On Exoplanets and Love
by On Being

Transcript for On Exoplanets and Love:

Natalie Batalha on Science That Connects Us to One Another

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Krista Tippett, Host: Natalie Batalha hunts for "exoplanets" — Earth-sized planets beyond our own solar system — that might have liquid water and harbor life. She works with the Kepler Mission at NASA, searching among millions of stars that emit "compelling signals" in the range of Kepler's space telescope. For her, it's only a matter of time — a when, not an if — that we discover planets where we know life exists. And, I've never met anyone who speaks more intriguingly than Natalie Batalha about the connection between science, love, and gratitude for life. She is a luminous voice for the way exploring the heavens — as we do that now — is bringing the beauty of the cosmos and the exuberance of scientific discovery closer home to us all.

Natalie Batalha: We are extending our senses out into the cosmos in a very real, tangible way, and that makes it so much easier to capture our imagination, to inspire us. You know, through the Curiosity Rover, we are standing there in our hiking boots on the surface of Mars. Man, I can practically hear the crunching of the dirt underneath my feet. You know, it feels like I could bend down and pick up a rock and toss it over that hill over there, you know? So in a very real way, these experiments are extending our senses out into the cosmos.

Ms. Tippett: I'm Krista Tippett. This is On Being, from APM, American Public Media.

Natalie Batalha is a research astronomer at NASA Ames Research Center and a mission scientist with the Kepler space telescope. She helped discover the first approximately Earth-sized rocky planet outside our solar system. Here on earth, she also keeps a lyrical Facebook page — like this entry from March 2012, on the third anniversary of the Kepler telescope launch. She wrote: "I am inspired by the way that science connects us to one another, transcending borders, transcending time. I am inspired by the way that science is reuniting us with the universe, with these distant places in the galaxy which are becoming destinations — real worlds in their own right with their own stories and ... who knows what else."

Ms. Tippett: I've really enjoyed just digging into things you've written, interviews you've given, watching the panel you were on at World Science Festival and also looking at your Facebook page, which is wonderfully profound.

Ms. Batalha: Oh, jeez [laugh].

Ms. Tippett: I mean, you've described yourself now as a planet hunter, and I wonder if you'd heard that phrase in your childhood. Was there anything in your earliest life that pointed at that? That this is being where your passion would go?

Ms. Batalha: No, not at all, not even remotely. You know, when I was a kid, gosh, what did I want to do? I wanted to be a gymnast. I wanted to be like Olga Korbut and Nadia Comaneci, and I wanted, you know — I was a cheerleader in high school and, you know, my parents didn't go to college, so I didn't really have examples in my life of what that was and I didn't know what it meant to be a scientist. I imagined it as a boring job. I imagined a, you know, Caucasian male, middle-aged, dressed in a white lab coat sitting by himself in a lab.

You know, that wasn't me. Nevertheless, there were things along the way, you know. I'm perhaps too young to remember the Apollo program. I was, I think, two or three years old when man landed on the moon, so I don't really have that as a guidepost. But certainly the shuttle program in the 1980s when I was in high school really, really, of course, it touched us all. We all got that bug of exploration and, you know, I saw that as just the most exciting job anybody could possibly have on planet Earth. So I think that that was the backdrop.

Ms. Tippett: I like the way you — I've seen you talking about how you got into science. Didn't you start out studying business in college? Is that right?

Ms. Batalha: I did, yeah.

Ms. Tippett: Yeah, and that you took a physics class and that you weren't actually very good at it, which is comforting. I think that's good for people to hear.

Ms. Batalha: Physics is hard, yeah [laugh].

Ms. Tippett: Yeah. And, you know, you weren't immediately a genius, but that you had this epiphany around somebody explaining rainbows in oil puddles to you.

Ms. Batalha: Yes, that's exactly right. I remember the moment very clearly. I enrolled in that physics class and, oh, boy, I struggled. Man, it was just a completely new way of thinking. I had never had to do that before. Developing those analytical, you know, powers, mental capacities, was really new. But as you said, that key moment came sitting in a lecture hall at UC Berkeley, you know, with those old wooden desks in one of these big lecture halls, the dusty chalkboard at the front and, you know, the professor with the blazer and all of that.

You can picture the scenario, you know. It's just stereotypical, right? And he's talking in just kind of monotone, in a monotone voice, about refraction, which is, you know, the behavior of light interacting with different media, bending the light waves and separating out the different colors of light in different directions and how we see a rainbow as a consequence. And he's describing this and he uses this analogy, the rainbow of color on an oil slick, you know, floating on top of water, which, of course, we've all seen. It's something so common to us.

