Episode 35: Crater?! I Hardly Know Her
Physicists: Lissa Ong, Charlie Barnhart

Transcribed by Denny Henke

Ben: Oh. Hello old friend, it's good to see you. Let's talk about this word facination. It describes an unquenchable urge which compels our hearts to quest and be captivated. As long as there are elegant explanations to complicated phenomena science will never lose its romance. Over the years I've traveled the world indulging in my facination with physics and now I find that a new hunger has woken within me a fiery need to share these great ideas with the people around me so I have assembled a team of some of the greatest most lucid most creative minds I have encountered in my travels and I call them my Titanium Physicists. You listening to the Titanium Physicists Podcast and I'm Ben Tippett, and now allez physique!

[1:48]

Ben: You know shooting stars, those are caused by little rocks in space which are about the size of a pebble and which are being vaporized high, high above you about 100 kilometers up in the air they hit the atmosphere going 30 km/second and they are vaporized and we see their color and we can say "shooting stars are pretty" and one of my favorite activities of the summer is the mid August meteor shower. They're called the Persiads because of the constellation they are centered around and I like to stay out late and stare up at the night sky and watch the stars fall. And it might suprise you but 15,000 tons of space stuff enter the atmosphere each year. Now it's mostly dust and sand and pebble sized stuff but sometimes its not. Now, I'm going to say two words, listen carefully: Chelyabinsk, Tunguska. So in February 15, 2013, a 20 meter asteroid entered the atmosphere above Russia. It was going about 19 km/second and the heat generated as it pushed through the air was so intense that the meteor heated up brighter than the sun and as it fragmented and exploded it released 20x more energy than an atomic bomb. 1500 people in the city of Chelyabinsk were injured by broken glass as their windows got blown in. And Tungustka, well on June 30, 1908, either a comet or a meteroid entered the atmosphere and exploded in the Tunguska River. It exploded at an altitude of over 5km in the air and the explosion was over a 1,000 times energetic as an atomic bomb. Trees were flattened over a region of 2,000 kilometers in size and windows were shattered hundreds of kilometers away. So the moral of the story is the horible things can come from space and bash into the earth. Today we're going to talk about the most world changing events when a big rock from space smashes into a planet. Okay, I thought for an episode on world changing cataclysms we should invite on an expert on post apocalyptic scenarios and one of my favorite pieces of post apocalyptic fiction these days is Adventure Time. It's a cartoon about a boy and his dog as they have adventures in a magical post-post apocalyptic earth and one of my favorite things in adventure time are Fionna and Cake, the ginger swap versions of Finn and Jake who exist only in the feverish fan fiction written by the ice king, my guest today is Natasha Allegri. She's a character designer and story boarder on the adventure time cartoon and she's the creator of Fionna and Cake. Natasha also writes and illustrates the adventure time with Fionna Cake comic books. Hi Natasha.

Natasha: Hello

Ben: How you doin?

[4:28]
Natasha: I'm good. How are you?

Ben: I'm so excited. Okay, before we go on we should note Natasha has a fun tumblr page where she draws and interacts with her fans. She also writes her cartoon Bee and PuppyCat on Frederator's Cartoon Hangover. Links to all these things will be available on our web page show notes. Okay Natasha, for you today, I've assembled two fantastic Titanium Physicists. Arise Lissa Ong. Lissa has her masters from UC Santa Cruz in Planetary Science. She was previously a doctoral candidate in the impact shockwaves at the University Arizona. Now arise doctor Charlie Barnhart. Doctor Charlie got his PHD from UC Santa Cruz in Planetary Geophysics. He's currently a postdoctoral scholar at the Global Climate and Energy Project at Stanford University. Charlie is one of the co-hosts of our sister podcasts "Science sort of". Alright everybody, lets start talking about horrible, horrible events.

Lissa: So, about 65 million years ago one of these big asteroids came and hit the earth and it is what we think extincted all the dinosaurs as we know them and it created a niche for mammals to become more dominant in our Earth's ecosystem. So this was caused by, we think, by a 10 kilometer diameter asteroid so that's pretty huge compared to the meteorite that Ben just talked about hitting in Chelyabinsk earlier this year and it hit in the Yucatan Peninsula although the crater itself, well it was discovered by some oil companies I think in the 1950s but they kind of kept it all hush hush and so it wasn't actually published as a potential crater for the dinosaur killing impact until the 1980s. So the reason we think it was an impact that killed the dinosaurs there's a couple things. There's a layer in between the two geological layers. Underneath theres the layer that has all the dinosaurs and above theres the layer that doesn't have any dinosaurs. So, clearly something happened there and there's a whole bunch of stuff between those two rock layers that has no business being on Earth. So one of those things is the rare earth element Iridium which comes from outer space and is, you know, the easiest explanation for that being there and a global layer all around the world because it came from an asteroid impact. And the other thing that we see are these tiny little glass spheres called micro ejecta that we think are pieces of melted rock and ejecta that blew out of the crater when it was forming and solidified into glass and then kind of rained down all over the earth. So, that's why we think it was an asteroid impact that killed the dinosaurs.

