Getting Curious with Jonathan Van Ness & Christina Hernandez

JVN [00:00:00] Welcome to *Getting Curious*. I'm Jonathan Van Ness and every week I sit down for a 40 minute conversation with a brilliant expert to learn all about something that makes me curious. On today's episode, I'm joined by NASA engineer Christina Hernandez, where I ask her: Mars Rover, How Do You Persevere? Welcome to Getting Curious, this is Jonathan Van Ness, and can I just say, if I could ever, like, change my music for an episode of *Getting Curious* and change it to, like, a very suspenseful, gorgeous, like, *Serial*-esque, like, podcast music I would, because the suspense is real. I'm so excited about it, I just I can't even build it up anymore right now because I think that was much as I can do without being too excited. So, welcome Christina Hernandez, who is an aerospace engineer at NASA's Jet Propulsion Laboratory in California. And you're working on NASA's Mars Perseverance Rover mission, which in real life is going to be landing, like, tomorrow. So, what do you do? How does it work? What does it mean to be, to be a literal aerospace engineer?

CHRISTINA HERNANDEZ [00:01:11] I'm still trying to figure that out, quite honestly. So, by trade I am an aerospace engineer. At work we have a lot of really fancy multi-word titles, so I'll, like, break it down. But it's a payload systems engineer. And really what that means is you now when it comes to getting things done, I'm your girl, right. Like, so if you know we're testing that day or if we have to have a meeting to coordinate with people from Europe to figure out how the instrument works and troubleshoot problems, like I'm definitely in there, I'm being nosy, I'm asking questions. And, at the end of the day, my job is to make sure that all of the science instruments, which are the tools that the rover's gonna use to do its thing once it gets to Mars, work, right, from the design, from the build, to when we're testing and finally when we're on Mars actually doing our thing. And so that's what I love about my job: it's not boring. I get to do a little bit of everything, and I get to ask really annoying questions and get them answered.

JVN [00:02:12] Ok, so here's the thing, I meant to ask more about like Mars and, like, what everything's going to actually look like at the beginning, but I'm just so fascinated with *you* and how you got here that I, 'cause what I was going to end with, like, how did you even get involved in this in the first place, but actually I have to start with it 'cause it's just where my curiosity is like taken me by the face and it's taking me there. So how did this happen? You were just minding your own business, like, in high school, and you were, like, "Wow, I'm really good at science and, and math," which is nothing that I've ever been able to say. And then, how, or did you know before that that you wanted to be involved in space stuff?

CHRISTINA HERNANDEZ [00:02:50] So, here's the thing: as a kid, I was actually really bad at math and science. So I got into engineering and science through reading, right. Like, I

wasn't those kids that you know take apart the remote and, like, are building things in the garage. Like, my beautiful space was the library, right? My mom used to take me and I used to look at books with pretty pictures of the planets and see photos of astronauts. And I always wondered, like, what, like, what do I need to do to be able to take that picture? Like, like, who, who are the amazing people that make that happen? And then, you know, as I started reading more, I got into science fiction and fantasy and just, like, my curiosity went off the charts. And, growing up, like, my parents were totally supportive of me being that annoying know-it-all kid, like Hermione Granger, right, in LA. And I just really was able to flourish in school because of that. And, you know, I was never particularly great at math and science. I just really loved learning and I wanted to always ask questions and learn and eventually that led to me being pretty good at math and science. But it wasn't, like, "Oh, I had this spark and, you know, it was magical and easy." It's like I had to work for it. But it's because I *really* wanted to help scientists answer questions about the universe.

JVN [00:04:15] I loved that it was *pictures* of planets and stuff. I mean, to me this feels like the equivalent, but, like, with science--of, like, you have made it to the Olympics, but, like, the Olympics are happening like 24/7, like, always working you know towards it. This is an exceptional feat to be involved in this level of, like, scientific precision. And I think you mentioned something which was that your parents were always really supportive, and you also said LA. So did you like, you grew up in LA, like that's where you went to school?

CHRISTINA HERNANDEZ [00:05:49] I am born and raised in LA, epitome of an LA girl.

JVN [00:05:53] Ok, don't say this, don't take this, ok this I did do hair in LA for 13 years or 10 years, and I did find all my clients who are born and raised in LA, special type of person, because you have to be, like, tough as nails to, like, deal with the traffic, the like, the, you do. It's like, it's a special person that's like an LA native person. So, for people, because I'm from a really little town and I think for people who have kids that maybe have, like, a spark for science or a spark for, like, interest, what do you think this is like, work, well we will get to Mars I swear to God, but what can I, I just am fascinated with, like, how scientists and experts that I've interviewed and especially now have gotten to your level, like, you work for the Jet, I can't even like say the full title without going back to make sure I say right. You work for the Jet or the, the Jet Propulsion Laboratory. I mean, this is such a high level of science, and so for, I, it's, how, what can parents and what can people do that, like, their kids have some sort of spark, some sort of thing in science, and, because it can happen. Like you did it, so how can, like, parents be more supportive of their kids when they see something and have that natural curiosity?

CHRISTINA HERNANDEZ [00:06:08] Yeah, so that's a great question. So there's always a little spark in everyone, like, I truly believe that science is in everybody because we *all* are

curious. We all love asking questions. And what parents need to do is they need to take you know a bottle of lighter fluid and light it up, right, like, oftentimes as kids, right, we don't know, you know, what direction to go, right. It's, you know information overload. Sometimes we think school's boring you know especially if our friends aren't really into it or like if our environment isn't really, like, you know, pro-academia and you know pro-science or, you know, whatnot.

But I really think as a parent, you know, you know your kid best and learn how to communicate through their means, right. So I've met so many engineers and scientists who love art, right. And they express you know their passion for math and science through art, right. And, other folks love, like, building things and touching things and tinkering. And it's like, you know, figure out projects that you can do together, even if it's as simple as like, "Hey, can you help me, like, put batteries in this remote?" "Can you help me troubleshoot this problem on my computer?" Like, it's the act of problem solving, the act of you know helping your kid overcome failure, right, because sometimes that happens um and it makes us better and know helping that process, it, it will build confidence and it'll build *passion* to kind of keep pursuing what they're interested in.

JVN [00:07:40] So you say, you also mentioned at the beginning you *weren't* the most amazing in math and science, but then you literally ended up becoming a NASA engineer. So, I mean, how long do we have to be able to suffer not, like, going to the end of a whole, like, like math problem, and then it's, like, negative 23.4, like, you just know what's wrong, you know. Like, I bet you do get a lot of, like, weird equations now because you're, like, such an advanced scientist, but you know how, like, when you're like, because that's when I fell off. It's, like, if you get to the end of that problem and I worked all the way down and it gives me some, like, number that I know is not right, like, ahh, how long until you got really good at it, like, how long do you think?

CHRISTINA HERNANDEZ [00:08:22] So I'll say this: I'm still not good at it. Like if you were to ask me to add up like 23 and 36, I'd be like "Uhhh, like," you know, I'm just, like, "Wait, can I get a paper and pencil?" So I would say this, right, you know as a kid, right, you know elementary math, you know, I had my groove on, right, you know, the problems were very straightforward, teachers were really good and teachers you know were very like nurturing. Like, you know, it's like, "Oh, it's ok, try again and go for it." Once I got into high school, and oh my gosh like college and grad school, it was like, you're on your own and you're writing, cranking out these math problems that are four to five pages long and it's insane. What I found helped is a) you know, having a group of peers that were fun to study with and you know work with, but I also recognized, like, I just had to get through the pain, right. Like, I *had* to figure it out, and one of the things that I think really helped me is this sense of grit that I have. It's one of my favorite words, right.

Like, and you go back to, like, the LA tough as nails, right. Because it's kind of like, it's gonna be tough. And you have to figure out, is this worth it to you, right. Like, how badly do you want to be part of space exploration; how badly do you want it? Ok, you've got to get through this. I will say this, though, you know, on a day-to-day basis, I'm not cranking out math problems like left and right. Most of my job is just asking questions and saying, like, "How do I not break this?" Like, "Ok, let's just try it anyways," right. Like, that's really my job, right. And the reason is, is because, you know, in my role, it's just to kind of poke at things and to help things come together. The foundation is really important, right. Like, does this make sense? And yeah like you use your math, right, your science, your physics and the background. But really, it's all a tool at the end of the day.

