

Selenology with Raquel Nuno

Ologies Podcast

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Oh heeeeyyy, it's that friend from high school who calls shotgun, and then leans over you to scream their order into the drive thru, Alie Ward. Back with another episode of *Ologies*. Oh man! This topic is one that is close to my heart and our planet, and full disclosure: I knew very little about any of this before this interview, so I may have asked the most stupidest questions of any episode to date, which is exciting! That's exciting. So get ready to get cozy with... the Moon! Our li'l buddy floating out there. What is its deal?

But first, my buddies, thank you for supporting on [Patreon.com/Ologies](https://www.patreon.com/Ologies). A dollar a month gets you in. Thank you for getting merch at [OlogiesMerch.com](https://www.ologiesmerch.com), and thank you for rating, and subscribing and reviewing *Ologies* on iTunes. Y'all know I creep your reviews. You know I do it! This week thank AceLee04 who says that they wish I lived next door:

... so you could drink wine while baking lopsided Chupacabra-shaped cookies while singing at the top of your lungs and looking through telescopes waiting for the sun to come up, so you could go explore the backyard with magnifiers and microscopes, in between REM-filled naps in Brazilian hammocks.

That life, it sounds like a good one, AceLee! I would like to sign up. Thank you.

Okay, onward and upward...to the Moon! The word selenology, it comes from the Greek *selen*, for moon. And someone who studies the Moon's movements, or composition, or formation is a selenologist. It's a real word! I mean yes, sure, sure, they can be geologists and astrophysicists too. There are many different names. Selenology, it's a thing, it's cool! And while the term peaked in the late 1960s due to all the Apollo hullabaloo, we're bringing it back right now, Ologites! This selenologist studies both Mars and the Moon. She is a wonder.

I am very lucky to have this gaggle of friends known as the Nerd Brigade, and I was introduced to her at a barbeque through Derek Muller, a.k.a. Veritasium on YouTube. Upon meeting her, all of us were like, "This person rules! We love her! She's permanent." She's currently getting her Ph.D. while also doing science communication. She's done research and production with Veritasium, she's written for NASA's Lunar Reconnaissance Orbiter Camera, a.k.a. LROC blog, and all around, she's just an earthling I'm very proud to know. She came over on a Sunday afternoon, she was wearing NASA sneakers, and we chatted on my couch. I am now so much more informed about the Moon! So get ready to marvel at the glow of selenologist, Raquel Nuno.

Raquel Nuno: Any tips on microphone use? Just talk straight into it?

Alie Ward: Yep! Just let me adjust your levels a little bit more. Okay, cool.

Raquel: Raquel, Raquel, Raquel...

Alie: Okay good. What exactly would you say... When you introduce someone and say what you do, what do you tell them?

Raquel: I tell them that I'm planetary geologist. That's just what I say. And people usually have no idea what that means. They're like, "I know geology, I don't know planetary, what does that even mean?" So then I say that I'm a space geologist! I study rocks on other planets! That's what I tell them.

Alie: And then they lose their mind?

Raquel: And they're like, "What, whaaat??" Yes, yes, that's what I do! *[audio clip DJ airhorns to the tune of X-Files theme]*

Alie: What does a space geologist necessarily do?

Raquel: I say that I'm actually an armchair geologist. I sit on a chair and do geology. *[laughs]*

Alie: *[laughing]* You're a reclining geologist.

Raquel: I'm a reclining geologist. We have samples from rocks on other worlds, but most of the time we don't. I essentially use base graph data to analyze either images, I also do a lot of programming, a lot of computational modeling of what's happening, surface processes that are happening in other worlds.

Alie: So you are crunching numbers and data to try to figure out what is happening with the rocks on other planets.

Raquel: That's right. That's what I do. *[laughs]*

Alie: That's crazy! All of the planets, or just a few of the planets?

Raquel: Just a few of the planets. My two babies are the Moon and Mars.

Aside: Raquel got her bachelor's in geophysics and space physics. She got a master's in geology, and she's now completing her Ph.D. in geology and planetary science! This is all at UCLA. The first day that I met her, Raquel mentioned that she studies rocks and she's always liked rocks. And I was like, Raquel, huh? Rock-el, ya, huh? How about that? She said that she'd never really connected that she has the word "rock" in her name! And this discovery, as you can imagine, thrilled your ole Dad Ward here to the point of giddiness. I was so much more excited about it than I think she was, but that's ok. Anyway, she studies Mars rocks as well, but...

Raquel: The Moon is my passion project. I love the Moon! It's just one of the coolest planetary bodies ever! And it's so close! You see it every day. It's just so tangible to me and to a lot of people.

Alie: We do a lot of staring up at it.

Raquel: Yes we do.

Alie: A lot of mooning toward the Moon! *[laughs]* I remember... Someone was telling me once, Isaac Mizrahi the fashion designer was on a podcast, and he got caught up in like, “Is the Moon a planet? Is the Moon a planet?” and he had one of those moments where he just didn’t remember.

Aside: Ok, so I looked this up because if I don’t share it, I will regret it to my grave. This was actually live on QVC, with host Shawn Killinger. She’s holding up a blousy, amorphously-patterned, turquoise and key lime top. It’s perfect for a ladies lunch in Boca Raton. She’s with fashion designer Isaac Mizrahi, who is not known for his humility. Anyway, I’m playing you a portion of this because I applaud QVC for being a safe space to chat space science. Also just a side note folks, do not feel ashamed to not know things because nobody knows everything, and you don’t learn unless you ponder something openly while selling a blouse on QVC! *[Audio clip from QVC broadcast]*

Isaac Mizrahi: I love that color. That’s such a happy, beautiful, rich experience.

Shawn Killinger: It almost kind of looks like what the Earth looks when you’re a bazillion miles away from the planet Moon. The planet Moon, from the Moon, looking back at the Earth.

Isaac Mizrahi: Yes! Yes, I just squinted at it. From the planet Moon, the planet Moon.

Shawn Killinger: Isn’t the Moon a star?

Isaac Mizrahi: No, the Moon is a planet, darling.

Shawn Killinger: The Sun is a star. Is the Moon really a planet?

Isaac Mizrahi: The Moon is a planet, honey!

Shawn Killinger: Don’t look at me like that. The Sun is a star!

Isaac Mizrahi: It’s a planet!

Shawn Killinger: Is the Sun not a star?

Isaac Mizrahi: I don’t know what the Sun is. We don’t know what the Sun is.

Shawn Killinger: The Sun is a star isn’t it?

Both simultaneously: The sun is a star.

Shawn Killinger: The Moon is not a planet. I knew it!!

Isaac Mizrahi: The Moon is a planet!!

Shawn Killinger: I knew it!!

Isaac Mizrahi: Excuse me?? No!

Shawn Killinger: You were trying to take me down that road. The Moon is not a planet.

Isaac Mizrahi: Excuse me, Chunky? If you're listening to me you have to Google the Moon, okay?

Shawn Killinger: This is Rosebud. Someone... I can guarantee you, someone's Googling right now, because I knew it was not a planet.

Isaac Mizrahi: The Moon is such a planet. I can't even stand it.

Shawn Killinger: The Moon is not a planet!!

Isaac Mizrahi: What else is it if it's not a planet?

Shawn Killinger: It is not! I believe it's a star, or it's something. It is not a...

Isaac Mizrahi: It's a moon.

Alie: Do a lot of people tend to think the Moon is a planet?

Raquel: If you'd ask a planetary scientist, they would say yeah, it's a planet, because it acts like a planet, it behaves like a planet, but it's just orbiting the Earth versus orbiting the sun. So in the true definition of what a planet is, it's not a planet. Though I'd have to say 'planetary body' because it is not technically a planet.

Alie: So it's a planet if it's orbiting the sun.

Raquel: That's right.

Alie: I'm gonna ask, just, stupid-ass questions. I have no shame. How do you guys determine what's a planet, what's an exoplanet, what's a planetary body? A planetary body is not orbiting a sun, but it could be orbiting another planet?

Raquel: Well, a planetary body can be a planet as well.

Alie: Ooo! Okay.

Raquel: So the Earth is a planetary body. So are asteroids. Asteroids are planetary bodies because they're orbiting... they're in our solar system, so they're a planetary body.

Alie: I feel like it's kind of like not all succulents are cacti, but all cacti are succulents?

Raquel: Yeah, yeah, yeah, something like that. You have to be a planet if you... you have to be round. You have to have enough gravity to have formed a round-shaped object. There's a lot of asteroids that look like potatoes, or look like weird dumb bell things, and those could never be planets because they're not shaped like a planet is. You have to have enough mass that you create enough gravity to round out your shape. You also have to have cleared your orbit, and what that means is that there's no debris in front of or behind you. You have collected all of the matter that's in your path to form yourself, to form the planetary body.