And at the same time, he's writing down all these mathematical equations on the board and it just struck me at that moment, my gosh, you know, the universe is not a random collection of chaotic, you know, events. It can be explained with numbers. It can

be explained with math.

Ms. Tippett: Even beauty can be explained with numbers and with math.

Ms. Batalha: Exactly. And at that moment, I think I all of a sudden had this idea that, you know, maybe all of the mysteries of the universe are there for us to discover. Maybe there's no limit to what we could know if the universe is so ordered. And that was very profound to me, so at that point, there was no going back [laugh]. At that point, you know, despite the "C" I earned in that class, I was actually quite proud of that "C." I was very, very proud of that "C" and took it from there and very quickly I did learn how to think that way and it changed my brain in exciting ways.

Ms. Tippett: So this sphere you've ended up taking this passion into is this world of looking for planets, or this world of exoplanets. I wasn't sure what that meant, you know, when I first heard it. It's planets outside our solar system. Is that right?

Ms. Batalha: That's right. We're looking for not planets in our own solar system. We're looking for — you know, exo means out, so outside the solar system, planets orbiting, gravitationally bound and orbiting other stars in our galaxy.

Ms. Tippett: And there was a great breakthrough in this in 1995. Could you explain what we learned then that's helped set this field off?

Ms. Batalha: Yeah, absolutely. I actually fortuitously happened to be there.

Ms. Tippett: Oh, I didn't know that.

Ms. Batalha: Yeah. I was a graduate student at the time, and my adviser was responsible for constructing an instrument on the Keck 10-meter telescope in Hawaii. This was the world's largest telescope at the time. And I had the great fortune of being able to use some of the data that was taken, that very first light data from that telescope, in that particular instrument. So I think actually he got invited to go to this conference and talk about the data, but he couldn't go, so he sent me instead. And very naively, as a graduate student, there I am sitting in the audience and Michel Mayor, a Swiss astronomer, gets up to give a talk. And there are television cameras kind of over to the side. And Michel Mayor proceeded to tell us about the very first discovery of a planet orbiting another star in our galaxy.

This was 51 Peg. 51 Peg is the name of the star; 51 Peg b is the name of the planet. You know, at the time, I mean, I listened and kind of took it all in, but it didn't really dawn on me at the time, I think, the implications and where this was going. And I've only later begun to appreciate the historical significance of that event. That was humanity's first discovery of a planet orbiting another star like our sun.

Ms. Tippett: I'm Krista Tippett, and this is On Being, today with astronomer Natalie Batalha. She's with NASA's Kepler Mission, which is searching for habitable planets. It's named after the 17th-century astronomer who first described the laws of planetary motion.

Ms. Tippett: So one thing I've come to, I think, understand through researching you is that orbit, that planetary motion, is one of the critical things we're looking for when we're looking for planets that could be — where life could be possible, right?

Ms. Batalha: That's exactly right.

Ms. Tippett: That could be habitable. Planets in what they say is this Goldilocks zone of not too hot, not too cold, just right [laugh].

Ms. Batalha: Exactly. We're looking for a planet for Goldilocks. That's right [laugh].

Ms. Tippett: Would you say a little bit more about Kepler? Because I just think he's in that league of Copernicus and Galileo and Newton, but I'm not sure he's known quite as well by people.

Ms. Batalha: Johannes Kepler, yeah. He lived in the 1600s and was a mathematician, very, very brilliant mathematician. But he was also very — I don't know if spiritual is the right word, but he also had this really deep reverence for nature.

There's a story. I don't know how much of it is myth and how much is fact, but there's a story that he was in a classroom giving a lecture on mathematics and geometry talking about the platonic solids, these solids that are comprised of equal-sided polygons on the sides and talking about how the geometry of them and how, if you nest them together, you get certain ratios between the radii of these shapes and, you know, just the geometry of it.

And there's this great story that, in the middle of this lecture, he's talking about these ratios, this geometry and all of a sudden he stops. It's like stops him dead in his tracks and he realizes that the ratios he's describing are found in the solar system. And that seemed like an amazing coincidence to him, too amazing. All of a sudden, it seemed like that the numbers and the symmetries and geometries were intimately connected to the universe in a very fundamental, spiritual kind of way. And so he got fixated on that idea and he set about to prove it.

