BOOKS AND IDEAS PODCAST

With Ginger Campbell, MD

Episode #31

Interview with NASA'S Dr. Les Johnson, Author of *Paradise Regained: The Regreening of the Earth*

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INTRODUCTION

This is Episode 31 of *Books and Ideas*, and I'm your host, Dr. Ginger Campbell. My guest today is NASA's Les Johnson. To get more information, including show notes and episode transcripts, please visit our website at booksandideas.com. You can also send me email at docartemis@gmail.com. And don't forget to join our new Fan Page on Facebook.

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Dr. Johnson's interview was recorded at Dragon*Con, which was held over Labor Day weekend, 2009, in Atlanta, Georgia. As you probably guessed from the introduction, the focus of this interview is Dr. Johnson's new book, *Paradise Regained: The Regreening of the Earth*. I have to admit that I haven't paid close attention to the space program in quite a few years, but I find Dr. Johnson's ideas quite thought-provoking.

In traditional science fiction a common theme is the idea that eventually humans will pollute the earth so badly that we will have to move to outer space. Dr. Johnson turns this scenario on its head by arguing that, instead, we need to learn to obtain resources from outer space so that we can preserve the earth as a place for life. His focus is the science and technology to make this happen.

I'll be back after the interview with a few brief announcements.

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INTERVIEW

Dr. Campbell: I'm Dr. Ginger Campbell, and this is *Books and Ideas*—my other podcast. My guest is Dr. Les Johnson from the NASA Marshall Space Flight Center in Huntsville, Alabama. He is the co-author of several books, and today we are going to be talking about his upcoming book, which is called *Paradise Regained: The Regreening of the Earth*. I would like to start out by saying, Les, I'm glad you're here today.

Dr. Johnson: Well, thanks for inviting me to be on your show. I appreciate that.

Dr. Campbell: I like to start out by having my guests tell us a little bit about themselves.

Dr. Johnson: OK. Well, first off, I'm a Kentuckian living in Alabama. I was born in a little town in East Kentucky called Ashland. It's a solid middle class kind of town. And when I was a kid I watched Neil Armstrong walk on the moon —when I was seven years old. I didn't know what NASA did, other than send people to the moon; but that was about the time I decided I wanted to do something associated with space.

So, I asked my parents, 'What do I have to do to do that?' And they said, 'Well, you have to study math and science.' And I said, 'That's what I'll do.' And so, I started being real interested in that, and reading science fiction, which was absolutely something that unlocked my imagination.

And I realized that the heroes in that era were always physicists; and I didn't know what a physicist did, but by golly, that's what I was going to do. So, that prompted me to really be interested in science. And then, of course, as I got older I figured out what that was all about, and have followed that throughout school, and ultimately ended up where I am today.

In terms of my interests, I'm a big believer of science and technology, and how that can better human life; and I think we need to get more people interested in science and technology. That's been a part of what I try to do, is go to conventions and talk about space and space science to let people know there's a career there, and it also is something that's to the benefit of all of us to do.

Dr. Campbell: Have you been at NASA your entire career?

Dr. Johnson: No, I went to graduate school at Vanderbilt. While I was at Vanderbilt I was actually recruited to come to Huntsville to work for a company called General Research Corporation. That was back in the late 80s when the whole Star Wars missile defense stuff was really hot. And the lure of the money they offered me was too much to ignore, so I went to work for GRC.

But I always wanted to work for NASA; and really the four years I was there, I was angling to try to find a way to get into NASA. And through some people that I met there I was introduced to other people and found out when there were some job openings, and was able to interview and get a position there.

Dr. Campbell: So, Les and I have a couple of connections. One is that he is married to one of my high school classmates, and the other is that I grew up in Huntsville, which is where he is now.

I wanted to talk a little bit about the moon landing and our memories. Do you want to start?

Dr. Johnson: Well, I mentioned that a minute ago. I remember very vividly. It was late at night—or at least it seemed like it was, to a seven-year-old—and I remember my parents waking me up saying, 'You've got to see this;' and watching this terrible picture on a little black and white television. I remember more about the TV, I think, than I do Neil Armstrong walking on the moon—because it was blue. And I remember looking at the blue side of the TV and this grainy picture, and watching that whole event happen.

I didn't really understand it at the time. I knew it was a big deal that people were going to the moon, but my parents were real excited about it, and so I got real excited about it. After that my sister started sharing her scrapbook with me, where she had kept news clippings of the whole development of the space race.

She was substantially older than I was. She was in high school at the time, and she had this wonderful scrapbook. And I knew how to read at seven, so I remember just reading through that, and suddenly getting really fired up about space and space exploration. And then I think I watched all of the other missions after that.

Dr. Campbell: Did you see Apollo 8?

Dr. Johnson: I don't remember Apollo 8.

Dr. Campbell: Apollo 8 was the one that took the famous picture of the earth[1] from the other side of the moon. It was the first picture, ever, of what the earth looks like from outer space. It happened in December of 1968—so about six months before the moon landing.

We had a black and white TV, so I didn't see it on TV. But the pictures were in, I guess, *Time* magazine and *Life*, and it just blew everybody away. In fact they say it was one of the things that motivated the environmental movement—people seeing that picture of the earth, what it really looks like, and how fragile it looks compared to all of outer space.