Alie: I don't think I've ever realized that we're kind of like a Swiffer. That's part of where we get all of our stuff to make things, is just by picking it up as we go?

Raquel: Yeah! It's actually interesting. Earth acquires a lot of mass just by traveling through space. And when you see meteor showers, that's us traveling through a trail of rocks, of stuff that then encounters our atmosphere, or that we encounter it, and then they come crashing, and a beautiful light shows in the sky.

Alie: That's so exciting!!

Aside: What voice was that? I'm sorry. I just could not contain myself here, thinking about meteor showers, and I sound like I've just found a kitten in my pocket for most of this episode. Anyway...

Alie: Have we always had the Moon?

Raquel: Essentially, the Moon formed very, very soon after the Earth did. When you're thinking of geologic time, yes, the Moon has always been here with us.

Alie: And why did you grow up loving the Moon so much?

Raquel: 'Cuz you see it! You see it. It changes every day. It's either a little bit brighter or a little bit darker. As a kid, you would hear songs about the Moon or read, like, *The Little Prince*. I love *The Little Prince*! Who hasn't been impacted by *The Little Prince*? I mean I was for sure.

Alie: Right. No pun on the impact crater.

Aside: *The Little Prince* is a novella, and it was written by this French writer, poet, and aviator whose name I can't pronounce in French, so I'm gonna sabotage it and try pronouncing with a Texas accent [*in exaggerated southern accent*] Antoine de Saint-Exupéry. [*back to normal voice*] Now the book was published in 1943. It's about a prince who lived on a tiny asteroid. Anyway, it's this pensive, moody, wonderful French tale about exploration and also love, and it contains gems like, "All the stars are a riot of flowers." And it involves a rose, and a fox, and a prince, and the geological composition in orbit of small planetary bodies. So yes, this book about an asteroid made an impact.

Alie: Let's talk a little bit about where you grew up. Where you grew up, was there a lot of light pollution? Were you able to see stars, and moons, and planets when you grew up?

Raquel: I actually grew up in Portugal, in Lisbon, so I did live in the city. But my birthday is August 11, and around that time there's a meteor shower that peaks on the 12th. So for my birthday every night we would go, me and my family and my friends, we would go out to the beach to watch the meteor showers. That was a thing every year we would go and do. Yes, there was pollution but at the same time there was this event around my birthday that we would go and see, so looking at space was always something that was special and fascinating.

Alie: Oh my god, it was like free fireworks!

Raquel: It was free fireworks, just for me! [*fireworks booming*]

Alie: When did you decide to start studying the Moon and studying planetary geology?

Raquel: Oh man, it's been a very, very windy road. That wasn't always the plan. I actually had an internship at JPL when I was a community college student, but I was studying electrical engineering. I was not gonna do planetary science. I wasn't going to be doing science at all because I wasn't that that was a practical thing. I actually didn't even know, really, what a scientist... I had no idea. My parents were artists, they were not scientists. I hadn't really been exposed to what a scientist does, so I'm like, "Okay, I like science, I like math, what's a practical thing that I can do? An engineer, of course, I'm going to go be an engineer!"

I got an internship at JPL to do engineering-type things, but my advisor there, the project wasn't set up yet so he's like, "Well, I have this data for you to analyze. Would you rather do that instead?" So I said yes. I was actually using magnetometer data, looking at the magnetic fields of Jupiter. That's what I started doing.

Alie: As one does. This was your busy work?? This magnetometer data from Jupiter?

Raquel: [*laughing*] Yes, yes. He was like, "While we figure out the project you do this." But it really opened up this whole field that I didn't know existed. I had no idea that planetary science existed. I knew about astronomy. I knew that there were people that would study the stars and the planets, and I always just thought those were astronomers. Working at JPL, that's the Jet Propulsion Laboratory here in California, in Pasadena, where they build a lot of these rovers and space craft that go study other planets, that's where I discovered, whoa! there's this whole field out there that is just dedicated to study our solar system, our world, and the worlds near us, and just opened up this whole world that I didn't even know existed about science.

So when I transferred to UCLA for my undergrad as an electrical engineering major, I ended up switching. I switched to geophysics and space physics because now I knew there was something I could study. I could study the planets, and I could help send spacecraft to other worlds, and I wanted to be part of that, I wanted to be part of that

world. [clip of song from *The Little Mermaid*: "I'm wandering free, wish I could be, part of that worrrrd."]]

Alie: Take me back a little bit too, because I understand you were in the military.

Raquel: I was, yes.

Alie: So before you got to community college, even, what was your process?

Raquel: I was 17 when I graduated high school and I joined the US Air Force right after graduation.

Alie: When did you move from Lisbon to the US?

Raquel: I was 11 years old, so I moved the United States when I was 11. The reason I joined the military was my father had terminal cancer, he was dying, and because we weren't US citizens at that time, and he couldn't work so he didn't have healthcare. You couldn't get Medicaid or Medicare because we weren't citizens. He was without healthcare. And just so he could be comfortable, pain medicine and anti-anxiety medicine that you need when you're going through the dying process was costing, I think it was \$1100 every 10 days. And we couldn't afford it, there was nothing we could do, and I'm an only child, I had to do something. I was 17, what could I do? I figured the military would be a good way to be able to provide for my family, and that's why I joined the military.

Alie: Oh, I'm gonna cry!

Raquel: No, don't cry! And honestly, I think that that's the thing that I'm the most proud of in my life is to be able to... [laughs] no, no, no!

Alie: [high pitched voice] That's so amazing!

Raquel: You're gonna make me cry too, but it's the thing that I'm most proud of that I think I've ever done because I was able to be there for him both financially and emotionally. The Air Force was great about helping us. I worked the night shift so that during the day I could take him to the hospital, that I could take him to his appointments. I made him a dependent of mine which meant that the military would pay for his medical care. So of course, it was terminal, he was going to die, but he could get the medicine that would make him more comfortable going through that process. It was great for that.

Aside: Sorry, I was fully red-faced, wet checks, ugly-crying recording this. [sigh]

Alie: Can you clone yourself? Can we repopulate Mars with just you? [Alie and Raquel both laugh] How long did you serve in the Air Force?

Raquel: Four years. I did four years. I wasn't a US citizen when I went in. I got my citizenship through the military, which was great, but I couldn't get any of the cool jobs in the

military because I couldn't get secret clearance, so I couldn't work with satellites or the space side of the military, which I had always liked space.

Alie: They don't tell you about what really happened in Roswell unless you have secret clearance? [*laughs*]

Raquel: [*laughs*] Nope. They don't tell me. Nope.

Alie: Just kidding, just kidding! [*clip from X-Files, Agent Scully: "Mulder..." Agent Mulder: "Don't...don't even start with me."*]

Raquel: How I ended up picking the job that I got... I worked in the medical field, I was the person who draws your blood and tests it. That's what I did for 4 years, testing people's urine, and poop, and growing bacteria. [*laughs*]

Alie: You were just on the bodily fluids committee?

Raquel: Yes, yes! That's what I did for 4 years. But I didn't know what I wanted to do when I got out. I wasn't crazy about the medical field, I didn't want to stay in there. I knew I liked science and math but I hadn't taken a math or science class in 4 years. I was really afraid to fail, so I bartended for many years, just trying to find myself and figure out what I wanted to do. I started going to community college, just taking a class here and there. Then I started doing well and I'm like, "Okay, maybe I can do this! This is a path I can take." Then slowly just taking more and more classes, and I was doing well, and I decided, okay I'm going to go get a science degree, an engineering degree.

Alie: Until you got...

Raquel: Until I got that internship at JPL that opened the world of planetary science to me. I talk to a lot of people and when I tell them what I do, "Oh, you're an astronomer." I'm like, "No, I'm not. I'm not an astronomer, I'm a planetary scientist. I study rocks." It's funny to think that all of the rovers that have gone to Mars, they're all robotic geologists. That's what they are! They're not astronomers, they're geologists.

Alie: Yeah, they're looking down, they're not looking up, right?

Raquel: Yeah, that's right.

Alie: Let's hot-goss about the Moon. I didn't learn until way too late that the Moon is made of a bunch of junk from Earth that just maybe chunked off? Explain to me, where does this goddamn Moon come from?