[7:14]

Charlie: Yeah, and I'll say that impact craters aren't necessarily horrible events as they've been introduced at the beginning of the show. They're just misunderstood. So every impact event before humans were on the planet were probably in some way good for our evolution. Primordial life dates back all the way, mitochondrial dna and rna to thermophiles, these are archaea bacterial that enjoy very very hot temperatures and these are the only sorts of things that probably could have survived in the very very early earth when we were constantly being bombarded by impact events and they were able to survive the hot liquid water temperatures that were probably throughout the earth's crust and life came from these things and we came from those things so those impacts were good for the advent of life as we know it. And then as Lissa mentioned, getting rid of certain species were conducive to species more closely related to us to come onto the scene so most impact craters were really really good us it's just the big one that's coming in the future that won't be so great for us but hopefully we'll be an adaptive and inventive species and figure out a way to defend ourselves.

Natasha: Whoa. I didn't know there was a meteor coming to earth.

Charlie: Statistically, absolutely. What is the rate Lissa, maybe once every million years you get something that can make about a 10 kilometer crater?

Lissa: Yeah, something like that.

Charlie: Which isn't an extinction level event but it would be devastating if it hit a land mass especially given population centers as they are.

Lissa: Even if just Tungustka happened, it was such a huge explosion and it felled, you know, like 80 million trees or something, so if that had happened over an urban center that would be a major bummer.

[9:06]

Charlie: Yeah. The Shell oil company discovering he Chicxulub crater which is thought to be responsible for the extinction of the dinosaurs is really pretty curious if you read some of the literature. They were finding gas and oil trapped underneath impermeable layers, that's what oil exploration does all the time underneath layers of clay for example but then they noticed that in some regions the entire stratigraphy, so that's different layering that makes up a rock column so you can think of it like a cake with frosting and different flavors of cake and different layers of frosting was totally upside down next to other places where it was right side up, so for some reason the entire rock flipped upside down right next to other bits of rock so some places they were finding oil and gas and other places the rock got flipped upside down so all the oil and gas leaked out to the surface. They were wondering what could have possibly turned the entire ground surrounding this one central area upside down and it turns out that impact craters when they carve out their massive cavity they produce this lip that builds the rim and ejecta curtain that will flip upside down then lay it down on the surrounding rim.

Ben: So, the meteor comes in, its traveling at 30 kilometers per second or something, burns right through the atmosphere because its a big giant monster meteor and it touches the ground. From the moment it contacts the ground we have good models describing exactly what happens and why meteor craters are shaped the way they are. I just found out this afternoon that we know all about it and I'm absolutely flabbergasted at how awesome it is. So, interested in knowing why meteor craters are shaped the way they are?

Natasha: Of course, I want to hear about the meteor cakes.

Ben: Yeah, me too. Come on Lissa!

Lissa: Ok so the biggest um misconception about how craters are made is that if you drop a bowling ball onto a memory foam bed and then you pickup the bowling ball again there's going to be a hole there, right?

Natasha: Right

Lissa: That's exactly what doesn't happen.

Natasha: Oh!

Lissa: So, what actually happens has to do with shockwaves. So think about like a soundwave, right, its just like a compression of air going back and forth. Shockwaves are just like a soundwave except they are going super fast. They are going faster than sound through the air. What happens when a crater forms is the asteroid is going super fast and its going to hit the planet and as soon as it touches the planet, because the asteroid is going so fast, its going to release the shockwave into the planet. And the way to think about this is, so imagine that there are a whole bunch of people in a crowded room and everyone is kinda spaced out evenly, and then someone right in the middle of the room throws up right, super gross. So, like, the people closest to the person vomiting are like oh man, I really want to get out of here so they turn around and start running in any direction that's not toward the guy vomiting, right? But they're going run into other people so then they have to push them out of the way and it sort of becomes this group of people that's pushing further and further and further away from that one central point and so that's exactly what's happening with the schockwave and the impact. As soon as the asteroid or comet hits the surface of the planet it sends out this shockwave that pushes all of the rock material further and further and further away from that one central point. It's not the actual asteroid that's carving out a hole but the shock, because it's been moving so fast, that pushes the rock out of the way and thats what makes this round hole crater is all of the rock trying to move as far away from that one central point as fast as possible.