JVN [00:10:16] So how do you, so, I mean there's two things going on here and now I feel like maybe I understand why I originally was, like, talk about Mars first, because now my brain wants to go on a bajillion places because I'm just so interested. So what about *Mars*? Like, because meanwhile there is this Mars rover and I'm, like, has it, like, there's been a lot of crafts that have tried to fly to Mars and land and do things, but I read that, like, 40% have like successfully completed their mission, which is, like, I'm not living, you know, it's, like, that's, like, not you know, it doesn't make me feel, like, if I only know my hair's got a 40% chance of looking amazing, I'm, like, let me just like do it a different way. Um so, not to compare Mars and, like, science to hair, but it's what I know. So that's, you know.

CHRISTINA HERNANDEZ [00:11:05] No, I love it. That's why my hair's usually in a messy bun, to be honest, 'cause of that success rate. Um, so I guess I would say like with Mars, it's, it's, you know, rocket science, aerospace engineering, science, it's *hard* because we still don't fully understand it, right? Like, you know, you imagine, like, these dudes in glasses and, like, crisp white t-shirts and skinny ties just cranking out problems, like, NASA's not like that anymore. Like, we're still cranking out problems and, you know, trying to figure things out, but we don't know it all, right? And you know what makes Mars so amazing, it's that it's, it's next to the Earth, right, it's one of our neighbors. And it's fascinating because it's like, why, why does Earth have life and water, and you know when we look around us, it's so green and blue, but Mars is *not*. Like, like what's different about Mars? Like, did Mars not just get the memo or, like, is that just, like, billions of years of a process that's happening that led to Mars, right?

And, you know, one of the things that I always find fascinating is kind of comparing Earth and Mars in many ways, right. So, like, you think about, like, the air we breathe. Right now I'm in LA, so it's, like, 80% smog, but, like, technically, right, it's, like, nitrogen and oxygen, right. That's what gets us going, that's what plants love, animals love. And Mars is just straight up, like, basically carbon dioxide, right, like, the stuff that we exhale. And it's, like,

well, life, does that like carbon dioxide? I don't know. But that's what the, the, the atmosphere is mostly made up of. And then you think about, like, the temperature, right. So, like, Earth on average apparently is, like, 60 degrees, but again, I'm from LA, right. It's like always a nice 76 degrees Fahrenheit with an ocean breeze. Mars doesn't have that right. You know Mars is pretty cold because it's further away from the sun, it's, you know, the fourth planet in the solar system. And so it can get as warm as, like, 70 degrees Fahrenheit by its equator, right, kind of like earth, right? But it can get really freaking cold, like, negative 200-and-something degrees Fahrenheit, right.

JVN [00:13:22] On the poles?

CHRISTINA HERNANDEZ [00:13:24] Yes! So it's like, ok, like, a parka is not going to be enough, right. Like, you're going to need like a habitat in a spacesuit if you ever wanted to send humans there. And you know, even gravity is different, right. Because of just the differences in the planets and how far they are from the sun. You know, on, on Mars, gravity is a third as powerful as it is on Earth, right. So, you know, you have more bounce in your step, you're lighter, you know, it's, it's just very different and unique. It really feels like, quote unquote, like an alien planet, right. It's like, why is Mars *like* this and Earth is this way. Like, that's one of the fundamental questions we're trying to figure out.

JVN [00:14:08] Do we think that it's just 'cause it's farther from the sun or is it, like, other stuff? This is another like really, like, random question and I don't really know if you're, like, but, you know, how like the Big Bang is, like, how they like, isn't that like how they like say it all started, like getting worse, like you can use like the telescopes to look for like, like, like what like that, like the **LIGO** study thing. And you look for the like, um, so, like, would it look different from Mars? Like, would it be good for us to, like, be able to go there and like, like look out at the universe from Mars because it would give us, like, a different vantage point or something? Or, like, see Earth in a different way or or something.

CHRISTINA HERNANDEZ [00:14:48] Oooh, that's a great question, you know what, I think you should be a scientist now, because those are the questions, right, that scientists are trying to answer, right. It's like in different places in the solar system, you know, do we have different vantage points? But, the reason why we think Mars is different is because it's not just further away from the sun, but, you know, just like climate change here on Earth, right, there's processes and things that Mars has *seen* that we just haven't observed because they potentially happened a billion years ago, right?

JVN [00:15:20] Do you think we're gonna turn into Mars?

CHRISTINA HERNANDEZ [00:15:23] I hope not, right. And like that's really what we're trying to understand: by us studying the solar system, we can understand planetary evolution, right. Like, we know from evidence, from rovers and our orbiters, which are our spacecraft that kinda go around Mars, that Mars used to be habitable, like it had water, it had lakes, it had oceans. Now why is it that it doesn't have that anymore, right? And, and so we go, we send these robotic geologists, right, our rovers, to try and understand you know, where did the water go? And we found water on Mars, right, you know, our Mars Reconnaissance Orbiter, which is currently observing Mars and taking these really beautiful high def photos of the planet, you know has seen evidence that, you know, there could be briny, salty water still on Mars, not like full-blown oceans, but, you know, it's there. So the question is, is where did it go? And, you know, obviously, once you start talking about water, you start wondering, well, there's water on Earth. If there was water, like, is there life, was there ever a life? And *that* is the big question that we're still trying to answer is, was there ever life on Mars? And if so, you know, what happened to it?

JVN [00:16:47] Ah! So how long does it take for, like, a year to happen in Mars? Or on Mars?

CHRISTINA HERNANDEZ [00:16:53] Mmh. That's a great question. Yeah. So, it's all about, a year is determined by how much you have to travel around the sun. And so for an earth year, it's 365 days, right? For a Mars year, it's roughly double that. So I think it's, like, 687 days, something like that. But it's basically double.

JVN [00:17:14] So does that make their day longer or shorter? Longer?

CHRISTINA HERNANDEZ [00:17:20] Mhm. That was a good question. So the day is actually determined by Mars's rotation. So you're going to get, like, orbital mechanics 101, but that means you're going to be a rocket scientist basically after this.

JVN [00:17:33] Ok. I would, oh my god, this is, I'm stressed out, this feels like the time when I signed up for astronomy and I thought that I was going to learn about, like, Aries and Pisces, but then it was, but then it was all this math, and I was 17 and I couldn't believe it. Ok, no I can do it. So this is how, like, Earth is spinning, so Mars does that, too?

CHRISTINA HERNANDEZ [00:17:51] Yes. So the day is determined by you spinning around your own axis, right. So like you're spinning in a circle, right. That's your rotation. And that's what determines the length of your day. So on earth, right, us rotating that determines our 24 hour cycle, right. So roughly 12 and 12, right, you know, 12 hours of sunlight, 12 hours of daylight. So on Mars it's almost the same because they're kind of roughly the same size, they have roughly the same spin rate, but it's slightly different. So

it's 40 minutes longer. So, whenever we have a day on Mars, er sorry on Earth, Mars will have a 24 hour and roughly 40 minute day, right. So this will be really interesting once we get to Mars and we can talk about that, like we go on this thing called "Mars time" when we're trying to work on the same schedule as the rover, right, because we're trying to keep a close eye on it while we check it out. And we work the Martian night shift, right. So the rover does its thing during the day and at night, the Mars night, we're cranking out on Earth like all the commands we're going to tell the rover the next day or sol, which is the Martian day. And so it's really funny because every day we come into work, we change our hours by 40 minutes, right, because we're not on Earth anymore. For our intents and purposes, we're working on Mars. So we have to adjust for this.

JVN [00:19:25] So, Mars just takes 40 more minutes to do one full turn on its axis?

CHRISTINA HERNANDEZ [00:19:34] Exactly.

JVN [00:19:35] And, ok, so each hour, like, 40 minutes divided by, like, 24, so each hour just has like a couple more minutes on it?

CHRISTINA HERNANDEZ [00:19:44] Basically, if you were to compare it to an earth cycle, yeah.

JVN [00:19:48] So, ok, so basically you have been working on this mission

CHRISTINA HERNANDEZ [00:19:53] So the rover that's going to land is called Perseverance. And so that's the rover I've been working on for almost six years, which is kind of crazy.