Raquel: The cool thing is actually we're not 100% sure, [*Lil Jon shouting "WHAT??"*] which is really, really cool, at just how many science questions are still left to answer. We don't know that much about the Moon. There's still so much more to learn. The idea is... the one that most people think is the real thing that happened is that a Mars-sized object, which we call Theia, was just floating around space and crashed into the early Earth,

[clumsy crashing sounds] and they collided, and stuff kind of was flung out into space, and coalesced to form the Moon.

When you look at what the Moon and the Earth are made of, they're very similar. They look like they're made of the same stuff. We think that that's what happened, things collided, they mixed together, and then several chunks of it got flung into space, and then eventually coalesced into what our Moon is today.

Alie: And it's gravity that's keeping it all together and into a ball?

Raquel: Yeah. That's how planets get bigger. You start out with little dust particles that are electrically attracted to each other and they start sticking together. Everything has mass, even a tiny dust particle has mass, so it starts attracting the next dust particle, and now you have little pebbles, now the pebbles start getting stuck together. Eventually you form a planet that's gravitationally bound to itself.

Alie: Do you think there's any place on Earth where we got in a collision, we still have a little bit of a dent?

Raquel: Yes! There's actually lots of craters that we see on Earth. Well, not lots compared to the Moon. When you look at the Moon all those dots that you see on it, those are craters. There are still some here on Earth. The thing about Earth is we have plate tectonics, which is always recycling our crust. We have the atmosphere, and the wind, and water which erases a lot of the evidence that we have of impacts that have happened here on Earth. There's a really beautiful one in Arizona, I don't know if you've ever been to Meteor Crater?

Aside: Side note, I haven't been, but the Nerd Brigade organized a trip in a motorhome a few years ago, and at the last minute I couldn't attend. But this meteor that bitch-slapped northern Arizona is estimated to have weighed 300,000 tons. It hit the Earth with a force 150 times that of the atom bomb in Hiroshima, and left what looks like a geological chick pox scar one mile across, 55 stories deep, near a town called Winslow. Which was made famous because it's 18 miles from a giant crater, but also Winslow was memorialized in the song *Take it Easy*, after a member of the Eagles had his car break down there once. [clip of *Take it Easy*: "I was standing on a corner in Winslow, Arizona"] The guy in the Eagles doesn't even mention the crater the song though, which is a disappointment.

But, this nearby meteor crater is sometimes known as the Barringer Crater, after mining engineer Daniel Moreau Barringer, who first postulated, "Hey y'all, I think this huge-ass crater was caused by a meteor! Let me dig into it and become rich!" So he got the right to mine it thinking there must be a huuuuuge chunk of iron under the surface worth hundreds of millions of dollars, but after 25 years and almost all of his savings he got a report that the meteor wasn't buried under the Earth. It just would have vaporized.

There was nothing to mine for, and days after getting this report Barringer died of a massive heart attack. But the Barringer family still owns the crater and scientists refer to it as Barringer Crater as kind of a tip-of-the-hat to be like, "Hey! Thanks dude, for knowing that this huge bowl in the Earth was formed by a space projectile. What a sincere bummer that the stress of it killed you." So why on Earth aren't there more of these craters to which we can take road trips?

Raquel: Our atmosphere protects us from a lot of them. If the rock is small enough, it'll just break up in the atmosphere, whereas on the Moon, there is no atmosphere, it'll just slam into the ground, and it'll be left, and there will be a hole there. That's actually one of the cool things about studying the Moon. The Moon has experienced pretty much everything that the Earth has experienced, and because it doesn't have plate tectonics and it doesn't have an atmosphere it acts as a witness plate to everything that the Earth has experienced.

Aside: So the Moon is kind of like a responsible, sober friend who recalls details that haven't been blurred by atmosphere or shifting plates. Also, what's in the Moon's core? Is it like a jaw breaker? Raquel says it has a core, it's just much smaller than the Earth's. Then she told me something truly crazy! I lost my damn mind!

Raquel: One of the cool things when I think about the Moon and the impact that caused it was, there was so much energy that collected from that original impact that formed the Moon that the entire Moon was just a magma ocean.

Alie: Whaaaat???? [*repeated at slow speed two more times*]

Raquel: Yeah, just imagine the whole Moon, just magma.

Alie: Nooo!! Whaat????

Raquel: That's the prevailing theory, and we have evidence for that. It's just lava. The whole thing is just lava.

Alie: Ohhh my god!

Raquel: What happens as you start cooling down, crystals start forming, and the heavier crystals sort of sink to the bottom and the lighter stuff floats to the top. When you look at the Moon, you see that there's different shades, there's the light stuff and then there's the dark stuff. We've brought rocks back from the Moon during the Apollo missions. We know that the light stuff is anorthosite, which is a very not-dense rock. It's a very light type of rock.

Aside: Again, a lava ocean! The Moon was a lava ocean!! Lava ocean!! Here we are thinking it's cheese, but at one point it was habañero queso. What is life?!

Raquel: Here on Earth we have different types of rocks, we have igneous rocks, we have sedimentary rocks, whereas the Moon is essentially all that light stuff is just one thing,

and the only way that you could form something like that is if it all just pretty much just formed at the same time from the same stuff. So we think it's just a big anorthosite crust, except for the dark regions you see on the Moon and those are ancient volcanic plains.

Alie: Wait, so there were volcanoes also on the Moon?

Raquel: Volcanoes. Yes. Yes! Yes!!

Alie: Okay, what a back-story! So something hits Earth, [*splat*] shit flies into the atmosphere. At what point does it become lava?

Raquel: [*laughs*] Well, from all the heat. From all the heat of it hitting. You know when you hit something you generate energy and that energy is probably heat, and makes sound and whatnot, but yeah, it's heat. Just from accretion, which is stuff coming together, it just melted the whole... cuz it's not that big, right? Well it is big, but not that big, so it's easier to melt the whole thing.

Alie: How big around is the Moon, comparatively? What's the size difference between the Moon and Earth?

Raquel: If the Earth were to be a basketball [*basketball bouncing*] then the Moon is a tennis ball. [*tennis ball bouncing*]

Alie: Oh! Perfect. Done. Amazing. And then what about these volcanoes?

Raquel: They were a long time ago, like 3 billion years ago. Very ancient volcanoes that flooded. There's not a lot of them on the far side of the Moon. It's not the dark side, it's the far side, because it's not dark.

Alie: We've been saying it wrong this entire time. Thanks Pink Floyd [*clip from Pink Floyd song Eclipse, Gerry O'Driscoll speaking: "There is no dark side in the moon really. Matter of fact it's all dark. The only thing that makes it look light is the sun."*] [*record scratch*] How dare you?

Raquel: The side nearer to us, the crust is thinner, so it's easier for lavas to bubble up. So what you see when you look at those dark regions, where ancient lava plains have flowed and found a low place on the moon and just settled there.

Alie: Okay, so this is very stupid, but where is the Moon at any given time? How do Moon phases work? Just pretend I'm someone you met at the carwash who doesn't know jackshit about the Moon because that's pretty much what's happening, but we're not at a carwash.

Raquel: [*laughs*] What we're seeing is where the Sun is lighting the Moon. During a full moon, the Sun is directly behind. If you were to be staring at the Moon and it's a full Moon, the Sun would be directly behind you. The reason if you see a full Moon and it's not an eclipse, it's because there's a slight tilt to the Moon's orbit, so it's not perfectly in line

with the Sun, so you see the Sun lighting up the full face of the Moon. Now if you're again staring at the Moon and you see only half of it lit, that means the Sun is either to your left or to your right. When it's a new Moon, when you don't see any light of the Moon, it's because the Sun is lighting the dark side of the Moon, what we call the far side.

Alie: So it's always a full Moon somewhere, it just depends on where you're hanging out.

Raquel: Yeah, on where you're hanging out. That's right. It's only our perspective that makes the phases of the Moon happen.

Alie: How does the Moon affect the oceans, and maybe us?

Raquel: The Moon has a couple of effects on us. It creates our tides, high tide, low tide. It's the Moon and the Sun. A lot of people think it's just the Moon but it's a combination of both, but the Moon is stronger because it's closer. It pulls on our oceans. Depending on which area it's closest to on the planet, it's going to tug on that part of the planet. So it actually tugs the rocks as well. It's not just the water. The water is just easier to deform.

Alie: Oh my gosh. So it's pulling everything?

Raquel: Yeah, our Earth is slightly oblate because we have the Moon tugging at it, the Moon and the Sun, of course. And we tug at it. We tug at the Moon as well.

Alie: Oh man, I'm gonna have galaxy brain breakdown right now.