The problem was that now we know it doesn't strictly hold true, but it seemed to him at the time through his human perspective that it was too big of a coincidence. It had to be true, you know. I mean, what ended up happening was he spent decades of his life trying to prove it and, in doing so, stumbled upon what is now known as the Laws of Planetary Motion.

Ms. Tippett: Oh, OK [laugh]. That said, that's the way life works …

Ms. Batalha: He ended up discovering — well, it is, but also it's a testament to the scientific method. We have human biases. We have human perspectives and they bias the way we look at the universe. But if we stick to the facts, if we stick to the observations, it's a method of removing that human perspective and, when we do so, amazing things happen. We stumble upon something that's even more wonderful.

Ms. Tippett: But is it also that he was seeing something that was intriguing and following that hunch even though it didn't follow all the way through, took him in a direction that pointed at a real discovery. Is that also a way to see it?
Ms. Batalha: It's true, but, you know, it could have also just been that he wanted to find out what moves the planets and how they move, you know. I mean, it was a coincidence that that inspiring thought led him to the Laws of Planetary Motion because there's really no connection between these platonic solids and the laws of gravity, right?

Ms. Tippett: OK.

Ms. Batalha: They're completely distinct. They're completely different. Another aspect of this story that has really touched me deeply is his persistence and the fact that he just encountered roadblock after roadblock. He went down blind alleys, got to the end and had to turn around and walk his way back and he never gave up. And he had times in his life where he was just feeling despair, total utter despair and failure, and yet he never gave up. And it's that persistence, time and time again, I'm seeing in the history of humanity, it's that persistence that always leads to greatness. And the Kepler Mission itself is kind of an example of that because, you know, it's a NASA mission, but it actually was rejected by NASA five times …

Ms. Tippett: I didn't know that [laugh].

Ms. Batalha: … before it was selected. Yeah, the guy whose brainchild this was has been working on the idea since the 1980s and it wasn't until the year 2000 that it was finally selected. But, again, he was an example of a man who just didn't …
Ms. Tippett: And what's his name?

Ms. Batalha: William Borucki, Bill Borucki at NASA Ames. He just, you know, doesn't see rejection or failure as — he doesn't take it personally, you know. You just keep on going because you love the science. He loved doing it. You love the process of discovery and learning. So that was another great lesson that I learned from Johannes.

Ms. Tippett: And when I listen and try to understand what the Kepler Mission is doing, how you're doing that science, I mean, just in the context of what you just said, it certainly is an exercise in just incredible patience, right? Almost superhuman patience, right?

Ms. Batalha: Right [laugh].

Ms. Tippett: You're looking at millions of stars. You know, you're looking for, you know, in lay terms, the needle in the haystack.

Ms. Batalha: It is the needle in the haystack, yeah.

Ms. Tippett: Right, that might be habitable.

Ms. Batalha: Yeah, that's right. You know, we're
inferring the existence of these planets by looking for these dimmings of light that happen if a planet in its orbit about the stars passes directly in front of the star, kind of eclipsing it slightly.

Ms. Tippett: So what you're actually looking — what will be your signal in fact is not something you see, but the dimming of light.

Ms. Batalha: So what we're doing is we're measuring the brightnesses of stars. We're not actually taking pictures of stars and planets. We're measuring their brightnesses. And in this one patch of sky that we're looking at, like you said, there are millions of stars, literally 4.5 million stars near the Milky Way, the plain of the Milky Way, a patch of sky that's about the size of my open hand, you know, stretched out in front of me.

And we've chosen about 150,000 that we're monitoring. So we collect the light through a space telescope and that light is sent down to a detector, which is just an array of CCDs. It's exactly what you have in your digital camera when you take a picture. And those detectors are measuring the amount of light that falls on them from these 150,000 stars. So we take a measurement of all these stars simultaneously once every 30 minutes, and we've been doing that for three and half years [laugh].

And the point is, you take these measurements and you want to do it without blinking because eventually some of those stars are going to have planetary systems that are orbiting and aligned in such a way that the planet will pass directly between our telescope and the star. And when it does that, that planet is going to cast its shadow out into space and that shadow is going to sweep across our telescope and our detectors are going to perceive that as a dimming of light. So that's how we're inferring the existence of the planets. Those signals are tiny and they last, you know, a couple of hours and they repeat once every year. So you really do need patience. You need to stare at these things consistently without blinking waiting for these signals to occur.

Ms. Tippett: I think it was on the third anniversary of the Kepler launch. When was that? 2009?

Ms. Batalha: Yeah. It launched in March of 2009.