I actually grew up in Alabama because my dad worked for Boeing, and we got transferred to Alabama in 1964 because of the space program. So, when the landing happened we got up in the middle of the night—I think it was like at 1 o'clock in the morning, Alabama time. I can't remember if that was for the walk or the landing. I think the landing must have been in the middle of the night, and then they did the walking during prime time. I really don't remember for sure.

Dr. Johnson: It was late.

Dr. Campbell: One of them was really late. I think I was 13; so, a little bit older than you.

So, can you tell us a little bit, Les, about what you do at NASA?

Dr. Johnson: Sure. I've been at NASA for 19 years, and I have to say I consider myself to be incredibly lucky, because I love what I do. I've had some really interesting jobs while I've been at NASA. I was the Chief Investigator (it's like a

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[1] Here is a link to the picture: http://apod.nasa.gov/apod/ap951225.html

chief scientist) for a mission called ProSEDS, which is a new kind of propulsion using tethers—which is a whole different topic. I'm going to Japan in about a month, where they're flying a tether mission, and I'm on the science team for that project.

And so, I do some fundamental propulsion research. But lately I've been more into the dreaded horrors of management; but I actually enjoy that. I'm the Deputy Manager now of the Advanced Concepts Office, and our office is charged with looking at what space systems we're going to do in the future. And so, when asked, 'What do you do?' my fun answer to give is, 'I design spaceships'—which is really what we do.

I lead teams of engineers and scientists. We understand what the scientists want to do with their spacecraft, and we build and design a spaceship that will take them where they want to go in the solar system to do that. About one in a hundred of the things that we study actually gets to the status of a flight project—but that's OK. Some of them shouldn't be flown, because you start looking at it and you realize this isn't going to work, or it's going to be too expensive, or there are better ways to do it. But you don't know until you do the work that we do to try to figure that out.

That's what I do currently. The most fun job I've had, as a science fiction aficionado, was that of (you'll love this title) Manager for Interstellar Propulsion Research. I had that job for about two years, and it was great to come to conventions and give my card out. But that was a time when NASA was investing a lot more money in technology than we do today.

And we were looking at, not a mission to another star, but a mission just beyond the edge of the solar system—what would it take to go out to where the long-term comets come from; which is just beyond the edge of the solar system. And that's

where I got interested in solar sails and a lot of the really advanced propulsion systems.

Dr. Campbell: Did you ever want to be an astronaut?

Dr. Johnson: Not really. I think if someone came to me and said, 'We have a 100% safe way to go to space and come home to your family,' I would have a hard time turning that down. But personally I'm content with someone else doing that, and me helping them do the science they want to do.

Dr. Campbell: If it wasn't for the science, the guys that want to go up there wouldn't be able to go.

Dr. Johnson: That's right.

Dr. Campbell: It's a team thing.

Dr. Johnson: It is a team thing—very much a team thing. I'm going to commandeer for one second, because I don't think people realize how much of a team thing it is. There is nothing we do, really, in space that doesn't literally take 500 to 1000 people across the country doing some little part of it to make it happen—whether it be the rocket, the people who do the up-front design, or the companies that make the piece parts that go into it. It's the best example of a team effort I can think of in terms of a big team.

Dr. Campbell: Yes. When Apollo 13 happened, in Huntsville—which is where I'm from—they did a lot of the simulation they used to figure out what to do to solve it, but they didn't get any press. Growing up in Huntsville I always felt that Huntsville got the short end on publicity—especially after von Braun died.

Do you think when you were in interstellar propulsion, that was your most rewarding job?

Dr. Johnson: I think it's all been rewarding. I know that's kind of a cop out, but it really is true. I've enjoyed everything I've done at NASA. That was very much an exciting time. I think it was the most exciting, because that would be an accomplishment of something we've really never done before.

Dr. Campbell: Right.

Dr. Johnson: Not to sound corny or trite—you know, 'go where no one has gone before'—that would have been it. But when we realized how hard that is, and how difficult technologically that would be, that was kind of put on the back burner in terms of projects. And so, that was a bit of a disappointment. But, again, that's part of the job.

Dr. Campbell: When did you start writing?

Dr. Johnson: As a professional I've always written for work in journals, conference publications, that kind of thing. But I give a lot of talks at science fiction conventions, and as I mentioned earlier, to the public—to the Kiwanis Club, to the Rotary. And over the years I had people come to me and say, 'Les, you ought to write down what you talk about.' To be a little bit not shy, people have told me I have a talent for explaining complex things so that they can understand them.

So, I thought, OK, one of these days (when that 'one of these days' happens, and we all mythically have time to do what we want to do) I'll do that. But then a colleague and friend of mine, Gregory Matloff—who is an astronomer in New York and a published author who wrote a great book called *The Starflight Handbook*—said, 'Les, why don't we take some of the things you and I have talked about in terms of how space exploration ought to be done, and write a book about it?'

So, we put together a book proposal about how we ought to use the natural resources of space to support our exploration of space, instead of the current way we do things, which is to bring everything with us as we go. Because the way we do it now really isn't sustainable. We have to learn how to take advantage of what's out there.

