the words correctly, because scientists use very long words sometimes.

The whole discovery process and the whole idea was so intriguing to me, to be able to understand how things work, how cells work, how these germs that are so tiny that we can't even see them...how can they cause disease? How does that happen? When we know how that happens, how do we know how to make a vaccine or a drug against it?

I never knew a time that I didn't want to be a scientist, so it was very easy for me.

**Dr. Biology**: Very early. That's actually one of the questions I usually ask at the end, is: "When did you know first that you were going to be a scientist?" It sounds like, as you said, that you were born to be a scientist.

I find that most scientists have had creative activities, and I like to say "creative." I think it's important to mention that science is actually very creative. We design experiments. We use that word for a reason.

There are often other creative avenues, other outlets. Do you have other creative outlets?

**Cheryl**: I do. I will tell you up front that a lot of my creative activity is devoted to planning our experiments and thinking carefully about our data, what our data is telling us, and then how do we take that and go to the next level and understand the system.

That really takes up a lot of my creative thinking, but I do have a lot of hobbies that I like to do. One of them is working on sports cars and racing sports cars. The other one is that I've always been very, very active in sports my entire life.

I think that's something important for our students, when they're listening, is that it keeps your body healthy. When you have a healthy body, you have a healthy mind.

You need to exercise both your mind, by staying in school, working hard, studying hard, taking those science and mathematics courses, and really loving what you do...that's really the most important thing in my field, is to love what you do.

I can't wait to get into the lab to find out what we're going to find next. But also, I think it's very important to, while you're exercising your mind, you should exercise your body. It doesn't matter what kind of exercise you do. Do what works best for you.

**Dr. Biology**: Race cars? Race cars? Well, what's your favorite race car?

**Cheryl**: Well, my favorite depends on whether you're talking about NASCAR or Formula 1. I've always had a strong love for American sports cars, the muscle cars, from the Dodge Chargers on up, and Corvettes.

I have a Corvette. I've had many of them, and right now they're so computerized that I can't work on them anymore. I've been known, in the past (before they got to that point) for changing my own oil, changing my own tires, and taking out water pumps and things like that was something that I liked to do.

A lot of times, it was with my father or with friends. I love being involved in racing at the track with them, too. I guess that's kind of my extreme sport.

**Dr. Biology**: That's your extreme sport? And this next question I'm going to ask, I might know the answer already, but you might surprise me. You have so far.

If you were not a biologist, if you couldn't be a biologist, what would you be?

**Cheryl**: I can't imagine not being a biologist. If I were not already doing what I'm doing, which is what I love, I would be an astronaut. The interesting part of that is that I was actually an astronaut candidate finalist in 2004.

The possibility exists that could happen. That, to me, would be the best of both worlds. I would be able to stay in my research, but I would also be able to explore space flight with that research as well.

Even if it doesn't happen, that I'm finally selected as an astronaut, that's OK, because I'm already contributing to the team with the work that we're doing here, on the ground. I'm very happy now, and I would be happy either way.

**Dr. Biology**: OK. I have one more question. I'd like to know what advice you would have for those scientists out there, or those scientist want tobes, or maybe those that didn't even think science was in their career path.

**Cheryl**: The most important thing is to pick for your career, not your job. This shouldn't be a job. If it's a job to you, then you don't love it. This needs to be a passion.

This decision to go into science means you love to discover things. You need to know. You have to know how things work. If that's your passion and that's what you love to do, then you're a perfect fit for this field.

It takes a lot of hard work, and it takes a lot of education. You have to stay in school past college, and you have to take a lot of science and engineering courses. But again, it doesn't feel like work if you love it.

So stay in school, study hard, work hard, and never let anyone tell you that you can't do something. If it's what you want, commit your best effort to it. This would be a fantastic field for you.

**Dr. Biology**: Well, that's a perfect way to bring a program to an end. Cheryl Nickerson, thank you for visiting with us.

**Cheryl**: Thank you.

**Dr. Biology**: You've been listening to Ask-a-Biologist, and my guest has been Associate Professor Cheryl Nickerson, from the ASU School of Life Sciences. The Ask-a-Biologist podcast is produced on the campus of Arizona State University.

You know, even though the program is not broadcast live, you can still send us questions about biology using our companion website. The address is askabiologist.asu.edu or you can just Google the words "ask a biologist."

I'm Dr. Biology.