Ms. Tippett: I wanted to read this back to you — it's very beautiful — of the Kepler saying, "The diversity of the phenomena of nature is so vast and the treasures hidden in the heavens so rich precisely in order that the human mind shall never be lacking in fresh nourishment." I thought that was an interesting way to describe at least some angle of, you know, what the scientific endeavor is. I mean, does that ring true for you?

Ms. Batalha: Oh, my gosh.

Ms. Tippett: One way to think about the meaning of science, this nourishment of the human mind?

Ms. Batalha: Absolutely. I mean, you read it and it makes my eyes all misty [laugh]. It does. I mean, I've lived it and I feel it and I have this intense, as I said, reverence for the mysteries of the cosmos and this drive of discovery, you know, this desire to know. Maybe it's because I want to find meaning for my own life. You know, there's something innate about us human beings that makes us want to seek the unknown, to push the boundaries, to find new horizons, to see new things. You know, I don't know why we're like that, but we are.

You know, Carl Sagan has a quote that's akin to this. He said, "Understanding is a form of ecstasy." It really is. I mean, when we have these aha moments, you know, when we really understand something or there's a spark of understanding, we feel that euphoria. I try to tell that to kids, you know. I talk to kids. In fact, I just got back from a two-week tour in India. I spoke to probably something like 3,000 to 5,000 children in India, high school-aged, and asked them why are we going out there and finding planets? Why are we doing this? And the answers are very diverse, but a lot of people raised their hand and said, "Because I want to know if there's life out there."

I also think that this act of discovery, this act of exploration, it changes us. You know, we're evolving toward something. I often wonder or I think about the transition that

life underwent here on planet Earth when it went from water or ocean to land. And then I extrapolate that and I wonder what will happen to us as a species as we transition from land to space. What potential will be released? You know, how will we change? How will we evolve? What implications does that have? And that thought excites me a lot.

Ms. Tippett: And the way you say that, it sounds like for you it's a given that we'll make that transition. I mean, I also hear it seems to me that a given or certainly a possibility that you and your colleagues are devoted to realizing is that maybe even in our lifetimes we might look out and know that there are habitable planets. Is that right?

Ms. Batalha: Well, that's a given. I mean, we're doing that now.

Ms. Tippett: That's a given?

Ms. Batalha: Absolutely. I mean, that's Kepler and it's only a matter of time before we will know of outposts that do harbor life. We're headed in that direction.

Ms. Tippett: How do you think about what is at stake in that discovery? What difference does it make in your imagination if that turns out to be true?

Ms. Batalha: When you look up at the sky, I'm sure all humans have had this experience of looking up into the sky on a very dark night and looking at those stars or that crescent moon or whatever it is. What do you feel, you know? You feel wonder, of course. You feel humility. But I think you also feel lonely, small, insignificant, you know.

There's a profound sense of loneliness, I think, or just the universe is so big and I'm so small. But imagine in the near-term future, you know, your grandchild or your great-grandchild looks up in the sky and his mother can point to a star and say, you know, that star right there? That star has a planet just like Earth, and it harbors life. That's a different perspective. That's completely different, you know, when we can look up in the sky and know that. It's a game-changer.

Ms. Tippett: You know, I suppose where most of our minds go would be to science fiction, which is the place where we have imaginatively explored that. But then it's so interesting for me to read that in 2011 Kepler actually discovered a planet that had a double sunset like the one in Star Wars.

Ms. Batalha: Yes, yes, like the Tatooine [laugh].

Ms. Tippett: Right. That's what seems …

Ms. Batalha: Science fiction, yeah.

Ms. Tippett: Yeah. So, I mean, do you watch science fiction or read science fiction? How do you populate your imagination with …

Ms. Batalha: You know, interestingly, I'm an exception to the rule. I did not grow up as an avid science fiction fan.

Ms. Tippett: Star Trek fan?

Ms. Batalha: I like it. You know, don't get me wrong. I do. I like it. It's funny

with Star Trek, more than the alien encounters, you know, I really enjoyed the ethical questions that Star Trek raises, you know. I loved the character Data and what that meant for our humanity. And I didn't need any help with my imagination, I guess. I didn't need science fiction. But it is interesting how science informs science fiction, but the opposite is quite true as well: science fiction informs — not informs science, but inspires science as well, and it's an interesting interplay that speaks to our humanity.

Ms. Tippett: Listen again, download, and share this conversation with Natalie Batalha through our website, onbeing.org. There you can also find out how to subscribe to our podcast — with all of my interviews edited and unedited — on iTunes. On Facebook, we're at facebook.com/onbeing. On Twitter, follow our show @beingtweets. I share my thoughts, @kristatippett. Coming up, how a life in science has made Natalie Batalha think about love as akin to dark energy.