JVN [00:20:03] That's amazing! And now how many from NASA, is this like our first, our, what, it's not our first, is it our third, second, how, what's the number,

CHRISTINA HERNANDEZ [00:20:11] Oh, my gosh, ok, so I need to count them. So you have one, two, three, four, five. So this is going to be our fifth rover if I did my math correctly, right. So we've been exploring Mars since you know forever, right. As soon as we've created telescopes here on Earth, right, we've been observing our neighboring planet because if you look out in the sky, and you could actually do this now at night, there's, it's not a 747, it's hard in LA to tell, but, like, it's just this little red orange dot in the sky; that's Mars. And so obviously as humans, right, we're like, "Wow, what's there, what's there?" And so, so, we built telescopes. Then we finally sent spacecraft to, like, go in, observe and fly by and take pictures. Then we got really sporty and we're, like, "Ok, well, let's actually land there," you know, no wheels, but like, let's touch down and see what the

soil's like and take some really good pictures. And then, you know, after a couple of, of those worked, we're like, "Alright, well, you got to put wheels on it and, like, drive around Mars and see what's up." And so the first of the rovers was Sojourner and Sojourner was part of the Pathfinder mission. And it started off as, like, basically a tech demo. We're like, let's see if this works. And honestly, it was the size of, like, an RC car, right?

JVN [00:21:25] When was this?

CHRISTINA HERNANDEZ [00:21:26] Um this was back in the late 90s, so like '97. And then after that our rovers just got bigger, right, because it's like go big or go home at that point. But it's really hard, right, and, you know, what's really awesome about Mars exploration is that actually right now Mars is the hottest club to be at, right. The United Arab Emirates just got there yesterday. China also just got there today, like, hot off the press. It's like everybody wants to explore Mars. And, we've had the European Space Agency also be a part of this effort with NASA. And on top of all of that, the science instruments that we often send, specifically on Perseverance, come from even more countries like Spain and Norway and France. So it's, like, really this beautiful, like, global effort to study Mars and try and answer each other's questions.

JVN [00:22:22] So what does this, so, I mean, even just to get into space in the first place, like what does a shuttle have to go through to even just get through like the burn and like the, like just, 'cause it's, what does it all have to do to even just get up there?

CHRISTINA HERNANDEZ [00:22:34] So, yeah, so it's, it really is usually like a six- to eight-year campaign, right. Like, starting from, like, you think of, like, paper, right. You're, like, scratching notes and trying to figure out, well what the heck are we going to do once we go over there. What do the scientists want us to do? Asking those really high level questions. And then you start to get into, like, the design, right. Like, ok, well, do we want to rove around? Do we just want to land? Do we want to orbit the planet? And, like, the design starts getting, like, fleshed out, right. And you, it's a concept, right. And over time, as you start refining that concept, then you, I guess the part that I like, right, like, you start cutting metal and trying to figure out how to put this thing together.

And so, you know, in my six years working on Perseverance, I started right after they had roughly like the, like the high level design, right. The instruments from all of our partner collaborators had just been selected and our job was to figure out, like, how do we get these instruments built? Where are they going to go on the rover in order for them to accomplish their science? And in a matter of years, that turned into having physical instruments that we can test on Earth to figure out, like, are they ready for Mars? And once you start doing that, then you slowly start building up the rover because it's not just

science instruments, which is what I worked on, but you've also got the team that's working the mobility system, building the wheels. You have the teams that are building the engineering cameras that are going to take those really cool selfies of the rover on Mars, right?

It's just, like, it's this insane amount of team effort and it's like the grueling day-by-day of testing and meetings and troubleshooting and eventually, back in end of 2018 when we were still here on Earth, obviously, and we were building up the rover, you go into the clean room--which is, like, this beautiful gallery, you can kind of see all the engineers who are building up the rover--you start to finally see her come together and it's, like, it goes from being paper to, to real hardware in a matter of, you know, several years. And, what it takes to survive space, space is, like, the nastiest environment imaginable, right. It's cold, it's hot, it's a vacuum when you're in cruise, right. It's you know, you have to survive a rocket launch, right. It's, like, you feel those when you're here on Earth and we go through so much testing and analysis, right. Going back to like, what's the math and science used for, it's used for that, right, to try and understand, you know, given where we're going, how do we design these science instruments, this rover, you know, whatever it is to survive launch, to survive the six-month journey to Mars, to survive entry, descent and landing, and on top of *all* of that, survive another Martian year of doing really cool science.

JVN [00:25:42] Wow!

CHRISTINA HERNANDEZ [00:25:46] Overload!

JVN [00:25:47] No! So when, so, oh my God. So when I think of like a space shuttle or, like, something taking off, like, I think of like that big white you know looking thing from, like, Apollo 13 when I watch the movies, you know, or like, you know, like I get it like, you know, three, two, one, we're blasting off. What does a rover look like when it's taking off to go to Mars? Is it on one of those big white things? Is it a different color, is it a different size?

CHRISTINA HERNANDEZ [00:26:15] So we definitely always decorate it, right, to, I mean, it's like we bedazzle it to be our mission, right. So we go on a rocket, right, so just like you're envisioning these rocket launches, the shuttle also kind of went on a rocket, but it was kind of like this appendage that went on it. But everything that gets to space basically has to go on a rocket. And we are cradled at the very tip of the rocket in what we call the payload fairing, and in there we have the rover. But it's not just like the rover as you see in pictures, right. It's kind of encapsulated in all of these layers because we have to take everything that's going to help us survive the journey, survive EDL, right, and help us land, and then the rover herself.

JVN [00:27:02] Entry Descent Landing, EDL?

CHRISTINA HERNANDEZ [00:27:04] Yes. Yes, I know. I'm so nervous, but it's gonna be so exciting because it's, every engineer on this project and scientists and even, like, the entire support system that we have, right, our business folks, even the people that help us with, like, facilities and testing, like, they all had one job; it's "help make this work." And so when you think about these nail-biting events like EDL or even surviving crews or launch, it's like you trust your team, right. You, you trust the, the work that everybody's done. And, yeah, you know, you're still nervous, but just cross your fingers and you know, know that you did the work to get yourself there.

JVN [00:27:48] Ok, so when I think about a space shuttle or whatever, so you're saying, like, the payload-carrying bit, like the important stuff, the rover that's got the layers, so there's like the two kind of like orange like blasters or whatever. I, in my memory I have like-

CHRISTINA HERNANDEZ [00:28:03] Ah, you're thinking about the shuttle launches.

JVN [00:28:04] Yeah!

CHRISTINA HERNANDEZ [00:28:05] Yeah. But it's kinda the same thing. So, so we can imagine, so we launch on an Atlas V rocket, right. So there are all these different types, right. And so our rocket, right, has a bunch of boosters at the bottom, and it's just, like, you know the traditional shape, right. It's long and at the very top, that's where all the important stuff goes, right. And so-

JVN [00:28:26] Ooooh.

CHRISTINA HERNANDEZ [00:28:27] -If you're doing a shuttle, you know, you have the astronauts in the shuttle. If you're you know going to the ISS, you know you have-

JVN [00:28:34] I just Googled it!

CHRISTINA HERNANDEZ [00:29:34] Yes, right! And so for us, right, we didn't have warm, squishy things, but we had a really important robot. And so that robot was at the top inside, fully encapsulated.

JVN [00:28:48] So fully encapsulated. So there's probably not glass on it because it doesn't need to see?

CHRISTINA HERNANDEZ [00:28:54] That's correct, right, yeah.

JVN [00:28:56] So, it takes off in the thing, I see the picture, ok, that makes so much more sense to me. So then, so is it, like, launch, cruise, EDL? Is that the three stages?

CHRISTINA HERNANDEZ [00:29:07] Yep, basically.

JVN [00:29:09] So you guys did your launch in July, you said, July of 2020?

CHRISTINA HERNANDEZ [00:29:14] Yes.

JVN [00:29:14] And then you said it's a six month journey.

CHRISTINA HERNANDEZ [00:29:16] Mmhm.

JVN [00:29:17] So, then, what happens in cruise? Like, you go out of the, the light blue sky, then it's, like I feel like there is one movie where you definitely go through a launch and it was like, is it, I can't remember which one, but it's, like, and then you get in outer space and it's like, "Wow, it's so pretty," like, the astronauts are, like, "Yay, we made it." And so, like, when are you as, like, an engineer, like, when is it nail-biting over from launch to, like, cruise?

CHRISTINA HERNANDEZ [00:29:39] Honestly never. But, because once it gets to cruise you're like, "Yes, we survived to launch, this is great. But now we got to take care of the rover for the next six months," right. And so we have a team who has been monitoring the rover 24/7 while it's been on its journey to Mars. And during cruise, right, after we launch, which is, like, you know, like, you're rattling the thing, right. You go and you check on her, right? You're like, "Ok, you know, science instruments, did you survive?" "Ok, you're good. Awesome." "Let's check on our heaters, let's check on all of the electronics. Like, is everybody cool? Is everybody comfortable?" And periodically, you know, we'll just do these checks. And along the way, we also are kind of adjusting our trajectory to account for the orbital mechanics that we run into on the journey. So even though it doesn't feel as intense, it's still like every time you talk to your box or the rover in space, it's, like, "Oh my God, like, please still be there. Like, are you good?" But we have engineers that are constantly monitoring the rover and have been this entire time.