Raquel: The other way it affects us is it slows down our days. The Earth used to be spinning a lot faster, but because of conservation of momentum, angular momentum, it has slowed down the Earth's spin.

Aside: So about every 100 years we get 2.5 milliseconds slower, and in 2012 we had to add a second to the World Clock just to make up for it! Moon's like, "I did that!" Likewise, Earth's gravity pulls on the Moon, the Moon slows down a little, and then the Moon becomes what's called tidally locked. Its orbit around us takes 28 days and its own rotation takes about 28 days, which means that it's daylight for over 13 Earth days straight! Raquel explains, and as you will hear, this was news to me.

Raquel: Right now it is rotating. The Moon does rotate. It spins around itself at the same period that it goes around the Earth. That's the reason why we always see the same face.

Alie: I never knew that. I never knew that!

Raquel: Yeah, it's not stationary. If it was stationary, you would see all of the faces. It's rotating with the Earth, so it is spinning, and that's the reason why we see the same face always.

Alie: I didn't know for the longest time that we don't see the other side of the Moon. It didn't even occur to me. The Moon changes so much. Sometimes it just looks like big old God

just left a toenail clipping right up in the sky, and you're like, "C'mon man!" and other times it's just a full beach ball!

Aside: Okay, listen, I am your QVC host right now. Let me be your QVC host, I will throw my pride into a dumpster and ask the questions we're all too embarrassed to ask. It's okay, I'm living in active inquiry. I'm not ashamed. How does the Moon work?

Alie: So, the far side of the Moon, what exactly is there? What's happening on the far side of the Moon?

Raquel: More craters, less lava, much less lava. Most of the ancient lava fields are here on the near side. The crust is thinner so it's easier for lava to bubble up on this side. The far side is a much lighter color to the Moon because it's mostly that anorthosite that I was talking about earlier, and lots of impact craters.

Aside: Side note: So yes, the light side is on the dark side, which is really the far side. The far side has tons of craters and it's lighter in color, and so far no alien communes. The near side is smoother and has darker splotches of basalt. Those are called Mares because waaay back in the day, folks thought they were oceans. The Mares are flatter and they have fewer craters because it's younger terrain. Lighter parts - anorthosite rock called the Highlands. The darker parts are basalt called the Mares. Boom.

Raquel: The Highlands and the Mare. Apollo 16 landed in the Highlands, in the lighter regions, but again, they tried to look for a place that was nice and flat, not with a lot of craters because it's safer for the astronauts and the lander to land in. Then Apollo 17 landed right on the edge between the Highlands and a Mare because they were trying to sample the rocks from the two different places.

Alie: How many times have we been to the Moon?

Raquel: Six.

Alie: We've been to the Moon six times?

Raquel: Yeah.

Alie: The first time everyone cared [*audio of narration of the first lunar landing: "It is July 20th, 1969, and man is about to land on the Moon." Neil Armstrong: "It's one small step for man... one giant leap for mankind."*] It's pretty cool!

Raquel: And we should go back! There's still so many questions to answer, and the Moon is so interesting, and it's so close, and it's just the perfect place to go before we go to Mars. There's water there. Did you know that there's...

Alie: Wait, there's water on the Moon??

Raquel: There's ice! Water ice on the Moon! Yes! Yes!

Alie: Where is it??

Raquel: At the poles, there's these craters that never see sunlight, they're so deep that sunlight never actually enters the crater. They have not seen sunlight for billions of years. It's actually one of the coldest places that we've ever measured in the solar system, inside these craters. Colder than the surface of Pluto.

Alie: Noooo!

Raquel: Yeah. There's trapped ice there. We've thrown a...something into one of these and then detected a plume that it spewed, and there's water! So we know that there's ice in these things. How much? We're not sure. We have guesses, but we think it's plenty to provide water, to generate fuel, to shield us from radiation because water is a great shielding material for radiation that might be coming in from the solar wind.

Aside: Okay, yes, of course I had to look up solar wind. It's a stream of plasma from the Sun, charged particles, mostly electrons and protons. Also, I found an article showing data that the Apollo astronauts have significantly higher mortality rates from heart disease than their colleagues who did not visit the ol' Moon! They did some studies with mice too and they found that yes, deep space radiation can affect vascular health.

Also, 12 people have walked on the Moon. Which is weird, because you can probably name two, maybe three? So if you're ever stressed out about an embarrassing thing that you said at a party, just know that there are 10 people who have walked on the frickin' Moon, and most of us don't even recall their names. Life is long, memories fade. Just do what you wanna do. Just be nice to each other.

Oh, and what did we toss into the Moon? Was it a firecracker? No. In 2009 we strategically dropped a spent rocket stage into a south pole crater. And then it was like [*Alie makes explosion sounds*] and then we followed it with a spacecraft covered in sensors to go whiff up the dust. Like a very well calculated "Oopsie-daisy, did I drop that?" followed by a robot blood hound.

Raquel: Another reason the Moon is cool is there's lava caves. Do you know about the caves?

Alie: No!

Raquel: There's caves.

Alie: Do I look like I know about lava caves??

Raquel: [*laughs*] Yeah, there's caves where we can set up human bases because they'll be shielded from radiation, and from the cold and the heat. The Sun heats up the surface a

lot, so it's either very, very hot or very, very cold, depending on if you're in the shade or in the Sun.

Alie: How cold, how hot are we talking?

Raquel: Oh man. In these permanently shadowed craters you can get down to 15 degrees Kelvin. So zero Kelvin is absolute zero and this is just 15 degrees higher than that. It is very, very, very cold.

Aside: To put that in context with the thermometer on your porch or your car's dashboard, daylight on the Moon can get up to 260 degrees Fahrenheit and at night it's a brisk -280 Fahrenheit. That's 127 Celsius at its hottest and -173 Celsius when it's cold. Which means, if we do end up cramming ourselves into caves on the Moon, we're gonna need a lot of extra space just for scarves and parkas for the 13 Earth days of night time! Also, perhaps, some flip-flops and a hibachi for those long-ass days and some sunscreen made out of magic. *[audio clip of song Margaritaville, by Jimmy Buffett, "Wasting away again in Margaritaville..."]*

Alie: It's funny cuz I think the images you see of the Moon look relatively flat, and everything looks so dark that it just seems very inert, like it must just be tepid, room temperature, and everything very flat, and that's just not what's happening!

Raquel: *[laughing]* No, no, it just wanders from hot to cold, hot to cold. So if we do set up bases there we need to shield our astronauts from that and I think caves are a good place to do it, or maybe inside some of these craters.

Alie: We started in caves here, pretty much, right?

Raquel: That's a good point! Yeah! We should continue. This is the way to continue human exploration. Just find caves and go live in them.

Alie: Would you ever go to the Moon if given a chance?

Raquel: I feel like my opinion changes often. Before I had kids I was like, "Yeah, of course!" And then I had kids, and I'm like, "They need me! They need me here until they are self-sustaining." *[laughs]*

Alie: *[laughing]* So, like 30?

Aside: Okay, I'm just saying, humans live longer than they used to. So maybe it's part of the natural order that it's getting later for us to make a blanket nest on the couch in the den and eat our parents' cheese until we're 34. Raquel's children, I'm sure, will move out when it's time.

Alie: Bring 'em to the Moon!

Raquel: I would be so happy if my kids became astronauts, I don't know why. It's super weird because it's probably not the safest thing for them to do. But to explore, there's something so poetic and beautiful about pushing the boundaries of what humanity has done and can do.

Alie: Do you read them *The Little Prince*?

Raquel: I have *The Little Prince* in Portuguese and I've read it to them, but I don't think they speak Portuguese, sadly. *[laughs]*

Aside: Just a little secret, I just Amazon'd her one in English, like a sketchy li'l holiday elf, but then the gift wrap option wasn't working so it's just arriving unceremoniously, with no card, just like, "Here", which is embarrassing. Also, do her kids like the Moon?

Raquel: My little... he's two and a half now, but I think ever since he was a year and a half he'll point to the Moon and be like, "Moon, Moon." I think every night I set up the telescope just to look at the Moon.

Alie: Really?

Raquel: Almost every night. I love looking at it and it doesn't get old. Every time I look through that eyepiece or through my camera it's *[sigh]*, it's beautiful and breathtaking to me every time. Doesn't get old.

Alie: Do you have favorite craters or Mares or Highlands? *[Raquel laughs]* I know the lingo now.

Raquel: Yeah! You're in it!

Aside: Oh man, she definitely has the patience of someone capable of raising a toddler. Bless her.

