Smologies #1: THE MOON with Selenologist Raquel Nuno
Ologies Podcast
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Oh hi, it's *Smologies*! This is the first ever episode. I'm Alie Ward. These are small *Ologies* episodes delivering little tiny bite-sized brain snacks, little episodes that are refreshers on your favorites, and classroom friendly. All-ages cuts of *Ologies* episodes that you love.

So, I hear it from folks; every day I get messages. "Yo, DadWard, I see you have bleeped episodes, but what about making *Ologies* super family friendly? Can you change your whole vibe for smologites?" And I can't. I love you, but I love the way I get to make full-length *Ologies* episodes that come out and land on your feet every Tuesday. But I did decide I can tweak what we have and release these clean, shorter, edited versions as free bonus episodes so that when you see the *Smologies* title, you know that you can listen with your kids (and my parents).

Smologies are quicker, cleaner cuts of the back catalog favorites that are just perfect for my wheezy jog around the block, or your dinner prep, or any time you have about 20 minutes to burn. And if you want the full scoop, all the juicy, full episodes with more facts, and backstories, and words that we would not say around youngsters, you can find a link to that full version in the show notes.

So with that, welcome to *Smologies*, which are dropping twice today as a little honeymoon break debut this week; just kind of an introduction to our podcast, baby. And then *Smologies* will be out every other week on Thursdays as a bonus. So, introducing *Smologies* #1: Selenology; a word that comes from the Greek *selen* for 'moon'. Get ready to bask in the glow of Selenologist Raquel Nuno.

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 a 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!

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.

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's not *technically* a planet.

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

Raquel: That's right.

Alie: 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 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 dumbbell 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!! 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.

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. Explain to me, where does this goddamn Moon come from?

Raquel: The cool thing is actually we're not 100% sure, 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, 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. Now you have little pebbles, now the pebbles start getting stuck together. Eventually, you form a planet that's gravitationally bound to itself.

Aside: 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 that's why the surface of the Moon is pitted. But What about the Moon itself? Does it have a pit like a peach? What's in the Moon's core? Is it like a jawbreaker? Raquel says it has a core, it's just much smaller than the Earth's.

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. 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: 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.

Raquel: That's how I like to think of it. So, 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.

Aside: And you can see more of those areas when the Moon is full. Which makes me wonder…

Alie: How do Moon phases work? Just pretend I'm someone you met at the carwash who doesn't know jack about the Moon because that's pretty much what's happening, but we're not at a carwash.

Raquel: [*laughs*] So, the phases of the Moon are caused by… 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. 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: 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 for 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. 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.

Aside: Yes! How cool is that?! Literally, very, very cool. So chilly!

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°F and at night it's a brisk -280°F. That's 127°C at its hottest and -173°C 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 nighttime! Also, perhaps, some flip-flops and a hibachi for those long days and some sunscreen made out of magic.

Alie: It's funny because 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: 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? 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.

Aside: 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! I really like Copernicus crater and Eratosthenes. And the reason why is I think 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 materials 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?

Aside: Also, what's with this Moon wobble that's in the news these days? Scientists in the 1700s discovered that the Moon's orbit does a little bit of a wonky dip every 18.6 years. And for half of it, the tides are a little lower, and for the other half, tides will be higher. So, hunker down for that between 2030 and 2040. Aren't we so thankful for planetary scientists? So much that we're donating to some of the ologist's choosing. Since Raquel says the Planetary Society is doing great work. Their CEO is Bill Nye, and their mission is to introduce people to the wonders of the cosmos, and to inspire and educate people from all walks of life. You can learn more about them at Planetary.org. That donation was made possible by the following sponsors.

[*Ad Break*]

Okay, let's blaze through some questions.

Alie: Are you ready for lightning round?

Raquel: Oh… water, a sip of water.

Alie: Yes, the answer is yes, you got this. Julie wants to know: Will we ever know what's on the dark side?

Raquel: There's a spacecraft right now 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. It's 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.

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: 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 healthcare during the Air Force. [*laughs*]

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.

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: 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: 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 a 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.

Alie: 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: 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.

And we love Raquel Nuno, Selenologist and everybody's best Moon friend. Also, a planetary geologist, who has the word 'rock' in her first name! It's amazing. Follow Raquel on Instagram and Twitter @TheSpaceGeologist. Her handle is linked in the show notes.

We are @Ologies, I'm @AlieWard. And since this is a shorty episode, you can find all the credits of all the amazing folks who work on the show in the show notes too and at AlieWard.com/Smologies.

One last thing before I go. Some DadWard life advice, which I will cap every episode with: Sometimes when you're tired or cranky, you're just thirsty. So if you're having a bad day, hydrate and see if that helps.

Okay, go ask questions. Berbye, Smologites!

Some links which you may find of use:

Full, uncut, original Selenology episode

More Smologies episodes

Raquel Nuno's website and Instagram

A donation went to the The Planetary Society

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Moonquakes ring out!

Get bit! Moreso during a full moon

Yeah no, the Moon doesn't make you crazy

Hippity happily

Does the Moon twist or what