JVN [00:30:51] What's the, so is there a level, to the risk? Like, is the launch riskier than cruise or is cruise even just as risky? Is it, like, is it a crescendoing risk until the very end?

CHRISTINA HERNANDEZ [00:31:03] So I think it's, you know, it comes in phases, right. And, you know, risk posture is always different.

JVN [00:31:09] Risk posture!

CHRISTINA HERNANDEZ [00:31:10] Yeah, I know. I sound like an engineer. Stop me.

JVN [00:31:13] No I love that. What does it mean? It just means, like, what the risk factor is, is that, like, the science word for risk factor?.

CHRISTINA HERNANDEZ [00:31:21] Yeah! And, and you, you have to understand that when there's always an amount of unknown, right? We know we were talking about, you know, as engineers and scientists, we, we know what we know and we also know what we don't know. And you have to have a way of accounting for that. And so we talk about, you know, risk and, and we measure risk throughout all the different phases of the mission. I would say, though, like, I equate risk to, like, nail-biting events, right. And so for me, right, EDL is, you know, the one that's really nail-biting, because like you said earlier, it's so hard, right. So many missions have not been able to make it.

And, you know, we're constantly learning and we're constantly trying to learn from mistakes or from things that could have been improved from past missions. But it's still, it's still not easy, right. Space is *really* hard. And so for me, I really think of, like, EDL, right, because you're, you're trying to land on the surface of another planet that kind of has an atmosphere, but not really. And so we have this elaborate mechanism with, like, rockets and this thing called a sky crane and a parachute. And it's like it takes all of that to land something that's literally one ton, right. It's really fricking heavy and it still needs to work, right, it's not like you can just do a crash landing.

JVN [00:32:47] So, so it's in cruise, it's approaching Mars, it's been super cold, and every time you guys are, like, checking it and it's, like, and it's, like, “Are you ok? Is everyone good?” And then, like, the system says, “Back to you,” and all those same, like, “Yeah, I'm good.” If something is, like, ker-ker, like, just not talking back, you're like, “Oh my gosh,” is there like a tool or a robot on the thing in that little capsule that can like fix it before it lands, like can the rover fix itself, like en route if something goes wrong or if something goes wrong is it like oh we’re fucked, like you know fucking land now or like, so what's the deal with that?

CHRISTINA HERNANDEZ [00:33:27] Yeah, so that's what, this is what I actually love about engineering is that you come up with the worst-case scenarios and then you design around it to protect yourself even more, as much as you can. So on the rover, right, the rover

actually has this thing called fault protection, right. So if it detects, like, "Hey, you know, my arm is kinda toasty, right, like this, I don't feel comfortable," it actually raises an alarm and it says, "Hey, I am gonna you know go into a mode where I'm safer and I'm going to let the engineers know that they need to come and check on me and do something." But that's actually what's really cool about robots, right, is that you can design them, right, so there is some sense of autonomy, right. Where, because we're not there, like, Earth, right, you know checking in like a doctor, right, you know, it, just always in constant contact with you, there has to be some self-sufficiency in order to survive these journeys.

And so, you know, while we don't have a way of, like, you know, actively fixing it with another robot, right, we have the rover protect itself so that we humans can come in and figure out, "Ok, what's going on." Is it, you know, a software update that we need to do or oh, maybe we didn't set a parameter quite correct, right. Or, you know, maybe it's something else. But it gives us time to kind of come in and assess the problem. And so that's really the beauty, right. The rovers, and *all* of our spacecraft, right, have this sense of autonomy to take care of themself and to let us know when things are not going so hot.

JVN [00:35:03] If something gets too hot, though, like, when, if the arm got too toasty, do you guys have a way of cooling it down? Like, is there like a little water spritzer on there?

CHRISTINA HERNANDEZ [00:35:11] Yeah, so the rover, because remember we were talking about Mars gets really hot, or not really hot for electronics boxes, but it's really cold in actuality and *really,* really freaking cold. It has, like, a thermal system, like a heat regulating system, if you will, right. So some parts on the rover wanna stay really warm and toasty, right. Other parts are ok being nice and cold. And so we've designed the rover to kind of help regulate the heat that we see in cruise to kind of keep things going ok, and adjusting them as needed.

JVN [00:35:46] So it's a *ton*, the rover is a ton, you said?

CHRISTINA HERNANDEZ [00:35:50] Yeah, it's really heavy.

JVN [00:35:51] So how big is it? Is it, like, as big as, like, a, how big is it? Is it, like, a room?

CHRISTINA HERNANDEZ [00:36:56] Um I compare it to, have you seen, like, the Mercedes SUVs or like you know a Land Rover? It's, like, roughly the same size of a car.

JVN [00:36:06] Fierce! Like a big ass Hummer, Landrover, like, a big old box.

CHRISTINA HERNANDEZ [00:36:11] Yeah, it's like a big car, right. I mean, when I stand next to it, like, I'm not taller than it, I'm about, like, 5'7.

JVN [00:36:20] I feel like I remember the pictures of the rovers that have, like, the conveyor belt wheels. Is it still, like, that or is it like car wheels now?

CHRISTINA HERNANDEZ [00:36:26] It's so, they're, they're not car wheels per se, but they're um, they're metallic wheels, right. So you kind of think of a bike, right. They have like almost spokes and the, it's made up of aluminum, right. And so they're, we can't do like cartwheels because if we puncture our tyre, we're kind of, kind of hosed, right. So these wheels have to be able to withstand the geology as we're kind of roving around on you know who knows what we're going to get. But, and, it also has like a suspension system, right, because like you can imagine, if you've seen *The Martian* right, it's a fantastic movie because it really helps show you the different, like, landscapes of Mars. Some you see, like, sand dunes, other times you see, like, all these rocks and you know sharp, sharp rocks too. The rover needs to be able to kind of adjust itself and you know keep itself pretty stable, right because we don't want to tip over. We don't want to, like, get into an awkward position. So our mobility system kind of helps regulate that.

JVN [00:37:32] Ok, wait, so I should have watched *The Martian* before this. I think after I saw *Gravity*, I was, like, kind of traumatized. Like I couldn't take any more space movies for a minute. So can you just tell us, like, so, I need to watch *The Martian*, obviously tonight or tomorrow. So, what are the parts of the movie that don't do a good job? You're like, "Oh, actually, the scientists like" w3ll, not to call out *The Martian* or whatever, but, like, "As a scientist, it's kind of more like less like this or like that, like just as it relates to the rover for my imagination." Does that question make sense?

CHRISTINA HERNANDEZ [00:38:01] So I'll say, yes, I'll say this, like *The Martian* did a fantastic job, right. Like, yes, there's always like, you know, if you're being, like a true geek about it, yeah, there might be some things, but yeah, we probably wouldn't do that or that's kind of sporty, right. But, you know, in reality, right, like capturing what it's like to be an engineer stuck on another planet, it's, like, even the snark and the sarcasm, we love our sarcasm, right, that's like you know what gets our day going, right. It just, it is really true to, like, what it would take to survive on Mars, right. And, you know, he grows, like, potatoes right on the planet, right. But it's kind of like, what's the thought process, what are the things you have to account for? And one of my favorite scenes, actually, which would be hilarious if you know this actually ever happened, right, is he goes and finds one of the old rovers that JPL had sent to try and communicate back to Earth, right.

And they're using, like, really basic you know, they're using hexadecimal, right, very basic forms of, you know, computer talk to try and communicate through images. And, I just thought it was hilarious because it's, like, you know, when you're out there, right, you can imagine yourself as an explorer, right. You know, the explorers that went to explore Antarctica, right, when we didn't have that much technology, right. You're really out there alone and all you have is what's in your head, right, and the tools that you happen to have with you. And so that's what I thought, like, the spirit of *The Martian* it really captured. Now, again, I told you, I'm a bookworm so, like, the book is *really*, really good. But the movie just made it so visual and awesome, so definitely recommend.

JVN [00:39:42] Ok must watch. So it's in cruise this, like, this, this thing on the rocket and then it has to adjust because, like, I mean Mars is, like, orbiting the sun *too*, right? So it's kind of, like, land on a moving target. And are we trying, or, *we*, are *you* trying to land on, like, the equator of Mars or, like, on the, like, where on Mars is it trying to land?