I'm Krista Tippett. This program comes to you from APM, American Public Media.

[Announcements]

Ms. Tippett: I'm Krista Tippett, and this is On Being, today with astronomer Natalie Batalha of NASA's Kepler Space Telescope Mission. We're talking about what she learns about life in the cosmos and on Earth through this work.

Ms. Tippett: So mystery is a term you've used and it's a term I hear a lot of scientists using. You know, with Kepler I think it would have had religious connotations. But even if it doesn't, I mean, it's a word Einstein used a great deal. It's certainly there for you. I mean, I want to read a little bit back of yourself …

Ms. Batalha: From Facebook?

Ms. Tippett: Yes, yes. Now I know. That's where some people write poetry. "Reality is a poem on the tip of my tongue that I can't quite remember, familiar yet distant. It's a form seen through a veil." And later on, you write, you know, that "as a scientist you live life as if every mystery is there for us to discover and understand."

Ms. Batalha: Yeah, yeah, I feel that, yes. I think that's what inspires me. I read a lot of people with the opposite perspective, and it seems very sad to me to have that perspective that there is a limit to what we can know. You know, interestingly, Carl Sagan's book Broca's Brain, one of the very beginning chapters is, I think, called "Reflections on a Grain of Salt."

And the idea is, you know, is there a limit to what we can know. I kind of have this feeling like we walk around in our human existence trying to create an image of the universe in our brain, trying to reproduce the universe by recording it in our brain and working towards making that image beautiful and accurate and, you know, learning and all of that. So Carl asked the question, well, what is the limitation of our brain? Can our brain record the universe?

Then he goes through this really simple argument. He says, well, you know, let's look at how many atoms are in a grain of salt, just one tiny crystal of salt. You know, if we're going to know a crystal of salt, if we're going to make an image of that in our brain, we have to know at least something about the positions of all the atoms. And, of course, there's more to know, right? How are those atoms moving and

interacting and all that? But let's just make it simple. Then he says, OK, if we're going to know the positions of these atoms, how many atoms are there? How many neurons are there in our brain? You know, what do we know about how we store information in our brain?

And he quickly concludes that, no, we cannot know the universe in our mind. Then he goes on to say, unless there are unifying theories, unless there are patterns, unless the universe is not chaos, unless the universe is ordered — because if it is ordered and if there are patterns, if there are rules, then we can boil down that one grain of salt into a couple of facts that we can record in our brain and use to reconstruct the universe. So that idea is very exciting. You know, how much of the universe is ordered? How can we coalesce it down into the basics?

Ms. Tippett: I mean, here's a way you've written about — just some language you've used. "What we observe out there is that nature is creative, prolific, robust." So I want to ask this question. How does that sense of the universe, of nature that you get, how does that inform the way you move through the world? The way you think about life and your life?

Ms. Batalha: Oh, goodness. There's a lot of suffering to human existence, right? So you made me think of that. You know, nature is prolific and robust and all of that and creative. We overcome adversity and we do things. We push the envelope. We do things that we once thought were impossible and all of that. I wrote those words thinking about the possibility of life. You know, there's kind of two schools of thought as to whether or not there's other life out there in the universe. On one side of the spectrum, you've got the pluralists, the people who say, you know, there are 400 flippin' billion stars in our galaxy and there are hundreds of billions of galaxies in the universe.

How could there possibly not be life out there, right? So the idea is just that there are so many stars, so many worlds out there, there's got to be life. On the other hand, on the other side of the spectrum, you have maybe I'll call them the Rare Earthers. These are the people that say, you know, there are so many coincidences that had to converge, so many subtle properties that all had to hang together and converge here on planet Earth to make life possible, and that's probably not very common. You know, it's a confluence of many different things that had to happen. So you've got these two extremes.

And, for me, I look around here on planet Earth and I say, well, you know, no matter how extreme the environment here on Earth, no matter how dark, how cold, how hot, how arid, how acidic, no matter how extreme the environment, there seems to be life. And that's what inspired me to say that nature seems to be prolific and creative and robust and, you know, put itself in every nook and cranny. And if it does that here on planet Earth, my thought is that it's going to do it out there in the universe as well.

Ms. Tippett: I mean, you also bring words like love. You just mentioned suffering. I think something that's very intriguing about you as a scientist, it's not that you're confusing these things with your science or conflating them, but I sense that this life of discovery that you're involved in does bring you back to think about something like love differently. That it informs and somehow infuses your thinking about that. So talk to me about that.