Natasha: Does the shockwave mimic the shape of the meteor at all?

[12:34]

Lissa: It doesn't really matter what the shape of the meteor is, it could be like a cubic asteroid and it's just one corner of that cube hit, as soon as that happens because basically it's punching the planet so as soon as one piece of it that's moving really fast punches the planet, the rest of it will happen.

Natasha: I see.

Lissa: So you might be wondering, does the shock keep going on forever and like, why don't we just get these like super, super giant holes that are always growing and the reason that doesn't happen is because the further and further away from the impact point that the shock gets the weaker and weaker it gets so just like my analogy with the guy who threw up in the room, like once all the people get far enough away it doesn't smell so bad so they stop running. So, eventually the shock stops pushing the material away and the hole that's made by the impact stops growing. What I just told you is was a kind of simplified version of what happens, actually there's not just the shockwave, there's two waves. There's a shockwave and kind of what's an anti-shockwave and it's called a rarefaction. So just like the shockwave likes to push everything together, the rarefaction comes behind the shockwave and it likes to pull things back apart and so both of them are still moving in the same direction, away from the center of the impact, it's just that the rarefaction, while it's still pushing things away is also pulling the individual rocks apart. And so the rarefaction wave is what actually causes the rocks to break into smaller pieces. It's not the shock itself but the wave that comes after it.

Charlie: I don't know if it's perfectly accurate but theres this awesome scene in the Matrix where the helicopter crashes into a skyscraper and the window in bullet time, it shows this ripple coming away from the moment of impact of the helicopter and the ripples pass through the glass but right after the ripple passes through then the glass explodes but for a moment there the glass just shows the ripples and so the shockwave is traveling but the rarefraction hasn't happend yet until the shockwave passes and then it structurally breaks.

Natasha: I feel like lots of anime explosions do the same thing. Like they'll show this pushing of like rock or boulder and like then like a bright light and then the rock will explode and like float apart.

Lissa: That's cool.

Natasha: They do the same kind of thing in lots of anime I think.

Ben: Yeah yeah, that's right. I think.

Charlie: Yes. It's a super cool effect.

Natasha: Yeah, it looks beautiful.

Ben: Yeah.

Natasha: In anime.

Ben: In addition to talking about the shockwave and rarefaction which are the two things that do all the damage, you can also what happens in these cratering events in terms of what happens to individual rocks.

Charlie: I'll try to talk about what happened to a rock grain that experiences this shock. Since the rock passes through it it's going to be compressed to a great degree and it will experience tremendous pressures, pressures that are so high that it will change its state, based on its individual state so this is a fancy thermodynamics concept so this state of matter is determined by the pressure, the surrounding pressure, the temperature, so I'm not that smart so I can think of things like water and liquationous state associated with water so if it's cold enough you get ice under atmospheric pressures and if it's hot enough it turns into vapor but it turns out at really high pressures matter like rock and even ice start doing strange things. And so a particular mineral grain that makes up the rock will, under high compression begin to reassemble itself molecularly and acquire different mineralogical structures. And, so, the liquationous state will take it to a new state because the pressure has got so high and so often an impact craters, in the bowl of the crater, we find really strange minerals so the quartz which is a very common mineral, that's what makes up sand, turns into things like coesite and ??? these are very strange arrangements of silicon and oxygen and so thats kind of the microscopic behavior at these impact sites. And they leave this shockwave, these really high pressures and really high temperatures leave a mineralogical fingerprint. Do you want me to talk about tubes?

Ben:Tubes!

[16:50]

Charlie: So just like the internet, the excavation of impact craters is a series of tubes. These tubes are really interesting because its a way to mathematically, quantitatively, track what happens to material beneath the crater. You can start at the center of an impact event right where the bolide kisses the surface of the planet and from that point you get these arcs that arc into the surface of the planet, radially away from that central point and then curve up, out of the planet and into the sky and so anything between two of these arcs just picture like ten of them or something, anything between two arcs is a tube and so all that material within a tube will travel in that same tube from the center of the impact if it started there or from halfway to the edge of the crater if it started there but will still assume this tubular trajectory, follow that tube and then be ejected at some velocity. Now where the tube exits the crater in relation to the center of the impact event will determine how fast it leaves the crater so stuff thats concentrated in tubes that are very very close to the center of the crater will eject at extremely high velocities. Sometimes so high that they will escape the gravitational pull of the planet and be ejected into space. Stuff that's further away from the center of the crater won't experience this high velocity and won't travel as far and it's often this stuff that's further from the center of the crater that contribute to the ejecta blanket. Now, the ejecta blanket is all the shrapnel from the crater that creates this spray of debris around the crater itself. Some of the first experiments that looked at how these tubes behave are nuclear bomb testing events that occurred in Nevada and it's really crude experimentation but it worked well. They just buried a bunch of Coca-cola cans and numbered them from the point of the explosion and then they let it off, it's called like snowflake, I don't know why atomic weaponry always has this cutesy names because it's pretty effed up if you ask me. Anyway, Snowflake popped and they went around and tried to figure out where all the cans ended up and then they could trace the trajectories. Now we have Maxwell's Z model and that's where the tube theory comes from.