So, we sent this off to a publisher. And I had talked to published authors about how difficult it is to get published. Three weeks later we got it accepted. I really almost felt guilty. That was our first book that we did together, called *Living off the Land in Space*. It was released in 2007—two years ago—and it did fairly well.

As we were writing this book, we had a chapter in there about a technology called solar sails, which is using sunlight to derive propulsion. And the publisher said, 'Hey, that would be an interesting book. Why don't you write another one?' I didn't realize publishers would actually give you an idea for a book, and throw a contract at you to do a book.

So, we said, 'Sure, we'll do that.' And that led to our second collaboration—this time with another colleague in Italy, Giovanni Vulpetti—for the book *Solar Sails: A Novel Approach to Interplanetary Travel*. These books are not technical books; these are popular science books. They're intended for the educated, interested person to pick up and read, but you don't have to have a chemistry or physics background. They're intended to let people know about how this all works.

Dr. Campbell: They're great books for the kind of people who like the hard science fiction, because some of the stuff you talk about—like the tethering, for example—you show that that's not so much science fiction as I think the average person thinks it is.

Dr. Johnson: We could do it. A lot of the things we talk about in our books are not things that are 50 years out: they're things that, if we really wanted to do it, the capability exists to go do it. It's just a matter of putting the resources to that end.

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Dr. Campbell: I wanted to concentrate on your new book. Do you know when it's coming out?

Dr. Johnson: The publisher originally said August; now they're saying October on their website. And let's hope it's October. It's a book called *Paradise Regained*, and it's really the book I've wanted to write for a long time. It's my plea—I guess is what it is—to get space advocates working with people in the environmental movement, because I think we really have common goals and can help each other out. And I think those two communities don't often interact and realize that they have a common agenda, really—that they can benefit from working together.

Dr. Campbell: Right. It's called *Paradise Regained*? Is that right?

Dr. Johnson: That's correct: *The Regreening of Planet Earth*. I didn't come up with the title—the publisher did that.

Dr. Campbell: Give us a brief overview of the book.

Dr. Johnson: I'm not known for being brief when I'm given a microphone, but I'll try. I guess the bottom line is this: In the United States, Europe, and Japan, we have a very high standard of living, our people live well, and we consume a heck of a lot of resources. The rest of the world has seen that, and they're fighting tooth and nail to catch up with us. China, India, they all want to have the lifestyle—not necessarily the culture, but the lifestyle—that we have.

And with that is going to come a dramatic increase in the consumption of resources and the potential pollution that comes with that. And the environmental movement wants to—rightfully so—be concerned about that, because it's a finite planet, and there are six billion of us, and if we all consume like Americans we've got a problem. So, the notion of recycling, reusing, and being more efficient is a very important thing we ought to be doing. We should be good stewards of our planet.

But if you look at the numbers, it's not going to save the planet. At best we're going to slow down the rate at which we pollute it or consume it in the industrialized world. We're not going to be able to—nor should we—till those who have lives where they are not in the affluence that we have, can't have it, because it will pollute the planet.

And so, if you look at it, recycling, reusing, and being more efficient is a band-aid. It's something we need to do, but a hundred years, or three hundred years from now it will not solve the problem. That's where space comes in, because I believe that we can use the resources of space and use space to stop the devastation of

the planet, provide energy for the planet, and help elevate the lifestyle of everyone in the world.

The original name for this book was *Park Earth*, because my goal would be to put the industry in space, put the power production in space, do as much as we can (mine asteroids, don't mine Africa, don't mine West Virginia—I come from East Kentucky; I don't like strip mining). Let's do that where there's no life and there's no potential of damaging an ecosystem, and let's have the earth be a place to live—for us and for the other inhabitants of the planet.

So, that wasn't so short, but that's the vision behind the book: to make the case for working together to make that end result—which is the goal of the environmental movement, and it's really a goal of a lot of people in the space movement. Let's work together.

Dr. Campbell: I haven't read the whole book, but I have some sample chapters, and one of the chapters was about moral issues; and so, you've led right into that. You argue in your book that developing technology to get resources from outer space is the moral thing to do. Why do you say that?

Dr. Johnson: It almost sounds a little simplistic, because I go back to the pithy slogan of that company, 'Life is good.' If you take that as a moral argument—that life is a good thing; it should be preserved—and you look at the universe (you mentioned the picture from Apollo 8), I use that in our book; because when you look at that, this earth is alive. And it's in an otherwise—at least in our local region of space—dead universe. There's no life out there.

So, the moral argument for me is that if we're going to have life, and an inevitable byproduct of life is fouling the nest, let's not do that where there's life. The moral thing to do is to do that where there is no life, in an environment where there will never be life unless we bring it there, and to realize that in that environment

(which people have pushed back on me—you know, 'You want to pollute the moon?') the sun pollutes the moon more just by shining on the surface of the moon than we could ever do. With the radiation that bathes the moon, what humanity could do would be totally insignificant.

And if it's preserving and protecting where life is, then to me that's a moral issue. If we have to have a civilization (which I'd like) and we want to improve the quality of life for people on earth (which we should) then we should do it in a way that does not damage life. And we have an option, and that option is to use space.