Ms. Batalha: Yeah. This has been the surprise to me actually that my perspective on love has been so informed by science, but it has. It's been fundamentally shifted, you

know. And then I read other scientists who've had the same perspective and it all kind of makes sense. I mean, Carl Sagan's quote, you know: "For small creatures such as we, the vastness is bearable only through love." This love, this idea, is this moving force. I mean, it just permeates our history, our culture. I've equated it to, you know, this analogy of dark matter.

Ms. Tippett: Right.

Ms. Batalha: Ninety-five percent of the mass of the universe being something we can't even see, and yet it moves us. It draws us. It creates galaxies. We're like moving on a current of this gravitational field created by mostly stuff that we can't see. And the analogy with love just struck me, you know, that it's like this thing that we can't see, that we don't understand yet. It's everywhere and it moves us. And science has given me that perspective, but also in very logistical, tangible, practical ways, you know. I mean, when you study science, you step out of planet Earth. You look back down at this blue sphere and you see a world with no borders.

Ms. Tippett: Right, right.

Ms. Batalha: You see a tiny mote of dust suspended in a sunbeam. You see the expanse of the cosmos and you realize how small we are and how connected we are and that we are all the same and that what's good for you has to be good for me, you know. I mean, it just changes your perspective.

Ms. Tippett: Was there a moment or did something happen where you first realized you were thinking about love the way you were thinking about dark energy?

Ms. Batalha: Oh, my goodness.

Ms. Tippett: I mean, because it's a really interesting connection. Also thinking it changes what you think about love. It is an energy, right? It's not just a feeling inside you.

Ms. Batalha: I mean, with my own personal experiences, you know, being middle-aged and having raised four children …

Ms. Tippett: I know. You have four children.

Ms. Batalha: I have four children [laugh] and, you know, just going through life and all of life's challenges and adversity and losing people that we love and all of those things make us think about love. You know, we need to be loved and to love to be happy. With science, I think about life out there in the universe.

I think about our connectedness. I guess connectedness is a key word. Studying science, you realize the connectedness of all things. You know, we are stardust and here I am, this bag of stardust, and it took how many billions of years for the atoms that make up my body to come together and make this being that's able to take a conscious look at the universe. I mean, I am the universe and I'm taking a look at myself through these senses that I have and that is an amazing thing.

Ms. Tippett: For you, that's such a concrete statement. Somebody else could say that and it might seem a little flaky, but you really know what you're talking about [laugh]. I mean, you've discovered the first rocky planet and things like that. You

really know these things.

Ms. Batalha: Yeah, yeah. Well, no, that's a good point. I don't necessarily mean it in kind of a hippie flowers-in-my-hair kind of way. You know, it's easy to say all these fluffy philosophical words that make us all warm and fuzzy, but there are really practical, you know, connections. There are things that I do see that are real, that are part of what we're discovering.

You know, I said to the kids in India actually just last week, I said, you know, we were talking about love at the end of my lecture. I said, OK — they were teenagers, right? So I said, how many of you are on Facebook? Of course, everybody raises their hand, right? I said, OK, why does it give you so much pleasure? Why? You know, think about the happiness that it gives you. You know, what is it exactly? You're connecting to other human beings and that gives you joy. You have this huge array of people that you resonate with and that gives you joy. So I'm thinking about this as love and how we experience the connectedness between us as creatures here on planet Earth.

And then I start to wonder what is the potential when we are able to connect not just with human beings on planet Earth, but with other species out in the universe? What will we feel? How can this idea of love be extended not just to my family, not just to my community, not just to my country, but to planet Earth and out into the universe once we find life out there? It seems to me [laugh] there's an awful lot of potential there that we've yet to tap into, right?

Ms. Tippett: This animating question that I'm always following is, you know, what does it mean to be human and what do we learn about that in all these different lives we lead and this knowledge we have? You're taking that question of what it means to be human, right? You're taking it to this place where you're also thinking about us connecting with life which may or may not be like us, beyond our species.

Ms. Batalha: Right, yeah.

Ms. Tippett: I mean, there's a definition on your Facebook page, again — I hope you pointed those Indian students to your Facebook page. I do. You said this, again, this question in my mind, you know, how does this work you do shape the way you think about what it means to be human and you wrote that you were "aware of the billions of years it took for the atoms to come together and make the portal to the universe that is my physical self." That is a fascinating definition of what it means to be human, that we are portals to the universe.