Natasha: This is just to track where things land after a meteor hits to... I'm sorry, I'm trying to figure it out. You want to know where ground goes after impact?

Ben: Yeah, yeah, that's right. Imagine I have a little rock, we'll name him Rocky and he's sitting kinda near the bottom where the meteor's about to hit and the meteor hits and Rocky gets shoved underground and he goes down under his trajectory doesn’t go straight underground, it kind of bounces back up and as he surfaces he surfaces with quite a bit of speed and then so he becomes airborne.

Natasha: Oh, these things go down and then out.

Ben: They go down and then they go back out and the closer the rocks are to center, you know, to the epicenter, the place where the collision happens, the farther they’re going to get tossed. They’ll bounce back out with a faster and faster speed and so ah the stuff really getting close ends up flying really, really far out. Like Charlie said, potentially, in space, the stuff that’s farther out essentially in the crater, ends up kind of hopping out of the crater or making the crater walls and kind of gives the crater its shape.

[20:15]

Natasha: So when you say tubes it’s because these things go around…

Ben: Yeah, well they go down under the ground and then back out. Imagine it as a series of tubes is just kind of a visual metaphor.

Lissa: Think of it like a Space Mountain roller coaster. It starts out at ground level, in the first half there's like a dip then it goes under ground and then it kind of bottoms out then there is a climb and it goes back to ground level and it keeps climbing above ground level into space and then it falls back down again on the ground. So its like ah, it goes down and up and up into space and then back down again.

Ben: So, you know the one that killed all the dinosaurs it fused all these little spheres - these spheres went flying as a result of this you know these tubes, they rocket it out and it got spread all over the earth and so anytime you dig down in the earth you see this layer ashy spherey things.

Lissa: Spheres of glass.

Ben: Spheres of glass.

Natasha: Dragon balls.

Ben: Dragon balls.

Charlie: But that's a real simple look at it. Things get way crazier and that's why impact science is alive and well. All sorts of things come into effect like how dense target is, whether it has paucity, the strength of its gravity there's all sorts of stuff but we can get into it.

Lissa: Whether it's layered.

Charlie: So the tube model doesn't really work but it's a good way to start thinking about it. That's how physicists do their stuff though, they start out with something they can understand…

Ben: And then they give it to the grad students. So, tubes are lots of fun. So essentially this, the thing that is at play that we've talked about, essentially give the craters their shape but apparently there are two different types of craters.

Lissa: So a lot of what we know about impact cratering from the beginning was just from doing experiments where like literally the people were standing on the tops of buildings and using shotguns and shooting bullets down into little sandboxes at street level. Now they have more fancy, experimental impact cratering apparatuses so they're called. They're gas guns where they basically shoot little pellets using gas as the accelerant. They were doing these experiments and it turns out that there are two different regimes for how craters form so one regime is strength dominated. Remember how we were talking about what actually stops the crater from growing, there are two different forces at play. One is the strength of the rock. So, if you are in a strength dominated cratering regime, basically once your shock wave gets weak enough, what that means is its too weak compared to the strength of the rock to basically bend it and push it out any more. That's strength dominated and that we usually see on smaller scales so like experimental scales like when we are shooting bullets at targets but what we see when we study planets are craters that are gravity dominated. What happens in those is that the gravity of the planet is the force thats actually stopping the crater from growing bigger after a certain point. The way to imagine that is have you ever seen one of those, like, super high-speed resolution videos of a drop of water falling into a pond?