CHRISTINA HERNANDEZ [00:40:08] Ah, that's a great question! So, before we launch, right, we know where we're going, right. So the rover is going to explore this place called Jezero Crater. And Jezero Crater is basically home of an ancient lake and delta, right. Remember, we were talking about finding signs of past life, right. So, you'd go where you think there used to be water, right, and so that's Jezero Crater. And so scientists and engineers basically calculate using orbital mechanics, you know if we launch on *this* date at *this* time in *this* direction in February 18th, right, like, are we gonna hit that target, right. And along the way, we do these slight adjustments and, you know, even once we're actually actively in the entry, descent, and landing phase, we have technology that kind of adjusts a little bit, um but it's, it's all automated, right, and the analysis is done ahead of time so that we know we're going to hit that landing ellipse or that landing area at Jezero, which is where we wanna go.

JVN [00:41:16] And then where is that on Mars? Is it, like, in the middle of it, like?

CHRISTINA HERNANDEZ [00:41:20] I have to double check. Like, where if it's on the equator, I'm pretty sure it's around the middle of the planet because honestly, you know part of the reason is, like, we're looking for signs of past life, right. So we're trying to use all the knowledge from past rovers to figure out where we go. And most of our rovers have kind of landed, like, in the middle part, not so much the equator per se, but, like, in that central part of the planet.

JVN [00:41:46] So how long does it take once it gets all the way to Mars, does, like, a signal take or like a picture take to go from the rover back to you on Earth?

CHRISTINA HERNANDEZ [00:41:54] Ok, so this is hilarious because, you know, being here on Earth, right, and talking to robots that are next to me, it's, like, instant, right, you know. I was recently on a cruise shift, right, checking in on my instrument about a month ago, and I was literally waiting seven minutes to, like, kind of hear back, like, for the command that we sent. So it's kind of the same thing. So it takes, you know, seven minutes for a signal to go from Earth to Mars, but then it also has to come back, right, so, so-

JVN [00:42:26] Fourteen!

CHRISTINA HERNANDEZ [00:42:26] Yeah, so that light, that light time is so real, and when we talked about you know the nail-biting parts, I can tell you this, everyone who's worked on this project who's heard about this project is biting their nails at that time, right, because you're just waiting, you're just waiting for that signal to hear that we've touched down on Mars.

JVN [00:42:51] so wait tell me about your instrument? What is your instrument on the rover that you, or your thing, when you say you were checking on your instrument, what's that mean? Which one?

CHRISTINA HERNANDEZ [00:42:59] Yeah! So I've worked on three out of the seven science instruments, um-

JVN [00:43:03] Wow!

CHRISTINA HERNANDEZ [00:43:04] I know, I've been very lucky. And what was a really cool perk is that two of them were from Europe, right, so I got to go to Norway and Spain. I got to travel and hang out with, like, you know, my Spanish friends and Norwegian friends. But the instrument that I was checking on was called PIXL and so PIXL it's, it's going to sound like a lot, but it's an X-ray spectrometer. And really what that is, it's a really fancy tool that uses X-rays to figure out what the elements are on a particular sample of rock, right. And we can use instruments like PIXL to figure out, you know, was there ever signs of past life in this particular sample.

The other instrument MEDA is a weather station. And it's really funny because I was talking to the principal investigator who's, like, the lead scientist, and he told me that they came up with MEDA because in Spanish it's called *me da*, like, *me da más data*, right, so it's, like, "It gives me more," and so I thought that was kind of cute. But so MEDA is also going to help characterize, you know, the weather in the climate of Mars. It has a camera, so it's going to be able to take pictures of clouds, like, we have evidence that they're like these light wispy clouds at Mars. And it's going to help us also prepare for humans, right,

because you can imagine if you're at Mars, you want to know: "What's the temperature outside? Is there a dust storm coming? You know, what do I need to do before I go outside?"

And the third one was called RIMFAX. That one's really special too because it's a ground penetrating radar. And so what that means is as the rover's driving along, we're actually going to be able to see underneath the surface of Mars through images, right. And that was really cool because it was Norway's first time working on a Mars project. And so they got to kind of go along for the ride and contribute this really cool instrument.

JVN [00:45:05] So for the first thing that you worked out what would be in there with the X-ray spectrometer, what would be in there, that would it would dictate the, "Ok, there's probably life here at some point," like, what would be in there that would make you as a, as a scientist think that there was life in there?

CHRISTINA HERNANDEZ [00:45:21] Yeah, so we, this particular instrument isn't going to be able to say, like, "Oh, this, this is evidence of life," right. It's, what this instrument's going to help us understand is that these elements, these could have been byproducts of past microbial life, right. So on Mars, that's really what we're looking for. It's, where are, so you kind of think of, like, fossils, right? You know, the imprints that fossils leave over time and that tells us on earth here, "Oh you know this was a T-Rex," or, you know, "In the amber there's, like, this bug that we had never seen before." Well, on Mars, right, we don't really have that. But what we think, though, is that three billion years ago, when Mars could have been habitable, there were these micro, microbes and microorganisms that could have left, like, these byproducts, right.

This is going to be kind of gross, but, like, when you don't brush your teeth, right, you get like tartar buildup, you get like this film on your teeth, which is kinda gross. But for scientists, that's really cool because that is, you know, a mineral evidence that a life process formed that. And so an instrument like PIXL is going to be looking for elements like carbon, right, that might be in that sample and could say, "Ok, we find something promising here." Now--we haven't talked about this yet--the rover is going to be actually collecting samples for a future sample return mission.

So PIXL would be like, "Oh my God guys, like, look here, you need to sample this because we found something that's really cool, really unique, and our other three instrument friends on the rover are *also* seeing really cool things in their data, like, let's sample this and hopefully bring it back to Earth." And so when we bring that sample back to Earth, we're going to have the full laboratories of all around the world, right, to really help understand,

“Ok, now let's really dig into this. Like, what's interesting in the sample, is there evidence of past life in here?”

JVN [00:47:25] And then how does it come back someday, hopefully?

CHRISTINA HERNANDEZ [00:47:30] Mmh, that's a great question. So currently, NASA and the European Space Agency are working together on what we call a sample-return mission. And so what that means, it's, like, different phases and, you know, we're working together to try and figure out, “Ok, we're going to send an orbiter there, and then you got to send like a lander and, like, a small rover to collect the samples that Perseverance leaves behind.” And then you got to have, like, some type of rocket that goes up into the atmosphere and then somehow a way to get back, right. So it's, like, this multiphase mission um and that's currently in work, which is really exciting. So Perseverance is really like the first step, right. It's collecting the gold nuggets that future missions are gonna wanna collect to bring back.

JVN [00:48:19] So what are the other tools on this rover that are, like, is there any way that the tools could work together to, like, find like definitive evidence? Like what if they go up there and they find like a worm and get a pic, like, if you get a video of a worm, like, fucking crawling around then, I mean, it is what it is right? Or no?

CHRISTINA HERNANDEZ [00:48:35] So we, what we don't expect to find, you know, a warm, squishy thing in terms of life, right, you know-

JVN [00:48:42] Cold squishy?

CHRISTINA HERNANDEZ [00:48:44] Warm squishy!

JVN [00:48:45] What about a cold, squishy, like, squishy worm? What about a cold, squishy, like a cold squishy worm?

CHRISTINA HERNANDEZ [00:48:48] Cold, squishy! Yeah, so I think a lot of our scientists have said that, you know, that's probably not likely, right. What we really think is going to be more promising is using all of our seven different instruments, right. So, we also have a laser spectrometer. We have a, like, the rover has this eye and it shoots, like, this green Raman laser at rocks and zaps rocks and figures out what elements are coming out. Yeah, this thing's really beastly. And then we have, you know, an instrument that is going to help take pictures, like, really high resolution zoomed pictures of rocks and the terrain. And so, you know, when I think of you know finding that the science goal of like searching for signs of past life, it's really, you know, we're looking at the geology, we're looking at the rocks.

Because, you know, realistically, we've been exploring Mars for some time, right. And we haven't found, you know, what you think of life in so many sci-fi movies. What we really think is promising is that we're going to find it embedded in areas that used to be habitable because we know on Earth that geology preserves evidence, right. You know, you think of fossils, or even in Australia there's been a lot of work on stromatolites, which are these, like, they almost look like these weird rock formations that form from a build up of these biofilms, like the tartar that I was talking about.