Ms. Batalha: Yeah. That's about as much as I can say about it. I mean, that's the reality, right? And why that exists, I don't know. You know, I don't know if there's any meaning. I don't know where I'm headed. I don't know why we're here. I don't know why we're observing the universe and making this record, this recording, this impression of the universe in our brain, this thing that is our brain. I don't know why, but I know that it's leading us someplace, that we do have this innate curiosity, this drive of using this portal to the universe to observe and to learn and it's taking us someplace. And along the way, it's changing us.

Ms. Tippett: I'm Krista Tippett with On Being, today with astronomer Natalie Batalha of NASA's Kepler Mission.

Ms. Tippett: What is the planet hunters project that involves citizens that you've been part of or you've been a real champion of, right?

Ms. Batalha: Yeah, absolutely. This is part of the Zooniverse project, which provides an interface of — it gives the citizens an opportunity to experience this excitement of scientific discovery. So what it is for Kepler, you go to the website and a backend computer system is going to serve you Kepler data. It's going show you the actual data that we look at. It's these brightness measurements as a function of time. And you can loop through these and the computer will ask you a couple of very simple questions. It'll say, you know, what do you see? What does this look like to you? It'll give you some options and just very, very simple questions. And you tool through this data and, in doing so, you have the opportunity to find something interesting that our computer algorithms have missed.

I mean, the human brain is an amazing pattern-recognition tool, right? We've tried to simulate that with a very, very sophisticated powerful computer pipeline that analyzes our data and it does really, really well. Don't get me wrong. But we can't design one algorithm that can handle the diversity of nature, right? There are going to be surprises, right? So you put a million people, citizens, in front of a computer looking and they're going to find things that we missed and that is exactly what's happened.They have had two papers, actually a third paper just came out, with new planet candidates that they have identified, four new planet candidates from the Kepler data. And in addition, they just found one of these circumbinary planets like Tatooine in Star Wars with one of these two planets.

Yeah, in fact, it's two planets orbiting a double-star system. So the reason I think that this is so tremendously important is because it shows — you know, I didn't understand what science was until I started doing it and experienced that thrill of discovery. It's all about that thrill of discovery, and it's not about a Caucasian middle-aged male in a white lab coat mixing chemicals in a lab all by himself. That's not science, you know. It's the discovery. And if people could just realize that at a younger age, I think more people in our country, you know, a country where people aren't necessarily opting to do science, I think that more people would catch that bug and pursue science as a career.

Ms. Tippett: You actually did make a really important discovery or you helped discover the first rocky planet orbiting a star outside our solar system.

Ms. Batalha: Yes, that's correct.

Ms. Tippett: What was that like?

Ms. Batalha: Oh, my gosh, that was an amazing experience. So the Kepler Mission launched in March of 2009. You know, you'd launch this thing. You put this very sensitive instrument on this tower of explosives and you send it out into space and it gets up there and, of course, you have to check out that everything's still OK. You know, it's like a one-month period where we're kind of on pins and needles checking out the spacecraft making sure everything's fine and doing all of our calibrations and all of that. Then there's this 10-day period where we open up the telescope to stars and we start taking our very first observations and it's kind of a trial run. And in that 10 days, in that trial run, we saw already the signal of a small planet, what could be a small planet, orbiting a star about 540 light years away, a star that we later called Kepler 10.

Ms. Tippett: And that was an exciting moment for you.

Ms. Batalha: Oh, it was tremendous. You know, to see the signal in the data so clearly in that first 10 days, of course, showed that everything was working right, so it was exciting from that perspective. But also, just to have that discovery, to know. I mean, that was our first indication that, oh, my God, we're going to find lots of these things. We're going find lots of Earth-sized planets, and that was tremendously exciting.

Ms. Tippett: I feel like something that's happening now and you just embody it is somehow these space telescopes are making a big difference. You know, Hubble is one that people see these images. It's kind of bringing all of that more into awareness, right? It feels more real and also getting a sense of the exuberance and beauty that's not just in the images that come back, but in this process of discovery. You know, in people like you who are working on this frontier.

Ms. Batalha: Right, yeah.

Ms. Tippett: You know, there's something new happening that doesn't all feel so abstract anymore.

Ms. Batalha: Interesting.

Ms. Tippett: What did Kepler call it? He called the work he was doing "celestial physics."

Ms. Batalha: Because I guess they hadn't even …

Ms. Tippett: That is very abstract, isn't it [laugh]?

Ms. Batalha: Yes, right.