Raquel: I really like Copernicus crater and Eratosthenes and the reason why is they pretty much set off the entire field of lunar science, and how we study how things age, and impact craters. Copernicus crater is a bright, bright crater. This is something where we could talk about space weather. If something is fresh, it's bright, and as it's exposed to space weather it darkens. If you see a crater that's very bright on the Moon, it's a younger crater than something else. The reason we know this is because this Copernicus crater has these crater rays, and crater rays are material that were ejected during the impact. You punch the ground and a lot of stuff comes up and then gets flown all over the place, creating these beautiful crater rays.

Some of those crater rays went into another crater, so that's how we knew that stuff that was bright must be younger than the stuff that is darker because we have these rays that are going into these craters. We call this superposition, and a lot of dating on

planetary bodies - because we don't have samples from it - get done through these crater-counting and superposition principles of what is on top of something else.

Alie: Is it kind of like paint drippings? You can tell what's on top because of the splatter? Kind of?

Raquel: Yeah! Something like that. Then we use samples brought back from the Apollo missions to sort of ground truth what we think the age of something is. Now you can create a curve of how many craters, what does that mean for age?

Alie: So you kind of test it out on the Moon and then those theories hold for other places?

Raquel: Well, people have fights about this at conferences. People will break out into... [*Alie laughs*] I had a professor tell me he saw somebody punch somebody else at a conference over crater-counting statistics. [*laughs*] People fight about this, [*audio of Jerry Springer audience chanting "Jerry... Jerry"*] because there's a lot of uncertainties, and there's different models, and if you tweak something small in one it's a completely different answer, so people are always battling like, "No, you did that wrong! No this is right! This is wrong!" Anyways...

Alie: Drrramaaaaaaa!!

Raquel: It's so much drama, yeah. Crater counting, so much drama in planetary science.

Alie: Maybe there was a full Moon that day. Who knows?

Raquel: [*laughing*] Probably, probably.

Alie: I wanna ask about a particular crater. I like to call it the Moon's buttohole, Tycho.

Raquel: Oh yeah! Tycho! Yeah! [*laughs*]

Alie: I mean it's just like a cat walking away from you, you know what I mean? Why is it named after Tycho Brahe? And do you know anything about him?

Raquel: I do know that his nose was cut off and apparently he died because his bladder exploded because it was impolite to leave dinner. He was at a dinner party. This is a story I've heard, I don't know if it's true or not.

Aside: This man, oh Lord! He was a Danish astronomer and a nobleman who had a looong mustache that looked kind of like two drooping, hairy lip slugs, and he made a ton of very precise astronomical observations in his time, which is all very exciting. But yes, hello, he did also lose part of his nose in a duel with his 3rd cousin! What was it over? Good question. Who was a better mathematician? But he also married a commoner for love and he was eventually exiled for pissing off the king's doctor. This man lived life.

Raquel: This is what I know about him. We actually thought about naming one of our children Tycho, but I knew the history of Tycho and I'm like, "I cannot name my child that."
[*laughing*]

Alie: He also had a pet moose that lived in his mansion that would get drunk off of fermented fruit. [*laughs*]

Raquel: Did he really??? No!

Alie: He was a real character! The fact that there hasn't been a John Malkovich movie about Tycho Brahe is criminal! If anyone is listening to this, I'd like to pitch it. But why is the biggest crater on the Moon that we see named after him? Do we know?

Raquel: All of the craters are named after scientists.

Alie: They are?

Raquel: Yeah, all the craters on the Moon are named after scientists.

Alie: Who gets to name these things?

Raquel: There's a committee. There are so many craters on the Moon, a lot of them are not named because they're not either big enough or maybe we ran out of scientists, because I think they have to be dead.

Alie: Oh, they have to be dead?

Raquel: I think, I think so.

Alie: I wonder if anyone is like, "Can you just do me a favor? Can you push me...?" [*laughs*]

Raquel: I want a crater named after me! [*laughing*]

Alie: Somebody poison my drink!

Aside: I did a little follow-up fact checking and the Tycho moose situation is even weirder. He would send his moose out to parties without him, and at one the moose just straight up drank too many beers and fell down some stairs and died. Also, the name of the Moon is different for different areas. Scholars are in one quadrant, Greek names are toward the North, and I found a NASA document from 1981 that read, "Newcomers to lunar studies often express dismay at the apparently haphazard and illogical disposition of names and letters on lunar maps. Their dismay is not without some foundation." Also, the Tycho crater is sometimes referred to as the umbilica. So now it's even more confusing. Bellybutton? Lunar butthole? So many names. Moving on.

Alie: Movies about the Moon. Are there any that you love? Hate? *Paper Moon*? *Moonstruck*?
[*audio clip of trailer from Moonstruck, Narrator: "The Moon is a little like love."*]

Danny Aiello: "Will you marry me?"

Cher: "I will marry you. I will be your wife."

Olympia Dukakis: "Do you love him Loretta?"

Cher: "No."

Olympia Dukakis: "Good, when you love 'em they drive you crazy."]

Anything Moon-related in pop culture that either really gets your goat or that you love?

Raquel: Oh my gosh, there's a book about the Moon that I really like. It's called *Sevneves*. I don't remember the author. I'm really bad with the names.

Aside: [as if over a radio] Neil Stephenson, copyright 2015.

Raquel: But it's called *Sevneves*. The first thing that happens, on the first page, so I'm not giving anything away, is the Moon explodes. [audio of a female saying "kaaboom"]

Alie: Ouch.

Raquel: And then it's the story of the next 5,000 years of what happens. It's a beautiful story and it's a good book. I highly recommend it.

Alie: Does it explode because some pesky human went and threw something in one of its lava caves?

Raquel: [laughing] I'm not gonna give anything away.

Alie: It's like, "Ouch dude! What are you doing?" And then, again, stupid question, I don't care. When the Moon is really, really huge in the sky and it's very impressive, or when it's reeaally orange at the horizon, what is happening when sometimes we look out and we're like, "Oh my god! Is a witch gonna fly past that? What's happening Moon, why you so big?"

Raquel: That actually happens to be a perspective thing. It just looks big because it's near things in the horizon. It's actually not that big. It's a perspective thing. It's the same size as later on when you look up and it just looks small but because there's nothing else around it, it just looks boring. It's kind of like in photography when you're trying to get the scale, if you're trying to take a picture of a landscape and you really want to convey the scale of something, if you just take a picture of the thing that's really far away, it's like *meh*. But if you put something in the foreground it becomes a lot more majestic because now you have this perspective of, "Okay, a human looks this big against it. Oh wow that must be huge!" So it's the same idea. It's the same thing.

Alie: Oh my god. It's an optical illusion.

Raquel: Yeah! Exactly.

Alie: Why is it when you see the Moon you're like, "Oh the Moon's so pretty I'm gonna take a picture and send it to my boyfriend and be like, look at the Moon!" and then you take a picture and it looks like shit?

Raquel: Because it's an optical illusion. Because the camera is actually capturing what it truly is, but your brain is interpreting it to be a lot more epic than it actually is. [*Audio clip from Bill and Ted's Excellent Adventure: Bill and Ted in unison, "Bogus!"*]

Alie: Oh my god, I did not know that!

Raquel: I know, I know, it's so sad!

Alie: But we can still marvel at it!

Raquel: Oh yeah, I do every time. And the redness is our atmosphere. Our atmosphere more easily scatters blue light, so what reaches us is usually more the red light if it's traveled for a long time. That's why sunsets are beautiful because it has more atmosphere to travel through so a lot of the blue light has been scattered away leaving us with just the red tones and the orange tones.

Alie; How do you feel when people get amped for super moons?

Raquel: I love when people get amped about the Moon because I get amped about the Moon. [*laughs*] It's cool because it actually does look bigger during the super moon. And it's bigger because it's closer. The orbit of the Moon is not perfectly circular, so there are some times when it's closer to Earth and other times it's further away. It doesn't get that much bigger in the sky but it's perceivable to our eye because we're so used to seeing it every day that any small change we're like, "Oh yeah! That actually looks pretty majestic, pretty epic." It might be 17% bigger, but to us apparently that's a big change for our eyes.

Alie: There's always been a certain number of super moons but we maybe let them make the news more.

Raquel: I think so. Absolutely.

Alie: I feel like we need something good to talk about, and we're like, "What do we got guys? The Moon's bigger? Well run that story!" Okay, I have questions from patrons. It's a lightning round.

Raquel: Oh my goodness, okay.

Alie: I got a lot of questions. I was like, "Oh damn!" Because we all love the Moon! The other thing about the Moon... what has the Moon ever done to you? I feel like the Moon is that

friend that you can rely on. Sometimes they're close, sometimes they're far but the Moon's never pissed anyone off.