Dr. Campbell: A quote that I wrote down from your book was, "Without human intervention space is anti-life."

Dr. Johnson: That's correct: it is. I'd have to say, what would happen to you if you went to space? You would be dead in minutes. And as we know it—and again, I'm being a bit anthropocentric here, because life as we know it is what we know—there is no life out there.

If you look at the environment of the radiation of the sun, the vacuum, the thermal environment, the galactic cosmic rays coming from outside the solar system into the solar system, the universe outside of our wonderful planet is a deadly place for us. And in NASA we spend a lot of effort just to keep people alive as we voyage out there to explore it. So, that's correct; and it won't be alive unless we make it alive.

Dr. Campbell: There's another phrase in your writing that sticks out in my mind. You said, "The earth is not a closed system." I thought you might explain this concept, and why it's an important one.

Dr. Johnson: It's important in relation to what we're talking about because the second law of thermodynamics—to delve into physics here—is one of the things that's really biting us right now. And that is that in energy production, no matter

what we do, we're inefficient at it. We can't get 100% at anything. Physics doesn't allow that: this thing called entropy happens. We lose energy, we're less than 100% efficient, and we can't do it 100%.

So, when you're talking about recycling, even if we gathered up everything we've used and we tried our best to reuse it, we'd still end up not being 100% on efficiency. You're still going to lose. You still have to put energy into the process; you still have losses and byproducts. And there is, I guess, an engineering corollary to the law of physics which says we don't know how to do anything with 100% efficiency.

Some people view that as meaning that we're doomed, and that we've got to have limits placed on what we can do as a civilization and as a people. There are folks out there that think we have to diminish the standard of living of those that have a high standard of living, and not let others improve their lot in life, because the earth is a closed system, and these fundamental laws are going to mean that we have limits to what we can do.

But the earth isn't a closed system. We get sunlight from the sun. Energy is coming into this system all the time. And we humans have the ability to go out and bring raw materials, and minerals, and the stuff of our civilization into this system.

So, by using space, it's no longer a closed system. It really isn't to begin with; but we make it, as people, even less of a closed system. And so, we don't have these artificial limits. They aren't real. They will be limits if we allow them to be limits. And if we don't allow them to be limits, then they aren't.

Dr. Campbell: So, let's get concrete. What kind of resources are out there?

Dr. Johnson: There are various things we can do with the resource question, and also space development in general. In the early phase, which we're doing

now, we use space to monitor where pollution is; we use it for understanding the desertification of what climate change may be doing to the planet. So, we're already using space for monitoring and understanding the planet.

But the resources that are out there: first is energy. Space solar power—which is not my idea, it's been around for a long time—is the idea that you go to space and deploy these big solar collectors to generate electrical power, and then you beam the energy down to the earth to supply power here on the ground.

The reason for doing this is that it's free energy, you just have to go collect it; and that it's expensive to launch all the mass up to do that with our current ability. But it's a way of producing power with no greenhouse gases; you don't have to strip mine the beautiful mountains of East Kentucky and West Virginia to get the coal; you don't have to have the risks associated with nuclear power. Although I am a big pro-nuclear advocate, I think it's an interim solution, not a long-term solution. So, power is one.

Right now we have nuclear fission, which is basically where we're splitting atoms. In the sun, which is very, very efficient at producing energy, atoms are combined in a process called fusion. And we've done fusion on the ground in laboratories; it has just not ever been at a point called 'break even,' where you get as much energy out of it as you put into it.

So, it's a loser right now. And a lot of researchers have been trying for decades to get past break even; because if we do, then we have a terrestrial power source where we can produce lots of power with very little pollution. It doesn't have nearly the by-products of our current nuclear reactors.

Well, there is an isotope of helium, which is prevalent in space and not so much on the earth, called helium-3, which you could get from the moon. And it just so happens that it makes that fusion reaction easier to do. Unfortunately it would

be the equivalent of doing a mining operation on the moon, and we can't quite do that yet. So, you can go there for energy.

In terms of other resources, there are near-earth asteroids which are almost orbiting the sun, almost with the earth. They come very close to the earth, and have an orbital period similar to the earth. In my parlance there's not much delta-v to go there (which means delta velocity, or propulsion—you can get there easily). We could easily nudge one of those into an orbit—not necessarily around the earth; a lot of people might be afraid of that—but in one where we could send astronauts or a facility on that asteroid to mine it, and then send the products back to the earth.

Dr. Campbell: What are the obstacles to making that a reality? Getting stuff up there to do it? Is that really where we're stuck right now?

Dr. Johnson: It's really where we're stuck right now. The technologies for getting around in space, once you get out of the earth's gravity well, and the earth's atmosphere, are pretty well developed. And in fact there are some on the drawing board today that I believe would be efficient enough and low-cost enough to make what we do out there affordable.

The big obstacle we have is the cost of getting from earth to space, and the complexity of doing that. The bottom line is we haven't found anything better than rockets. And they are complicated, risky, and expensive right now. There are a lot of folks trying to solve that problem, but right now it's just too expensive to go do.