And so that is actually what's probably gonna be most likely, if any. And so all of these science instruments that are on board the vehicle are basically contributing in some fashion, right. But ultimately, the, it's always about the proof, right. And that's why we're collecting samples because we know we're limited to what we can do robotically on another planet. But if we bring them back to Earth, we can have the minds of the world and the labs of the world studying these samples for years and really finding, you know, what's interesting about them.

JVN [00:50:54] Will the photo, or will the thing taking the photos be able to confirm if there's clouds or not, like, from the ground?

CHRISTINA HERNANDEZ [00:51:00] Absolutely! So we actually *know* there's clouds on Mars right, they're, like, wispy little things, right. Like you kind of think sometimes you see these really light clouds and so Mastcam-Z and MEDA--with its radiation and dust sensor--will be able to image the atmosphere because they're looking for dust particles, for dust storm predictions, and you can also take pictures of clouds and even cloud movies, which would be really cool.

JVN [00:51:26] Oh my God, I *love* that story. Ok, and how have, how have the rovers themselves evolved over their missions? Like, how have they changed from the ones that, like, I remember, I think seeing, like, in school that had the conveyor belt wheels?

CHRISTINA HERNANDEZ [00:51:42] Yeah. So we have definitely gotten a lot bigger and heavier. The other aspect is that our science instruments, like, always, like, one-up the past rover's science instruments, right. Like, we're really trying to push the limit of what science we can do autonomously from a rover. But oftentimes, right, when you bring, like, your power tools if you will, you need more energy from the rover, right. And so our rovers over time have gone from being solar-powered to powered by what we call these thermo, these, they're called RTGs: radial thermal isotope generators, which is basically, it's heat, right. We're converting heat into energy and electricity to constantly power our batteries. When you think about something that's solar-powered on a dusty planet, right. Over time,

we're not going to be getting energy right, and you're going to be really limited about what you can do. And you can't do science at night.

Perseverance can do science at night, right. PIXL is one of the instruments that's going to be taking its really cute X-ray scans of rocks for 12 hours at night, right. We have so much more capability and part of that comes from learning from our first rover, Sojourner, what it takes to operate something on another planet. So the rover's more autonomous, right. You know, it can tell itself, "Hey, I have energy to do this new thing, I'm gonna go ahead and do that," right. Like, and it's more efficient, right, because ultimately, you gotta get the most science for your buck, right. And that's what we're really pushing these rovers to do.

JVN [00:53:26] So what does that look like this time? Like, what will this be able to accomplish? Like, well, like yeah what will it, like, I mean, we've been talking about that, but like, what is it really want to be getting us back, like, every day? How long is it going to function for? Like once it lands.

CHRISTINA HERNANDEZ [00:53:41] Yep, so the rover is designed for at least one Martian year, so that's about two years. But historically, if you look at our rovers, we had the Opportunity Rover who is no longer with us and was cutely called Oppy--which is so cute--but Oppy was with us for, like, 14, 15 years. It was designed for *90* days on Mars, right. So we really think that these rovers are going to last much longer. What Perseverance brings to the table is a) now we're actively looking for signs of past life--which we talked about--we're actively collecting samples for the first time. We have not done this before, right.

JVN [00:54:19] Okay.

CHRISTINA HERNANDEZ [00:54:20] This is, this is cutting edge. We've collected samples and studied them in situ, but we've never *actually* tried to bring them back to Earth, and that's what we're prepping. But not only that, right, because I mean, we, we always try and one up ourselves. We haven't talked about our other friend that's coming along, Ingenuity, which is a fricking helicopter. So on top of sending this one tonne rover, we're also sending a *helicopte*r to Mars. I'll let that sit!

JVN [00:54:51] You buried the lead queen! How is it gonna fly? What's going to happen to it?

CHRISTINA HERNANDEZ [00:54:56] Ah oh, my gosh, so it's really exciting. So this is another tech demo, right. So we're trying to understand, can we fly on another planet? And what can a helicopter do from the perspective of either human exploration or science exploration. And so Ingenuity is basically kind of hanging out on the belly of the rover. And

once the rover lands, the helicopter is gonna be dropped off and the rover will kind of move out of the way. And then the helicopter is gonna demonstrate a few test flights. So it's going to fly up, it's going to fly down, it's going to go in circles, it's going to take images. Like, we're really trying to just test out the technology. What can this helicopter do and is it possible to even make it bigger in the future, right. So flying technology is a new thing that we're bringing to the table.

JVN [00:55:47] How big will it be? The helicopter.

CHRISTINA HERNANDEZ [00:55:50] So the helicopter is, you know, roughly, like, the body, like, it kind of looks, like, a mosquito to me, a cute mosquito, I guess, right. So it's like, you know, it's about this big. So maybe about five inches, right, in terms of the body, the cube. But the wings are you know at least maybe two to three feet long, right. Because if you think about it, Mars doesn't have an atmosphere like Earth, right. So in order to create lift, you have to spin really, really fast and you have to have a large, large wingspan. And so that's really what the helicopter is. It's mostly wing and a little bit body so that we can make sure to try and be successful when we try and lift this thing off on Mars.

JVN [00:56:33] So what's your world going to look like once it lands? Because, so you can't really communicate with the rover in real time because it takes 14 minutes. So you were saying, like, you'll be programming, like, your things, 'cause you, will you be having to talk to all three instruments for these whole two years? Like every night?

CHRISTINA HERNANDEZ [00:56:52] So I might actually be focused on PIXL and will also at the same time be learning about the other instruments so we can help our colleagues. So one of the things that um it really comes down to is we have to be well rested so we can make good decisions, but we have to be well rested on Mars time. So we were talking about this earlier, right. We, we work on the Martian night shift and every day on Earth I'm shifting my schedule 40 minutes every day. So eventually, while everybody is, you know, having fun in the sun, like, I'm gonna be sleeping and while everybody's sleeping, I'm going to be driving around LA either eating tacos or, you know, working on shift. And so the reason for that is because we want to be able to send the rover commands overnight so that she can be ready for our next agenda and itinerary on the next day. And so I will be part of the operations team instrument operations, where I'll get to check in on all of the instruments um and at the same time helping PIXL and the team there learn about their instrument, get ready to, to do science on Mars once we fully checked it out.

JVN [00:58:04] So what's, like, security, like, how do you tell the rover what to do? Is it kinda, like, very, like, gorgeous secure networks like other, like, you know 'cause like, like, how does it work? How do you tell it what to do?

CHRISTINA HERNANDEZ [00:58:16] Yeah, so it's definitely really secure, right. So we have all these ground data systems, these tools, right, that allow us to write up commands, right. So we'll say, you know, "PIXL, power on." "PIXL, do science." "PIXL, get data." "Ok, now PIXL go to sleep for the night," right. And all the systems have that; the rover has that, the other instruments, the cameras. And so we send these lists of instructions and that gets sent through ones and zeros, right, through these waves, right from the Deep Space Network which are these huge antennas that are on Earth and they go all the way to the rover and the rover listens for those instructions and they'll say, "Ok, I got them. I know what to do when I wake up in the morning."

JVN [00:59:03] Wow! And then so do you have to, but would you know if it missed one in real time because it takes 14 minutes to get to you?

CHRISTINA HERNANDEZ [00:59:13] Yeah, so that's a great question. So remember we talked about the rover has to be able to take care of itself, right. So if something happens, say we sent a bad command or say the command didn't work because of something else that was happening on board that we didn't know at the time, the rover would say, "Uh something's wrong, ok, PIXL is not doing what I expected." It's telling me that it's not feeling well. Ok, PIXL is gonna get powered off. I'm gonna make sure that she's safe. And then the next time you talk to me, Earth, I'm gonna give you all this information so that you can figure out what's wrong with PIXL and you know help her get better on the next sol, alright. So the rover is constantly monitoring its instructions, right. It's constantly monitoring the instruments and it's checking in on it. And when something is not expected, it says, ok, we're gonna stop, we're gonna get some data and then we're going to let Earth know so that Earth can go in and react accordingly.

And so when we come in on our next shift, once the rover's gone to sleep, we'll say, ah ok, these three things happened, ok, and we got all this cool science data, but let's figure out you know how to fix these three things and, so we can keep going, right. So it's really this game of, you know, in baby steps rolling out the rover. We're not going to land and just, like go, right. We land and we stop. We figure out what state the vehicle's in. Where did it land? You know, is everything working as expected? And we slowly start checking things out. And so for the first few sols on Mars, that's all it is; we're doing our health checks. We're saying, "Ok, we've survived launch. Did you guys survive landing? Ok, alright. PIXL's good, MEDA's good, RIMFAX is good, the wheels are good," right? We're just going through this checklist of things and about after, like, two months on Mars, then we start doing the science, then we start you know checking out the helicopter and hopefully doing some really cool flying on Mars. But it's all baby steps, right, because we want to be really careful.