Raquel: Not yet. It's getting further away though. Every year. About 3.8 centimeters every year, it's moving further and further away.

Alie: [*sad, high pitched voice*] Where is it going?

Raquel: The orbit is getting bigger.

Alie: [*sad, high pitched voice*] Did it find another planet it likes better?

Raquel: [*laughing*] It's gonna go love on Mars or something.

Alie: [*high pitched voice*] Oh no!

Raquel: It's like, "Ugh! These people suck!"

Alie: Actually, before I get to Patreon questions, how do you feel about the Moon just being called the Moon? All the other moons have frickin' names!

Raquel: Yeah. This is the Moon with a capital "M". This is something that I get upset about when people talk about the Moon and it's in lower case, I'm like, "NO! It's upper case! It's The Moon!" [*laughs*] If you talk about "Earth's moon" then it can be lower case, but if it's "the Moon" then it's capitalized.

Alie: It's like The Edge, the guitarist for U2. Who else is gonna put a capital T, capital E? You know what I mean? That's baller.

Raquel: That is baller.

Alie: So the fact that it doesn't need a cute little nickname based on a Latin or a Greek god, just call it the Moon!

Raquel: That's right. Let it do its own thing.

Alie: Just call it the Moon. Do you feel weird that our solar system is just called "the solar system"?

Raquel: Well, it's the best one because we're here. It formed us. I'm not upset about those things because we are here, that's our perspective. If we weren't here the solar system would be boring because there would be nothing to appreciate it or to study it. I think a lot of, when it comes to astronomy, planetary science, we are able to appreciate that. So, yes, it's the Moon because it's our moon and we are the ones who are studying it, so this can be our thing.

Alie: Right. It can rain diamonds on Titan but this is our Moon!

Raquel: This is our Moon! Exactly. Screw Titan!

Alie: It's got lava craters, it's our Moon!

Aside: So the Moon is like mom. If it's anyone's mom, that's a lower case. If it's your mom, that's like The Mom, capital T, capital M, because it's special, it's ours. And super-quick, before the lightning, rapid-fire round, I wanna do a very quick promo-swap with another podcast. They are listeners of *Ologies*, they have their very own show in which they freak each other out with ghost stories. Is it science? Not so much. Is it fun? Heck yes! So I'll let them tell you about them.

*[theme music from Two Girls, One Ghost.] Two Girls, One Ghost is a podcast hosted by us, Corinne and Sabrina. It's not what you think. Or is it? It's not. It's a paranormal comedy podcast. Who doesn't love a good ghost story? We sure do, and we bring you new, haunting tales each week. Are you planning a hike? Not anymore! What about a trip abroad? You might want to rethink that. Pack your sage sticks and prepare to find out your favorite pizza place is anything but family-friendly. We cover topics like black-eyed kids, shadow people, haunted prisons, *[in demonic voice]* exorcisms, visits from family members and pets, and everything in between. So join us every Sunday as we scare ourselves, each other, and you. Two Girls One Ghost is available wherever you listen to podcasts. See you on the other side!*

Okay, we're back with Raquel.

Alie: Are you ready for lightning round?

Raquel: Oh... water, a sip of water.

Alie: Yes, the answer is yes, you got this. I'm gonna just fire off as many as I can and - total transparency - I didn't look through them ahead of time because I just put this up last night, so we're gonna go for it.

Raquel: Got it.

Alie: Okay. Julie wants to know: Will we ever know what's on the dark side? *[In muted audio: Also Januslickjachus_petite [ph.], Taylor Munich, Mark Larsen, Lauren Harter, Bonnie Joyce, Anthony Stull, Emily VandeKieft, all requested some hot gossip about the far side of the Moon.]*

Raquel: We know. There's a spacecraft that's orbiting the Moon called LRO, the Lunar Reconnaissance Orbiter, and it has taken spectacular, high definition, beautiful pictures of the entire Moon. You can go to their website and find pictures of the dark side or far side. It's not the dark side, the far side, of the Moon. The coolest thing I think those cameras have done is that they've imaged the Apollo landing sites. So you can see the footprints and the rover prints that the astronauts left at the surface, and the lunar module and rover, you can still see it. It's in the images taken by LROC, the cameras on board LRO.

Aside: Recently on Raquel's Instagram, @thespacegeologist, she did a live-stream of her looking at lunar dust under a microscope because some other folks in her lab were studying the optical properties of it. How light or dark does it look in certain lights? [*in chipmunk voice*] Moondust. [*sound of chimes tinkling*]

Raquel: We have moondust lying around and sometimes my advisor takes it out to show classes and every time I'm like, "oh my God!!" [*laughs*]

Alie: I saw someone asked if you're afraid to sneeze around it.

Raquel: Yes! Yes! I've been so afraid of sneezing around it so I try to cover it. We've used these samples for outreach events where there will be tons of people coming through, and I will always cover it with glass because I'm petrified of people bumping into it. I don't want to lose moondust! NASA would be so mad at us, because it's on loan to us by NASA. Very precious stuff.

Alie: Can you own anything from the Moon?

Raquel: Not the stuff that was acquired by the Apollo mission. I think that there's been some Russian selling of samples. I think there have been missions by the Russians that brought back samples, not manned missions, but robotic missions that brought back samples from the Moon. I think I've seen some of that on sale on eBay or something, but it won't be an Apollo mission dust.

Alie: I mean, if I put a pumice stone in the Vitamix, [*Raquel laughs*], I could make a killing on eBay. Just so many jabronies. So excited. Remind me to make some extra cash that way. Maria Kumro wants to know: Have you ever yelled at the Moon like Buzz Aldrin on *30 Rock*?

Raquel: Did he? Did he do that? [*Audio clip of Buzz Aldrin from 30 Rock: "I see you! I see what you're doing! Return to the night! You've no business here!"*]

Alie: Never saw that one?

Raquel: I had no idea!

Alie: The answer's gonna be no, I guess?

Raquel: Yeah, no. Never yelled at the Moon.

Alie: Jason Kaw wants to know: Is there a man in the Moon? Because I see a woman's face.

Raquel: Oh! I loved asking people this. Do you see anything when you look at the Moon?

Alie: No.

Raquel: What???

Alie: I never see a face!

Raquel: Okay, but there's other things you can see. I've seen all kinds of things.

Alie: I just see the butthole. What does that say about me? [*Alie and Raquel start laughing*]

Aside: We pulled up a photo together and Raquel showed me that she sees a frog jumping onto a lily pad, or a bunny with two ears. Also, weirdly, if you're in the southern hemisphere, the Moon is upside down to how us Northerners see it. How bananas! Raquel pointed out the face of the man in the moon, which I had literally never seen before.

Raquel: [*pointing to Moon image*] Eyes, nose, mouth, maybe? Do you see those two? Maybe?

Alie: Oooh! Wow! This is like Magic Eye.

Raquel: [*laughs*] I feel like you have to squint to be able to see these things sometimes.

Alie: I feel like you might have to just get pharmaceutical-grade LSD to see it, which is not gonna happen for me anytime soon. Okay, so a face...OKAY! I've never seen that before in my whole life. I swear! Whenever they talked about the man in the Moon, I was always like, "Okay, that's something I don't get." This person, Jason Kaw, says that he sees a woman's face. You?

Raquel: I always see the frog. That's the first thing that pops out to me, the frog jumping onto the lily pad.

Alie: It's such an ink blot test! I guess, everyone, go look at a picture of the Moon and see what you see and report back.

Raquel: Yeah, let us know please.

Alie: Christina Shuy [ph.] wants to know: Which theory on the origin of the Moon is your favorite?

Raquel: The impact theory, that Theia hit early Earth and it formed the Moon

Alie: And now here we are!

Raquel: Here we are.

Alie: Howard Yermish wants to know: What would happen to the Earth if the Moon got either closer or farther away?

Raquel: Well, depending on what caused it to go further away... It is getting further away. The tides would be less, and I think that our days are slowing down, and it would slow down even more, so that would happen to the Earth. You see how an ice skater, when they stick out their arms they slow down, and when they bring them in they go faster? It's the

same thing that's happening. It's just the distribution of mass of the Earth-Moon system. If the Moon were farther away the whole thing would just slow down more.

Alie: So we could get more done in a day! This is cool! I guess the Earth is like, "Moon, give me a little space." It's working, okay. Lydia McGinnis has a question that I'm sure so many people do, which is: Do the phases of the Moon affect people's moods? You also worked a little bit in health care, during the Air Force.