And if you're in a corporation where you have to make money, and somebody comes in and says, 'I've got a money-loser for the next 20 years, but it's going to help the environment,' they're going to get laughed out of the board room. But as these resources dwindle, and as we as a society perhaps start considering that

there are other costs than just the bottom line dollar, I think the innovation will happen and we'll find a way to go get it.

Dr. Campbell: But you'd like to argue for doing it before it's a desperation choice?

Dr. Johnson: Yes. I'm an optimistic person by nature. I think humanity has a wonderful potential. But there's a little bit of a pessimist in me that says that perhaps our civilization has got a window, where we have enough affluence and enough people with a will to do things that we don't have to do just to survive today, where we can start thinking about the long term and make the investments so that two generations out they have an opportunity for prosperity.

I'm afraid that window may not be open forever. That's a concern I have: that we're going to reach a point where this competition for resources is going to get really fierce and that window might close. And that is a depressing thought. So, I don't want to depress you. The potential is there, the optimism is there. We just have to do it.

Dr. Campbell: I'm going to ask you sort of an off-topic question. Is it true they lost the plans for how to build the Saturn V rocket?

Dr. Johnson: Zing! Well, to answer that I have to first give a disclaimer I should have given at the beginning of the podcast. Although I work for NASA, I'm here representing me, Les Johnson, as an independent. I'm not representing the agency here. And writing these books, I've done that as a hobby of mine, actually. I should have given that disclaimer at the beginning.

But the answer to that is, no, it's not true. The plans are still there. We could go build it. The question I have, and the belief I have is why would you want to do that? Because the total computing power to monitor the systems on that vehicle

was probably less than you have in your watch—let alone your cell phone or your computer.

The materials from which it is made—the aluminum and the structures of the Saturn–were a lot heavier than the materials we could build today. You could go down each of the systems that are in there. The machine tools to make them are not in use anymore, because nobody wants that antique stuff any more. So, even though it exists, it wouldn't be something that would make a lot of sense just to go dust off and build.

Dr. Campbell: OK.

[music]

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Dr. Campbell: There was something we were talking about before that I wanted you to be sure to tell people; and that's about what really goes on when the shuttle is up there and we see that big plume that we think is smoke.

Dr. Johnson: Oh, yes. OK. There are two propulsion elements that get the shuttle to orbit. There are the space shuttle main engines, which are on the bottom of the orbiter itself—they're the big engine bells you see on the orbiter—and there are the two solid rocket motors. The solid rocket motors use solid chemical propellant, and unfortunately that does pollute.

But that big plume you see coming up when the shuttle launches is steam; it's not smoke. What's happening is you've got liquid hydrogen and liquid oxygen, and when that combusts and combines, hydrogen and oxygen makes water. And so, the byproduct of that combustion is basically steam. And you see a lot more steam than would just come from the engines, because before we launch the shuttle there's essentially a big swimming pool underneath it that's filled with water.

And the reason for that is because, as the engines start, it's a vibration. That vibration, if it weren't damped out somehow, might be enough to basically shake the shuttle apart. And in order to damp the vibration, they fire with water underneath the orbiter, and that water helps absorb the acoustic energy to keep it from shaking the orbiter so much.

And so, when you see that big plume of smoke, and everybody says, 'Oh, my gosh, it's polluting,' it's really mostly steam. Now, not all rockets are that way. There are some rockets that use chemical propellants that are not that way. But hydrogen and oxygen is one of the best we know. It's really the way to go, as far as rocket building, if you have the infrastructure on the pad to keep the things cold.

Dr. Campbell: I think this is a good example of why we really miss Walter Cronkite; because I think we would know this if we still had a Walter Cronkite.

Dr. Johnson: I can't argue with that.

Dr. Campbell: Remember him telling us all the little things with the models, and exactly what was what?

Dr. Johnson: I have to tell just one other thing in defense of the space industry; because those solid rocket motors unfortunately do put out some perchlorates, which are not the best thing to put in the environment. And there

are alternatives that are not that way. NASA is actually working on—as are other companies—green propellants that would be perhaps not as benign as steam, but not far away.

But one of the things we've heard from the environmental groups in Florida on the space coast is, thank goodness NASA is there. Because there's a big nature preserve around the Kennedy Space Center that's not developed with condos and beach houses; and the rest of that coast is totally developed.

And from what I've been told from people who live down there is, thank goodness you're here, even though there's a little bit of pollution that comes from launches; because otherwise this would be nothing but condos. Right now there's a big nature preserve there. So, there are two sides to at least that isolated spot of what we do.

Dr. Campbell: Do you want to talk a little bit more about how you see environmentalists and space enthusiasts working together?

Dr. Johnson: Yes. It's something that, when I've talked about this with my friends who are active in the environmental movement, it takes some convincing. Aerospace companies tend to be companies that also build things for the defense department. They build big heavy equipment. They don't just do space. And I think there's an assumption out there that big aerospace is not green, and therefore is somehow on the other side of the fence—somehow on the other side of the argument.

That's a big one to break down, because people's implicit assumptions are hard to get around. It takes some effort to convince people, 'Hey, wait a minute, I want the earth to be a park.' I work in NASA and I work with people in aerospace that share that same vision. They're engineers, so they want to go build the gadgets to go make the earth a better place.