JVN [01:01:23] So we land February 18th, everything hopefully goes well. How long until, like, we know that everything was ok after February 18th, like, a couple days?

CHRISTINA HERNANDEZ [01:01:33] So once we land, right, we're gonna get confirmation. So we're, you can follow along landing coverage, right. We're actually having it in Spanish for the first time as well, which is really cool. And so you'll hear when the engineers say, "Alright, touchdown on Mars." So we will all know you know if we touched down. After that then the engineers, who are working on, like, the first day's activities, which we call "sol zero," will go in and start looking at the data in the images that the rover took. And so, you know, I'm sure there's going to be updates every single day, right. Like, "Ok, we've checked this out. This is good to go. Here's a, here's one of our first images from Mars," right. We, we tend to do that, right, because everybody wants a really cool picture. So I would imagine that that image should come down in the first few days. So I'm looking forward to that.

JVN [01:02:29] Oh my gosh, I am too. That's amazing. So what, you mentioned earlier that there's, like it's the hottest club right now, so what are the other people trying to do at Mars? Like, are they also trying to get, like, some gorgeous samples to send back? Like, do, do we tell everybody what everyone's doing or are we, like, "Mmh we're doing our thing, but like, you have fun over there, like, like on that other delta and then let us know." And like, like, how's that part work?

CHRISTINA HERNANDEZ [01:02:52] Yeah, so I will say this: when it comes to like space exploration and science, it's always about the science. It's never about borders, it's never about you know nationalism. It, I mean, there's a sense of, like, pride, right, like, your country helped design this and now it's another planet. But *really* it's for the science, right. That's why we do this. And so a lot of teams learn from each other, you know scientists and engineers are always writing papers, lessons learned about things they could have done better. And everybody's growing together.

The countries that have just gotten there--so I mentioned the United Arab Emirates, the first Arab country to actually go to Mars--and so they're now orbiting the red planet and they're going to be studying the atmosphere, um, and that's called the Hope Mission. And so China also just inserted into orbit *today*. So they just got there. And I believe they have a probe that they're gonna release sometime in May. And so it's really cool because, like, you see everybody's steps towards becoming a multi-planetary species, right. It's kind of, like, for a sci-fi geek like me, it's like, it's happening, right. We're all trying to figure out these fundamental questions and it starts with Mars.

JVN [01:04:11] How long do you think until a person could feasibly get there?

CHRISTINA HERNANDEZ [01:04:17] Oh my gosh, I can't wait. I would say, you know, everybody's saying, like, mid 30s, you know early 40s. So we still have some time, right. You know one of the things that's really exciting is, like, now you're starting to see all these astronaut missions to the ISS, right. And, you know, especially with the Artemis program, right. Because we're trying to, you know, dust ourselves off, right. You know, like, we're trying to now get ready to do that next endeavor of going to another planet, not *just* the moon, right. And so training, and making sure we're prepared, our astronauts come home safe, you know, the science that we do on, on Mars, understanding the climate, understanding how dusty it is or the radiation environment of Mars, that's all gonna benefit the human exploration program whenever we finally do send astronauts to Mars.

JVN [01:05:08] Okay, that's really exciting. So, so the wheels are kinda like spokey deals and so that they can, like, get through rocks; how else does the rover look different?

CHRISTINA HERNANDEZ [01:05:21] Yeah so, I would say, so it has the instruments. The ro-, so we still have like the robotic arm, right, which actually functions like your hand, right. So you can imagine if you're ever wondering how the arm moves, just kind of, like, flex your bicep, turn your wrist, you grab a tool, right; it's the same concept. What's different about the robotic arm is that we have these two instruments, SHERLOC and PIXL, along with the sample caching part, which is like the sample return aspect, but it's roughly the same size, it's roughly the same weight. We have over like, like 27, 30 cameras on the rover, right. Like, we really like our selfies, we like, you know, taking images, because at the end of the day, like you mentioned, right, if you take a photo of something, a really cool rock or cloud, like, that's, that means so much more, right, because it's context; it gives you an understanding of like what's happening.

The other things that are really cool--and this is kind of maybe more on the instrument side--but the Spanish instrument, you know, the Spaniards have been to Mars, you know, several times before, right. They are our go-to like weather station people. And on Perseverance, they have this really cool wind sensor, it's called La Navaja, which means switchblade in Spanish because it basically like, boom, it, like, deploys out, right. And it's going to be able to take these really cutting-edge, accurate measurements of the winds on Mars, right. So a lot of the upgrades, if you will, are either in software land, right, like making the instr-, the rover more robotic, more autonomous, being able to be more efficient. And also with the science instruments, the helicopter. Oh, my God, I can't believe I forgot one of the instruments: MOXIE. So this will be important when you, when you watch *The Martian*, but MOXIE is going to be able to breathe in that carbon dioxide in the atmosphere that we talked about and convert it into oxygen.

JVN [01:07:25] Ahhh!

CHRISTINA HERNANDEZ [01:07:26] We've never done that before. And that's really cool because a) that's air to breathe, right, but it's also fuel, right. You can use oxygen um either as fuel for a rocket to leave Mars or, you know, fuel for, like, a human habitat on Mars. So that's another tech demo that's going to be helping towards the human exploration effort.

JVN [01:07:50] So is Mars just like all carbon dioxide, or does it have, like, something else too?

CHRISTINA HERNANDEZ [01:07:55] It probably does. Like, you know, I, I from, from an engineering perspective, I see it as mostly carbon dioxide, a little bit of water vapor. But you know oftentimes there's trace elements of other stuff, just kind of like the Earth atmosphere.

JVN [01:08:10] And in orbital mechanics--I think I get excited about it and then I like interrupted you earlier--what is orbital mechanics again? So that's just, like, how it spins, but like, how is Mars' orbital mechanics different than like ours? Does it have, like, a tilt or something? Like, is it pretty much the exact same?

CHRISTINA HERNANDEZ [01:08:27] Ok, so orbital mechanics is how stuff *moves* in space, right. So if you were to send you know--my cats are named Goose and Maverick 'cause I love Top Gun--like, if I was to send Goose and Maverick on a journey to space, right, I would use orbital mechanics to guide them and to understand how they're moving about. So *anything*, as soon as you launch it, it has to abide by the rules of orbital mechanics. And so orbital mechanics is also dictated by the size of a planet, the tilt of the planet.

And so in general, Earth and Mars are, are all kind of on the same plane, the ecliptic plane as the sun, right. So they're kind of level, if you will, for the most part. They all spin at different rates--like we talked about, because they have a slightly different day--and Mars has to travel further around the sun than the Earth, right. And so there's little differences like that. I also think the tilt of Mars is slightly different. Like, the Earth has a tilt; Mars also has a tilt. The radiation environment is different. The atmosphere is different. And so there's all these small, little contributing factors as to what makes Mars so different than Earth.

JVN [01:09:39] So on the 17th, as the rover starts to approach Mars, like, it is, like, coming in *hot*, like it is like, which I guess would really be like today in this podcast land, but, like, what is it going to go through? Like, it's going to get super hot, like will the layers come

off, like is there going to be a door that comes down and like rover's, like, "I'm *here*!" and, like, wheels out? Like, what's going to happen when it arrives? Like, on the landing and the descent.

CHRISTINA HERNANDEZ [01:10:07] Yeah. As soon as we touch the atmosphere, you know we're in our, so we're in our cruise stage, right, it's our little cocoon, right, and the cruise stage is gonna, has the heat shield that's going to help keep us cool as we're penetrating the atmosphere of Mars because it gets *really* hot. Even though there's not much of an atmosphere, all the friction, right, of the air, the carbon dioxide, all that moving past the heat shield gets really hot and we need to protect what's inside, which is the rover. At some point in that process, the back shell, which is kind of like the cover of the heat shield, it pops off. And that was--we're still flying, though, we're flying really, really freaking fast--then the, the parachute pops up and the parachute, it's huge and it helps slow us down.