Raquel: [*laughing*] No. It doesn't because the Moon is still there, it's not any closer or any further. Even if it does, it wouldn't have an effect on us. It's just the sunlight. It's what we see the sunlight hitting one side or the other side. I don't see how it could affect us.

Alie: The tides are affected more on a day-to-day basis, not around the month, right?

Raquel: Right, yeah.

Alie: I do have a friend who gets her period on a full moon, every time, no matter kind of birth control she's on, no matter what happened. Every time.

Raquel: The Moon is very regular. It rotates on itself.

Alie: What is the effect of a 28-day menstrual cycle and the Moon? What's up with that?

Raquel: I think it's just coincidence. But that is your friend's timing. Her cycle is like 28-point-something days and it just happens to coincide with the Moon. That's pretty cool. I'm sure there's gotta be other people. I mean, if you have enough women, enough people, one of them will eventually have that same cycle.

Alie: One in 28 chance. [*Alie and Raquel laugh*] Okay, so about 3%, 3.5%.

Aside: P.S. Looked this up, and in the age of apps, we have a bunch of data to play with, for good and for bad. There's a period tracker called Clue that analyzed 7.5 million users' cycles and found no correlation between lunar phases. None! Natalie Mastick, Julie Platten and Michael Bolaz [ph.] also asked this, and sorry, science is saying it's just rando, folks. Talk to yer crotch. I got no answers.

Alie: Rhyan Carter wants to know: Given that the prominent theory for the Moon's creation, early impact with Thea, isn't matching up exactly with what we're seeing in the Moon's composition, are there any competing theories that are coming to the fore, a combination the explains the inconsistencies?

Raquel: Not that explains everything that we see. Theia hitting the Earth is still the one that answers the questions.

Alie: So nothing new, like it was aliens. [*Alie and Raquel laugh*]

Aside: So for funzies, feel free to look up the Hollow Moon or the Spaceship Moon hypothesis. That is what it's called. Essentially some folks think that the Moon is a Death

Star. No biggie. Before you go spitting up your Folgers laughing at this, do know that our beloved Carl Sagan for a while, thought that one of Mars' moons was just a cavernous storage shed installed by clutter-bogged Martians. So the Universe, it's a mystery.

Alie: Juan Pedro Martinez wants to know: Why don't we go back to the Moon?

Raquel: I know, that's what I'm saying! We should! The Moon is the next logical step, I think.

Alie: It's right there!

Raquel: It's right there. We can set up bases! We can make things there. We can make fuel there. It's much less gravity, so it's easier to launch from there. It just makes so much sense to go to the Moon and not Mars. It's harder to leave the Earth's gravity well, whereas it'd be so much easier to do that from the Moon.

Alie: It reminds me of living in L.A., it's like, why would I go vacation in Florida when there's a beach right here? Jay Owens wants to know: Does it really ring when impacted? Does it ring like a bell?

Raquel: I've heard that before. There's definitely Moonquakes.

Aside: I looked this up and according to an article by NASA, because the Moon is dry and rigid, Moonquakes continue to rumble. It's like vibrations hitting a metal tuning fork. Something to consider if you move into one of its space caves. And I wonder what they would charge for rent?

Alie: Renee Coley wants to know, who owns the Moon?

Raquel: Nobody. There's a space treaty that was signed. I don't remember the year.

Aside: *[slowed down and slightly morphed]* 1967.

Raquel: But it says that no one nation owns anything in space.

Alie: Okay, so if you go and pee on it, it's not yours?

Raquel: *[laughing]* It's not yours.

Alie: Dang it. Well, there goes my plan.

Raquel: There was a company a few years back selling Moon plots. They were like, "Well, I'm not a nation, I'm a company, so I'm just gonna claim that it's mine." I think some people actually bought stuff. I dunno. I don't know what happened to that.

Alie: What are you gonna do, go retire there? *[Raquel laughs]* Congrats!

Raquel: Maybe one day. That'd be so cool! Imagine going on vacation to the Moon.

Alie: To the Moon! Bring a parka! It's a little chilly. Mads Clement wants to know: If there were 2 guys on the Moon and one of them kill the other, would that be fucked up or what? *[laughs]* That's the only question, okay. I think it's a yes!

Raquel: *[laughing]* Yes, definitely.

Aside: *[Bill Lumberg from movie Office Space, "Uhhh... yeah."]*

Alie: Marlee Schilbe wants to know: How do you feel about the Moon impacting the way humans feel? Like, if it impacts water and the tide, we're made of water, is that a thing? Not a thing?

Raquel: I don't think that's a thing. I think there have been studies that show that it doesn't. I remember a few years ago people were saying that there's higher hospital admissions during a full Moon, but I think that's been debunked. I think that there's been studies that show that that's not true.

Alie: Okay, it might be flim-flam? I'll investigate.

Aside: Everyone wanted to know this. This question was also asked by Heather Shaver, Ana M. Castro-Reynoso, Kelly Rand, Rae Casha, Kimberly, Thomas Maher, Meredith Ostrow, Micah Eckard, and Elizabeth Gabel. So I did a little digging, and according to data, no real correlation! The hypothesis that the Moon is tugging on our sloshy brain waters doesn't make a ton of sense because its effect on the tides happens even when it's not fully illuminated. So it may just be that when the Moon is bright, people stay out at night longer and just clinically speaking, are out wildin'. Or, it's bright and people get less sleep, so they're a little bit cranky and clumsy. Or maybe we're all distracted by the Moon and we crash our cars into trees. Or trip on things.

Alie: Sonya Karpelevitch says: Why is the Moon seen as feminine, as in it's often associated with Artemis and other women?

Raquel: Cuz it looks delicate, maybe? I don't know.

Alie: Cuz it's purdy?

Raquel: It's pretty, it's beautiful, yeah. That's what I think, For example, in Portuguese, it's female, lua. It's a female and I think in Spanish the same thing, la luna. I think it's because it's beautiful, I'm gonna go with that.

Alie: Yeah? Cuz we see it as an object for us to look at and probe. *[Alie and Raquel laugh]* No, because it's a beautiful thing. Maybe because, this is sinister, but maybe because it accompanies us? Maybe we put women in...

Raquel: Helper roles...

Alie: Yes! Exactly. We put it in a “stay in my orbit, I’m the big thing,” and almost like Eve was made of Adam’s rib and the Moon is made of Earth chunks. Maybe that’s something to the mythology of it. But I think, in reality it’s complex [*Alie and Raquel start laughing*] and had taken some shit from meteors and is still up there doing its thing.

Aside: Ok, so maybe it’s in-built misogyny of treating women like accessories, or maybe it’s because of the 28-day thing. I dunno, whatever.

Alie: Anna Thompson wants to know: What is the biggest unknown about the Moon still? Or the coolest thing we’ve learned about the Moon?

Raquel: I think the biggest unknown is just how did it form? It’s so similar to our Earth and made of the same stuff, but you’d think it’d be a lot more different and it’s not. The coolest thing, there’s water there. That’s pretty cool.

Alie: Bree Johnson wants to know: Do you think there will ever be a time when humans can live on the Moon. And Lindsey K. Trotter also asks: Can we colonize this thing, or what?

Raquel: Yeah, for sure, but I think that’ll be more of a jumping ground. You might go to the Moon first to acclimate. Not in the sense of acclimate to the weather, but acclimate to living in space environment, or not-Earth, and lighter gravity.

Alie: How’s the gravity on the Moon versus Mars?

Raquel: A sixth. So you could jump pretty high. There’s actually this really cool compilation video of the Apollo astronauts hopping and falling, and somebody sped it up and put some silly music in the background. [*laughing*]

Aside: Looked this up and I found a video of Apollo 17 astronaut Gene Cernan fully suited up in his Moon ensemble just lightly bounding along the lunar landscape, singing as he went. [*clip of Gene Cernan singing, “Hippety-hoppety, hippety-hoppety!”*] So there’s your little frog and bunny on the Moon. Also, astronauts will train in zero-gravity flights. They fly in these parabolic curves and it gives a few seconds of the sensation of weightlessness each curve. Now, for a civilian to experience zero G’s, it costs about 5G’s. Warning: it got the name Vomit Comet for a reason.

Raquel: I was on the Vomit Comet once and it’s not just zero gravity, they also do diminished gravity, so Mars gravity and Moon gravity. For the Moon gravity you can hop pretty high. It’s really cool because you get to experience what it would be like to jump. You can jump so high! It’s awesome.

Alie: So there’s much less gravity on the Moon than Mars because it’s a smaller planetary body?