And that's not evil. It gives us the longest lifespan and a healthier lifespan. The quality of life for people has improved dramatically since we were 'living in nature.' I, for one, would not want to go back three hundred years when the earth was a lot greener place. But look at the plight of humans three hundred years ago: I don't want to go back.

Dr. Campbell: And we've gotten an awful lot of data about the environment from NASA.

Dr. Johnson: That's right: NASA, and our other space agencies; and now there are private groups that are doing space monitoring. I want to use this opportunity to talk about one of the neatest things I've learned in the last few years that's kind of a segue into other technologies—transgenic food.

We all know about the genetic engineering of plants. Well, even though we are doing transgenic crop growing, there are strict controls as to how many acres can be planted of, for instance, this transgenic corn. And the EPA is responsible for monitoring that and making sure that the farmers aren't cheating and planting more acreage, or that there's not something weird happening where the transgenic corn is going out of the areas where it's supposed to be grown.

The way they typically do that is they send agents into the field—literally the fields—to take measurements and get all this data. Well, some enterprising scientists in Huntsville realized with the instruments they flew in aircraft, that using a technique called hyperspectral imaging—which is basically just saying they look at the color of light reflected from the plant with instruments that can see a lot finer detail than our eyes can see—they discovered that this corn reflects light a little differently than corn that isn't genetically modified. And they've tested this out on airplane flights.

So, now they're looking at putting an instrument on a satellite so that it can be orbiting the earth and looking down and monitoring wherever these transgenic crops are being grown—in every orbit monitor its spread, and how it's contained, and where it's located, and if it's spreading beyond where it belongs. So, there are lots of ways, from an environmentally activist point of view, that space can contribute to the same goals. The people, literally in the field here, who are worried about the spread of transgenic crops, can use space technology to help us understand that; can help us better monitor it and help make sure that things aren't happening.

Dr. Campbell: That's a great example. Before we open up to questions from the audience, is there anything else you want to share?

Dr. Johnson: I really can't think of anything you haven't covered. I like to talk about the promise of space, and the things we can do. I guess there's one thing I do want to mention that comes up when I talk about near-earth objects: we have the ability to do something that the dinosaurs didn't have, and that is to build a spaceship and go stop that rock before it hits and terminates us as the dominant species on the planet.

I think there's a whole other panel on near-earth objects that will be coming up here this weekend. But about once every hundred years we get hit by a rock from space. The last one was in Russia—the Tunguska impacter. That was basically like an H bomb going off. Today if that were to happen we would have virtually no notice (if it were one that we didn't see), and in countries like Pakistan and India, if it happened there, their first thought isn't going to be, 'Hey, we got hit by a meteorite;' their first thought is that their potential adversary set off a nuke.

And so, one of the concerns I have is that we need to be monitoring these things. And for the ones that we can see that pose a threat to us, we ought to be looking at plans for how we might do something about it. That's another chapter in the

book, because one way to ruin paradise is have it obliterated by an asteroid, and a nuclear war that might follow that—quite honestly.

So, I think we need to be looking at all these things; because it's not a risk that we have to worry about today, but the probability is that in the lifetime of us here, there's going to be something that hits. Once about every hundred years there's an impacter of that size. It's something to think about.

[music]

One of the best things about doing a live podcast is the opportunity to take questions from the audience. This year our live audience was fairly small, but they asked some pretty good questions. Before playing the Q&A, I want to thank Swoopy, from Skepticality, for all the work she does to make the Podcasting Track at Dragon*Con such a success. You will hear Swoopy start off the questions.

[music]

Swoopy: Go ahead and raise your hands, and I will bring the microphone to you so we can record you. As the moderator, I'm going to hog it for a second and ask a question that I'm interested in. As someone who, of course, is a lover of science and all of these things—and your talk is fascinating—everybody needs to hear what you're talking about, and getting that word out, and making it interesting.

Like Ginger said, we don't have Walter Cronkite anymore. And CNN fired their science correspondent. So, it's really important for people to find this information out. What is it going to take to make the public at large more interested in these things that they should all know about, but probably very few of them do?

Dr. Johnson: I wish I knew the answer to that question. On an individual basis, that's why I'm here: that's why I go talk at these events. But that reaches such a small number of people. I try to reach a broader audience with our books; but candidly, popular science books are a niche publication.

The press run for each of these books was 5000 copies—we're a country of 300 million people—and that's basically the total market for a popular science book about space, unless you're Stephen Hawking. You've got a few people that break out of that. It's not something that breaks across to that mainstream. I don't know. I'm looking for ideas: let me know.

Woman 1: What would be the mechanism for mining in space? Would it be manned, or would you be using robots or whatever you're using on Mars—that same sort of technology? You would obviously be doing the moon; and would you be going to Mars?

Dr. Johnson: If I were laying out a plan to make this happen, the first thing is (this is getting speculative; I have to reemphasize, I'm not speaking for NASA here) I would take our space efforts—for a fraction of what we paid for a bank bailout—and I would say we're going to develop space solar power.