But remember the rover's only one ton, right. Like, it's *heavy,* and so a little parachute--little in quotes, right--isn't going to be enough to make sure that you have a soft landing so that parachutes doing its thing, it's not enough, then all of a sudden the heat shield will pop off, right, because we've slowed down enough where we're not heating too much, and what's inside the cocoon now is called the descent stage. And so that descent stage is home of what we call the infamous sky crane maneuver, right. So if you Google, you know, Perseverance EDL, you're gonna get a photo of the descent stage with, like, some cables and the rover kind of like hanging off, right. I don't know if you've seen those, but that starts to happen right where, the descent stage has rockets, right, it'll use rockets to kind of slow us down a little bit.

And once we get pretty close to the surface, we still have to slow down. And so the descent stage will just drop the rover, drops the rover, but we're hanging on these cables, right. So the, so now we're kind of, like, attached. But remember, the descent stage is powered by rocket, so it's kind of, like, going like this. And so we need to be able to drop the rover, and now we've slowed down enough. So this thing basically cuts the cord, the descent stage goes flying, like crashes somewhere far away, and we're left with the rover wheels down on the surface of Mars. But it's like the most, like, crazy yet well orchestrated thing that I feel humans have ever designed.

JVN [01:12:37] So where do you test this? Do you test, like, in smaller scales, like, or do you do it out in, like, the desert with, like, a real one just once when nobody's looking, like, how does that how does the testing and preparation work?

CHRISTINA HERNANDEZ [01:12:49] That's honestly one of the things that has fascinated me the most about what our EDL team, right, the folks who actually work on entry, descent

and landing do, right. Because, you can't really test that on Earth, right, you have to test it in segments. And so I know a couple of folks on the EDL team, like, they went to NASA Ames to do a bunch of parachute testing in this big wind tunnel. You know, we'll test the, the rockets in labs at JPL just to, like, make sure they turn on. We can deploy the mechanism like the sky crane mechanism to make sure that works. But from like an end-to-end perspective, you *can't*, right. And that's kind of where we were talking about what does an engineer do at JPL, we ask a lot of questions. Those are the questions we start to think about, like, wait a minute, ok, so we can't do this on Earth, what are the things we should be worried about? You know, is there any analysis we can do to kind of help bridge the gaps? And that's in my opinion, what makes EDL so *freaking* hard is that you, it's not easy to just, hey, we're going to go out to the desert on a Saturday night and test this out, right. Like part of it is you know analysis, engineering judgment, and you know there *is* luck involved, right; that's what makes it so nail-biting.

JVN [01:14:13] Ah, ok, I'm obsessed with that. I am *so* excited for, to see how this happens and I really want to, there's also this, like, really cool feature that I was learning about that, like, we're going to be able to hear what things sound like in space?! What's that about?

CHRISTINA HERNANDEZ [01:14:30] Yes, we are sending two microphones, right, so we're sending one microphone to listen to EDL, right. So as this, like, you know, violent thing of entry, descent and landing is happening, we're going to be able to listen to all of the noises that the rover's going through, right. And then once we land the SuperCam team, which is an instrument that's built in France, is, has also brought with it a microphone. And so that microphone, you'll be able to hear the wheels as they go over really rough rocks or as SuperCam zaps rocks with its lasers, it'll also be able to listen to those laser zaps. So it's really cool, right?

JVN [01:15:12] And that's never been done before? Has that ever been done before?

CHRISTINA HERNANDEZ [01:15:16] Nope.

JVN [01:15:18] Wow. ok, I can't wait to listen to that. And then kind of back to where we started, it's like, well I have one more question. What is the biggest misconceptions that people have about working in, and you mentioned at the beginning, like, a bunch of people, like, white dudes in, like, white button-up shirts, you know, being like, "Oh, Houston, we've got a problem." But what are the biggest misconceptions about working in this field now that you wish people knew?

CHRISTINA HERNANDEZ [01:15:45] We're actually fun people. Like, you know, part of the reason, right, and I actually went through this myself, right. You know, when you say you're

going to study engineering and be a scientist, right, you feel you have to fit in this box, right. Like, you have to, you know, as a, as a woman, right, I was, in college I, like, didn't do my makeup, I didn't have fun hair color, didn't do my nails, I wore baggy clothes. I still wear baggy clothes. But, like, it's just like I wanted to just not be seen and I wanted to just get the job done. One of the things that I *really* appreciated after coming to NASA and meeting, like, all these amazing advocates and women and you know people from different communities, it's like, it's totally ok to authentically be yourself, right.

And so at the end of the day, what matters is just what's in your brain, right, and being a good person and being a good team member. And, you know, that's what I really see as NASA, right. It's folks who come from all different walks of life, from the city, from you know rural towns, from different countries, you know, look different, just have different experiences. But they *all* are space geeks, right. Like, you know, and that's what I love, right. It's that for the first time, I feel I can authentically be myself, yet still be a really cool engineer and be really good at my job.

JVN [01:17:15] So I feel never more excited for like a space moment ever. I cannot wait to see how this goes. I want to follow along. Where can people follow along to see how this goes? You were mentioning earlier.

CHRISTINA HERNANDEZ [01:17:28] Yes, um so you can definitely watch all the landing coverage if you follow @NASA and @NASA_es for the Spanish coverage. But, you know, YouTube, Facebook, Twitter, if you just Google, like, "Perseverance landing," right. We're going to have a bunch of events also leading up to the landing coverage and, you know, on Twitter, space Twitter, as I call it, you know, you have a bunch of engineers and scientists we'll have a bunch of, like, insights into what it's like to work at JPL, what it's like to work in the mission leading up to the landing coverage so you can meet you know all these quirky engineers and scientists who have been a part of the mission. And then on landing day, starting at 11:00 a.m. Pacific, we are going to have, you know, full coverage, right. You'll be able to listen to the voice of EDL as she narrates the event, and we hopefully you know see a successful touchdown.

JVN [01:18:24] Ahhhh, so excited! Now, it's, I, I do this like silly like little metaphor that I do at the end of my podcast, where it's like Yogi or Yogini recess--I need to learn, like, the Sanskrit word for non-binary--but like it's that part in yoga where, like, you know, you really wanted to learn something, but then they just really didn't focus on like inversions or like, you know, Ardha Chandrasana, or whatever you're really trying to learn that day. So what would we just be remiss if I didn't ask about or we didn't get to about Perseverance and the rover or *you* or any other thing that you're passionate about around this subject that you would like to share.

CHRISTINA HERNANDEZ [01:19:02] I would say, you know, oftentimes I get questions of, you know, "What does it take to work at NASA?" You know, if I want to be an engineer or scientist and I don't know how, you know how do I get there? And I think one of the biggest things that I've learned is that you take up space, you know, you belong, and at the same time as you're taking up space and doing your thing and being your rockstar self, you know, make space for others as well and create this inclusive environment. Because ultimately, the reason why we can do these really cutting edge things at NASA and across the world in the aerospace community is because there are engineers who want to bring the best and the brightest to the table, whatever that means, and, and listen and to hear the ideas of others. And so, you know, if you're interested in this, like, jump in you know feet first, like, just go for it. And again, like I was talking about, you know, be yourself authentically, because that passion, that's what it's gonna take to get you through the tough moments that you know we were just talking about on this podcast.

JVN [01:20:12] And then my *last* question: what *is* your dream mission of all time?

CHRISTINA HERNANDEZ [01:20:18] Oh my gosh, ok, I would say either, you know, designing a mission that helps us go into, like, interstellar space--I just watched *Interstellar* and I thought that was really cool--or helping design a mission that would help with climate change, right? You know, a lot of the times when people think of NASA, they think of this far out exploration of the universe and the solar system. But we *also* really care about the earth, right. You know, in grad school I worked on um orbital debris or space junk, and I would love to help clean up outer space. And I'd love to help, you know, figure out solutions for climate change on one of our next Earth missions.

JVN [01:21:03] Ah, I love it. Would you ever go to space?

CHRISTINA HERNANDEZ [01:21:06] Hell, yes.

JVN [01:21:08] Oh, my gosh, ok, I'm obsessed with you. I'm obsessed with this podcast. Christina Hernandez. Thank you so much for your time. Thanks for coming on. And just thank you for everything that you do. And thanks for coming on *Getting Curious*.

You've been listening to *Getting Curious* with me, Jonathan Van Ness. My guest this week was NASA aerospace engineer Christina Hernandez.

You'll find links to her work and more information on the Mars Rover landing in the episode description of whatever you're listening to the show on.

Our theme music is “Freak” by Quiñ - thank you so much to her for letting us use it. If you enjoyed our show, introduce a friend - show them how to subscribe.

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