Raquel: On Mars it’s a third of the Earth and the Moon is a sixth of the Earth.

Alie: Oh! So it’s hippety-hoppety, like one of those places you can go on the trampolines!

Raquel: Yes! Yes. All the time.

Alie: Sign me up! I'm looking for a couple more questions. Kjersti Chippindale says: Can a moon have its own moon? Is that possible? [*Jeopardy theme music*]

Raquel: [*record scratch*] I'm sure it's possible. It's probably just not very stable because the bigger object would end up grabbing it and then it would just orbit the bigger object instead. You know what I mean?

Alie: Okay. E. Brown asked... I didn't even think of this question: How come you can sometimes see the Moon during the day?

Raquel: The Moon is always orbiting us. Sometimes it's orbiting us when it's nighttime and sometimes it's daytime. It's always either on our side during the day or the other side. It just depends on where it is on its orbit.

Alie: It's just cruising!

Raquel: It's just hanging out, yep.

Alie: Oh it makes me sad to think of the Moon as a kid with divorced parents where it's at one house or the other. [*Alie and Raquel laugh*] Sometimes it's gonna be on this side or our side, okay! Meggie Schwenker said: So the Moon is tidally locked, has it always been this orientation to the Earth?

Raquel: No.

Alie: Ooooh. Or did the first little footy-fish hauling themselves out of the primordial ooze see a different part of the Moon?

Raquel: They might have seen a different part of the Moon, yeah. Although we think that it got tidally locked pretty early because it's so small that it's easier for it to become tidally locked.

Alie: I never knew that was a term! Justin Westerfield wants to know, casually: What would happen if Elon Musk blew up the Moon? [*clip of Elon Musk: "It's like a never-ending explosion."*] Is he gonna do that? [*laughing*]

Raquel: [*laughing*] I hope not. The tides wouldn't be as pronounced if we didn't have the Moon anymore. I mean if he blew it up and it disappeared, right? And, our planet might wobble a lot more. The Moon makes our planet stable, kinda like a spinning top. You know how sometimes it moves? The Moon actually keeps us from doing that. Our seasons are a lot more stable because we have our Moon to stabilize our orbit. If we didn't have our Moon, we might go through ice ages and crazy warm periods a lot more than what we do now.

Alie: God, once again, Moon's like a woman. Stabilizes shit. So, two questions I always ask: Shittiest thing about your job, or the worst thing about the Moon? Feel free to vent about the Moon right now. I can't think of a thing the Moon's done to anyone, but I don't know.

Raquel: Ah... what's the shittiest thing about my job? It's hard.

Alie: Do you have to answer a lot of conspiracy theories about not landing on the Moon?

Raquel: Oh, yeah. *[Alie and Raquel laugh]* I get that sometimes. Mostly on social media because I do a little sci-comm through my Instagram, and inevitably, always, somebody's like, "Well, we never went there so I don't know how you can say that that's actual Moondust." I actually had somebody DM me that. People have their mind set up because they will always say, "Well those images are doctored. Those aren't really the footprints or rover prints. That's Photoshop or something." And it's hard to argue with that.

Alie: What about computer crashes?

Raquel: Just code not working and sometimes it's just because you forgot to put a semicolon somewhere and you spend hours trying to figure out, "What did I do wrong?" and it's just something stupid like you put the semicolon in the wrong place. *[laughs]* It's stupid shit like that. That's the nature of the job. I don't know, problem-solving's kind of fun. It's cool.

Aside: Side note: How much do you love someone who loves to solve programming errors??

Alie: What's the best thing about what you do? Or the best thing about the Moon?

Raquel: The best thing is getting to think about these things that are so much bigger than myself. It takes me out of whatever's going on in my personal life or whatever's going on in the world. Just focusing on something that is out there, and it's so much bigger than us, and bigger than whatever is happening in our world, it's kind of like a vacation in a way, from everyday problems. I think that's what I love the most about it, to be able to think about these things that might not impact me, that probably don't impact me at all directly. There's relief in that, in not having to worry about me or anything directly related to me.

Alie: I guess it's all about perspective, the Moon, once again. I think, especially in L.A. where we don't get a lot of weather, getting to be able to track the Moon and see where it's at, and check in with it, it does feel like a little buddy. Like, "Where are you in the sky right now? Hey, what's going on?" What would your dream job be as a planetary geologist?

Raquel: I would love to be involved in mission design and just thinking about what are the big questions we still have to answer and how can we design missions to answer those science questions?

Alie: Get us back on the Moon man!

Raquel: Yeah, right?? Come on!

Alie: Whadda we gotta do? Get us back! It's right there!

Raquel: Although you know, for all that we can say about this administration, they love the Moon. NASA is actually part of the Executive Branch, I don't know if you knew that. So whatever the President says is what happens. It's an Executive Branch department of the government. [*clip of President Trump saying "space force"*] NASA actually ends up being at the whims of whatever administration is running it. Which is kind of crazy. You end up losing a lot of money because you start designing a mission and most of the time it will go to completion, but you might lose funding at some point because this administration doesn't like this project. Right now this administration really likes the Moon.

Alie: I wonder why?

Raquel: I don't know. Because it's close, and I think what it is, is that there's a lot of commercial partners where if you do something really far away, like Mars, so much more can go wrong that commercial partners don't want to be involved. Private companies don't want to be involved. With the Moon I think there's a lot of interest.

Alie: Are we gonna mine the Moon?

Raquel: We could!

Alie: Whoa! I wonder what they got up there? Cheese?

Aside: And where can you find Raquel on social media?

Raquel: The one that I spend the most time on is Instagram, and you can find me @thespacegeologist. [*laughs*] There's also some baby stuff in there, but mostly science things that are happening.

Alie: I love your Instagram. I always learn things!

Raquel: Oh, thank you! Oh, that's so nice!

Alie: I love it so much! Whenever you have a new story pop up, I'm like, "Oooh! What's she got?" I get very excited about it. Cool Moon photos, and I'm like, "Ah, she's killing it." Thank you so much for doing this!

Raquel: Thank you for having me!

So keep asking smart people stupid questions because look at how nice they are! And you can follow Raquel again [@thespacegeologist](#) on Instagram. You can find *Ologies* @ologies on [Twitter](#) and [Instagram](#). I'm Alie Ward on [both](#). If you like *Ologies*, tell a friend. If you want merch, go to [ologiesmerch.com](#), thank you Bonnie Dutch and Shannon Feltus for managing that. Thank you patrons, at [Patreon.com/Ologies](#) for making this show possible. Thank you Erin Talbert and Hannah Lipow for managing the [Ologies Podcast Facebook group](#). The theme song was written and performed by Nick Thorburn of the band Islands, and editing was done by the luminous Steven Ray Morris, host of the *Purrcast* and *See Jurassic Right* about cats and dinos, respectively. And also this week, we got some editing help from the disturbingly handsome Jarrett Sleeper. It's unsettling, really. He hosts the wonderfully candid and really funny mental health podcast called *My Good Bad Brain*. You should check that out, we all have brains.

If you listen to the end of the show, I tell you a secret, and this week this my secret is that I slept 12 hours last night and then I took a 2-hour nap today, and I'm making myself go to the doctor about it tomorrow. This is weird. I feel like a Hefty bag filled with wet cement. Maybe I'm just tired. I'm not sure. Okay, I'm going to sleep now. Berbye!

[*Outro Music*]

Transcribed with mooning eyes, but not bum, by Wendy Fick. Greetings and happy reading from Iowa City, IA, a UNESCO City of Literature!

Some links which you may find of use:

[*Please enjoy these QVC moon ponderings*](#)

[*Pink Floyd mislead you about the dark side*](#)

[*Teleport back to ABC Moon coverage*](#)

[*Joe Rogan and Elon, stiffly chillin'*](#)

[*Eagles stranded in Winslow*](#)

[*The tragedy of Barringer crater*](#)

[*Heart disease in astronauts: not cool*](#)

[*Tyco Brahe, your new favorite person*](#)

[*NASA's like, "Lunar names suck, we get it"*](#)

[Lunar oopsie-daisy rocket drop](#)

[Upside down Australia!](#)

["Seveneves" by Neal Stephenson](#)

[People who have been on the moon:](#)

[Lunar footprint hoax: debunked](#)

[Moons n' periods](#)

[Hollow Moon Theory aka Deathstar](#)

[Moonquakes ring out!](#)

[Get bit! Moreso during a full moon](#)

[Yeah no, the Moon doesn't make you crazy](#)

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[Does the Moon twist or what](#)

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