And we would be devoting our energies as a country, for 20 years it would take, to develop the infrastructure to have clean power from space, where we're independent of any other country on this planet to provide our energy, and do it in a way that's sustaining and would make us not subject to oil embargoes, and, like I say, strip mining my beloved mountains in East Kentucky and West Virginia. That's what I would do first. I would say energy would be near the top of my priorities.

After that would be using the ability to go build these space solar power stations. I would then devote that capability, perhaps, to going to the moon. You could go

to the moon, and you'd have a few people, but you would probably do most of it robotically, with people overseeing. It's called telerobotics.

I think you'd have to have people there, because things will break. Things will not work as you expect them to work, and you need people there to go fix them. But I think you would probably have a few people, and lots of industrial machines that don't look a whole lot different from what we grade the earth with here, that would be doing the work on the moon.

Woman 1: Sort of similar to Antarctica.

Dr. Johnson: Yes, that's right. It's not something we have the ability to off-the-shelf go make happen today, but we know how to do it. And with the people that we have, if we had the resources, we could make it happen.

Woman 2: You were talking about the jet propulsion system that you were working on. Was that the same one that Chang-Diaz, when he left the astronaut program, worked on? He worked on one.

Dr. Johnson: He is an advocate for something called VASIMR—Variable Specific Impulse Magnetoplasma Rocket. We actually did some work with Franklin at Marshall, helping him test part of what he's working on. And when I mentioned the things in space propulsion that we could go do, VASIMR is a candidate for that. It's not ready yet, and there are things that it can't do yet, but it is a very promising technology for that. So, absolutely.

But what I've worked on is two areas—solar sails, which is using sunlight for propulsion (those listening to the podcast can't see me picking up my prop here, but I'm holding up a piece of paper—a book—and the light from the lights in here is going to reflect off of this and push on it). In space, the sunlight reflecting off of a lightweight reflective material causes it to move. And that gives you free

propulsion—you don't run out of fuel. That's what I've devoted some of my energy to, is developing solar sail technology.

And also these tether systems. A tether is a long cable—a long wire. Talking about the moon, the moon has no atmosphere, and one of the ways to get things off the surface of the moon without using a rocket would be these long cables, spinning slowly, that could actually come down to the moon and grab payload from the surface of the moon and take it to space. It would lose a little bit of energy in the process, but the sun is providing plenty of power.

So, you have ways that you can scavenge energy. And these are things, like I say, do we know how to do it today? No. Do we have the materials? Yes. Do we understand the structures? Yes. Do we understand what it would have to do and how we'd build a system to do it? Yes. Give me 10 years and the resources to do it—yes, we could do it. If someone said, go build it today—no. But 10 years from now we probably could.

Woman 3: That actually brings up a good question for me, because I recognize the solar sails as something that was a fixture – I believe, wasn't there a short story from Arthur C. Clarke, or Isaac Asimov, or several, involving using solar sails? So, how many of the ideas that you work on were fueled with the seeds of these classic science fiction stories?

Dr. Johnson: I would say a lot. A lot of the classic science fiction writers were either scientists or engineers, or wished they were scientists and engineers and were very smart lay people. You mentioned Clarke and Asimov—Clarke has patents on, and invented the whole idea of the geostationary communication satellite. He was a brilliant man. They had the good fortune of being there at the dawn of that genre, and were able to be the first to postulate these things and write some great stories about them.

So, yes, a lot, is the answer to that question. I remember reading these stories. Of course, some science fiction gets into warp drives; and as much fun as that is, we don't have a clue how you would do something like that. So, I have to be a little bit more down to earth than I'd like to be. And I wish it were as easy as the movies made it look.

Kinsey Swartz: Well, I could probably ask questions all day, but I'll just limit it to two. First of all, when you talk about the tether, is that the same as the space elevator, or is that a different technology?

Dr. Johnson: It's related, but different. The space elevator—for those that might be listening to this—is the idea that you would build a cable, essentially from somewhere on the equator, that would go all the way up to a geostationary orbit where we have the communication satellites, that would essentially have an elevator that would take people from the earth all the way out and back. And the energy use on that would be fairly low.

We don't know how to build that today. We don't have the materials. We don't know how we would build such a large structure. And to be a little bit of a naysayer on the space elevator idea, I'm not sure we want it. The reason for that is it would stick up from the earth, and every satellite in earth orbit would eventually cross paths with it.

You would have to make the conscious decision that we don't fly satellites in low earth orbit, because they go around the earth every 90 minutes, and their orbits are constantly changing a little bit. And eventually something is going to hit this space elevator, travelling at 8 kilometers a second, and it won't be pretty. We'd have to give up everything else to have the space elevator—GPS, we couldn't do that. So, as much as I like the idea—and it's a neat, elegant idea—the practical side of me says, even if we had it, do we really want it?

But the tether is a strictly in-space system. (Again, for the people listening, I'm spinning my hands up here.) Imagine a cable that's a hundred miles long in space, slowly rotating. It's not rotating very rapidly; it's a very slow motion. But it's got a lot of energy because it's so large. You can use that to—essentially like a sling—send payloads out of earth orbit to anywhere in the solar system.