Ms. Tippett: Right, but astronomy and physics at that point, interestingly, were two separate disciplines. Yeah, do you know what I mean? That's why I think when people hear somebody like you talk, it's a revelation that this is what science is, that this is what it is to be a scientist and it's the spirit of it. It's the joy of it as much as anything else. It's the discovery.

Ms. Batalha: You know, I think what you're saying maybe is that now in very concrete ways we are, through our instruments, our telescopes, our robots on Mars, we're extending our senses out into the cosmos in a very real, tangible way. And that makes it so much easier, you know, to capture our imagination, to inspire us. You know, through the Curiosity rover, we are standing there in our hiking boots on the surface of Mars. Man, I can practically hear the crunching of the dirt underneath my feet. You know, it feels like I could bend down and pick up a rock and toss it over that hill over there, you know. I mean, that's what it's like. So in a very real way, these experiments are extending our senses out into the cosmos.

Ms. Tippett: When you take a walk or take a run and you look at the night sky, with all this work you do, with all this data and these images that you're working with all the time and everything you know about what we call space, what do you see? What do you take in?

Ms. Batalha: Goodness, I have so many examples it's hard to pick just one.

I've had some really key moments in my life, two in particular, maybe I can tell you about. One is very simple. I was out on a run actually. You mentioned running. I was out on a run and it was summertime, so I like to run at night when it's dark in the summertime because it's nice and cool.

As I'm running, I'm thinking about lots of different things. But, of course, I also think about work and the discoveries that we're making and, you know, I talk to people a lot about it. So it's a lot on my mind. As I'm running home, I look up at the sky and the moon was hanging on the horizon over in the west and I look up at the stars. And in that split second, just that fraction of a second when I first saw the starry sky, I saw not pinpoints of light, which are stars. I saw planetary systems. I saw solar systems. I saw other planets out there. And it's really hard to describe what I felt.

It's really hard to articulate that kind of an experience. It's something very personal. You know, when you look up and you see something in a very different way, it's like I internalized deeply what I've been discovering, what Kepler has been discovering as a scientist. So that's what I mean when I say that when we'll look up at the sky and we will look at it differently. I've experienced that in a very real, tangible way. So that's one example.

Another really important moment in my life was when I went to Chile to the European Southern Observatory when I was a young post-doc and working in Brazil. In the middle of the night, the sky, of course, is completely black. I mean, just starry sky — and you're in the Southern Hemisphere. I decided to climb up onto the roof of the telescope building that I was using that night. There was like a ladder and stairs that go up to the top and a platform where you can stand. Astronomers do that, you know. We go out and we look at the sky and see how it's doing, seeing if there's clouds and all that kind of stuff. So now I'm on top of this gigantic mountain, not only on top of a mountain, but on top of a building on top of a mountain. So I lay down actually on the roof of this building and literally all around me there was nothing but stars, right?

We don't get to experience that very often, having this complete dome over your head, which is the universe. But the experience that I had was that I saw the Milky Way arcing through the sky. I saw planets that were in the sky. I think there was a crescent moon that was in the sky. I could see the large and small Magellanic Clouds, which are satellite galaxies of our own Milky Way. I saw the Coalsack Nebula, which is this giant molecular cloud between us and the center of the galaxy. I saw all of these things and I knew something about them. I had knowledge of them and this knowledge of them gave me three-dimensionality to the universe. It transformed itself.

It was not a dome over my head. It was a three-dimensional universe that I was suspended in and that was an amazing moment for me. It changed the way I saw the universe and my place in the universe. And it was afforded me through my knowledge and my studies of astronomy and I think that it's a gift, and I wish it for humanity. I really, really deeply do.

Ms. Tippett: Natalie Batalha is a research astronomer at NASA Ames Research Center and a mission scientist with the Kepler space telescope.

NASA has extended the Kepler Mission to 2016. In its first four years, the mission confirmed over 100 new planets — but the search for one just right for life continues. Early interpretations of Kepler data point to as many as 17 billion Earth-sized planets in the Milky Way galaxy alone.

Hear this program again, or my unedited conversation with Natalie Batalha, at onbeing.org and through our podcast on iTunes. Also at onbeing.org, find links to other programs we've done with astronomers like Mario Livio of the Hubble space telescope and George Coyne and Guy Consolmagno of the Vatican Observatory. On Twitter, use the hashtag onbeing to connect with other listeners. Follow our show @beingtweets. I share my thoughts @kristatippett.

[Sound bite of music: Don McLean's "Vincent" ("Starry, Starry Night")]