And using another kind of tether embedded in it, called an electrodynamic tether—which is what I'll be going to Japan for in about a month, for their launch—it uses the earth's magnetic field to push on its magnetic field that it generates from a current flowing through it, like two north poles of a magnet, to re-spin the tether back up so you don't lose energy. You still have the second law of thermodynamics to contend with, but you're out in space where you've got energy from the sun coming in all the time.

So, we could set up these things around the earth and be sending payloads all over the solar system without using any fuel. That's the kind of thinking I want us to be looking forward to. Let's not take hundreds of pounds of propellant for every launch, just to send propellant into space. Let's use what's there. Let's be smart about how we do things. That's a long answer to a short question.

Kinsey: I'll just ask one more short question. You haven't stated it explicitly, but it sounds like your vision of the future is to use space to help earth, and not so much to send people into space or to terraform, other than what is necessary to do work in space for the benefit of earth. Is that correct? Are you against an attempt to terraform Mars in the long term, or is that just not your main focus?

Dr. Johnson: If you had asked me that question 15 or 20 years ago, I would have answered that my focus was sending people out, and terraforming, and exploring. But I'm at that point in my life now where, as I've looked at the data coming back from these probes, and we realize what a wonderful place we live—

how it might be unique, or nearly unique, in this part of the universe—that makes it very, very special.

And I think I want to devote my vision of the future and my efforts toward the future to keeping it that way and preserving it. So, I would say I wouldn't be against sending people to Mars and maybe changing Mars some day to be a place where we can live. But that's so far out; and I would advocate doing that after we make sure that the cradle of life is protected here. So, I would put that as my priority.

Woman 4: I just had one more comment. You were talking about how to get the word out more to everybody: I know for me, as a NASA educator with my students, and going out and doing the workshops for the teachers, that's the key—getting the kids interested and getting it to them, since they're going to be the future of the space program.

Dr. Johnson: How do we keep them? That's a topic for another panel. I mean my daughter—who may be listening to this one day—is in ninth grade. She's a whiz at math. She was on the math team last year, she wants to be a doctor, and she's very good in biology and these things. And I'm so proud of her. But I can see the peer pressure working on her, telling her that this is not cool.

Woman 4: It's going to be also the enthusiasm of the teachers that has to follow from middle school, to high school, to the university level. It can't stop in between, after middle school or high school. It has to be the university teachers, and the high school, and middle school keeping them interested.

Dr. Johnson: Yes, I agree with you. And it's a challenge. And we don't seem to be doing it real well. It's a concern.

Woman 4: And it also has to be the drive from mass media—that's constantly telling them otherwise—to find a way to make it as exciting as all the other things that distract them.

Woman 5: I just wanted to point out that girls do not really go into science very much—even now. I know it was an old study, but it was showing that black men and white girls are not interested in physics; or they don't do as well on the GREs when they're going to grad school. They were really scoring very low on it—even though the GRE isn't that indicative of how well you're going to do in college.

Dr. Johnson: I don't know. I do know that at NASA in the engineering field (most of my colleagues are engineers) we have had a dramatic change in the workplace from when I started almost 20 years ago to today, with a large number of women engineers in the work force. Maybe we're a little bit skewed, because (I'll be a little immodest here) there's a little bit of a cachet to work for NASA, and I think we get the cream of the crop, quite honestly.

A lot of the engineers that come out of school want to work for NASA. And I think, maybe because of some of these social pressures, you've got some really talented women engineers. And we get real lucky, because I think we get a lot of them—maybe a disproportionate share. I haven't seen it so much in the sciences. I don't know about that. But I think in the engineering fields the influx of women has been pretty strong; and I see it reflected in our work force.

Dr. Campbell: Well, thanks, Les. That was great. I appreciate your coming.

Dr. Johnson: Thanks for inviting me to be on. I enjoyed talking about it, and it was nice to get to talk to you.

[music]

I want to thank Les Johnson again for being such a great guest. I'm looking forward to going back to Huntsville soon to visit with Les and his wife, Carol. If you go to my show notes at booksandideas.com you will find a link to pre-order Les's book, which is currently scheduled to come out in December, 2009. You will also find links to his previous books.

Also, thanks to the work of Lori Wolfson I now have transcripts for all 31 episodes of *Books and Ideas* posted on the website, booksandideas.com.

I have to say it's good to be back on a monthly schedule for *Books and Ideas*, and I appreciate the emails from those of you who have said you're glad the podcast is back.

During my summer break I gave serious consideration to ending this podcast because, although I put just as much work into it as I do the *Brain Science Podcast*, *Books and Ideas* continues to have problems finding a bigger audience. I really need your help with this.

Recently a listener on our new Facebook Fan Page suggested reclassifying the show as Science within iTunes. I have done this, but now I really need each of you to go in and leave a review.

Also, I need you to encourage at least one other person to subscribe. I really think if we could get the show featured on iTunes that it would take off.

As always, you can send me feedback at docartemis@gmail.com.

Thanks again for listening. I'll be back with you again next month.

[music]

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Theme music for *Books and Ideas* is "The Open Door," by Beatnik Turtle. Be sure to visit their website at beatnikturtle.com.

[music]

Transcribed by Lori Wolfson

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