Natasha: Yeah

Lissa: So you see it, it kind of makes the hole, and then it like, eventually the hole stops growing right, and it splashes back up and sometimes it makes like a little mountain in the middle, like it splashes higher than the water level then that thing falls back down and it makes all these ripples right? We see the exact same thing happening on craters on planetary scales which is really, really cool. In addition to the simple bowl shaped craters that we see which are normally the smaller, energetic ones, the gravity regime or the gravity dominated craters start changing shapes and some interesting and different looking that you might not even recognize as a crater if I showed you a picture of one. So we have these simple bowl shaped craters and then if it gets a little more energetic like a bigger asteroid or moving a little faster then we get what's called a central peak crater so it looks like a bowl but has a mountain in the middle, which sounds really familiar, right because we've seen those in videos of liquids. And then if we get even more energetic we see like a really big but flat crater that has like one or two rings of mountains around them and then even on some planets we see what these are called central ring craters or peak ring craters, we see them with up to like ten rings around them so that it looks kind of like waves that we see in videos of a drop of water falling into a bowl of water which is really cool. So it seems like somehow the gravity is freezing these craters at different stages of formation the bigger and bigger they get.

Natasha: That's amazing. I googled pictures of it.

Lissa: Yeah, you want to see pictures of these things because they are really cool looking. And we see them all over the place. We see them on rocky planets like the moon and Mercury and we see them on icy planets or icy satellites like Europa which is one of Jupiter's moons. So, we see these whole different range of crater shapes all over the solar system and it basically just depends on how big and energetic the asteroid or comet is that you're hitting compared to the gravity of the planet and how strong the material is that you're hitting it into.

Natasha: So, if a planet has a huge amount, like a high level of gravity, is the crater going to have less of that shockwave impact?

[25:38]

Lissa: The bigger the planet the more gravity it has which just means you need a way more energetic impactor to make the same shape of crater that you'd see on a smaller planet. They're bigger on smaller gravity planets than they are on bigger gravity planets because these things are gravity dominated the bigger your gravity the smaller the crater diameter you need to get these multi-ring impact craters or multi-ring basins.

Natasha: Ok

Ben: Does this mean that we're going to see more of the really cool, like wavy craters on moons than we'll see on like big planets like the Earth, or you know, Venus.

Lissa: Yeah, well, one other thing to keep in mind though is that, for example, Mercury is closer to the sun so in general the things hitting it will be going faster because they are getting sucked in by the sun and so they get accelerated more so its kinda hard to tease out the different effects by just looking at the different crater populations on each planet, but yeah, if Europa which is an icy satellite of Jupiter is about the size of our moon we see lots of these ring crater structures on Europa and on Ganymede which is another of the icy satellites. If you want to see the equivalent structure on Earth it has to be a way, way bigger crater. So on Europa those ring structures happen for craters that 40 kilometers in diameter but on Earth a 40 kilometer crater wouldn't necessarily have all of those rings going around it. It would be a more traditional shape.

Charlie: Alright Natasha, should we move on to the thing that blew my mind this morning?

Natasha: Yeah that's exciting.

Ben: Charlie, tell us about the thing on Mars.

Charlie: Alright, impact events are incredible geological events and this actually wasn't even known till like the 60s. The guy who started thinking about impact events as a geological phenomena like a volcano or plate tectonics or something was Eugene Shoemaker. Turns out they are one of the most significant geological events. We just don't see them on a daily basis and so we just didn't realize it was occurring and if you're going to be a planetary scientist you have to pay homage to impact craters because they define the planetary bodies and you can use them as clean slates to determine what happened, once one has formed, to a particular area of a planet. And so some of the most exciting things are, of course, are the biggest impact crater events that have happened on a particular planetary body and usually planetary bodies kinda max out. You can get an impact event just big enough that you don't entirely destroy a planet and so one planetary body that's suffered from about as big of an impact event as it could have without being completely destroyed was Mars. And so, I don't know if you've ever seen the globe of Mars is most easily seen if you look at a topographic map. It turns out that Mars, the entire northern hemisphere of Mars is low and the entire southern hemisphere of Mars is high and if you look at the surface features the northern hemisphere of Mars doesn't have too many craters, the southern hemisphere has about as many craters in a given area as the Moon. It's just totally riddled with craters. One of the most prominent theories for explaining this is that Mars suffered a massive, massive impact event so big that the entire half of the planet is an impact basin and then the other half of the planet is a big ejecta rim.

Natasha: Oh

Charlie: It's like half of Mars got pied in the face.

Natasha: Right, it's like a sucked in face.

Charlie: It's absolutely incredible, any much bigger than that would have totally destroyed the planet. And so, the whole northern half was probably liquified and became a magmatic ocean. The planet probably oscillated like a piece of silly putty, like squeezed inward and outward over the course of a few days. It probably scattered a tremendous amount of ejecta that smashed into moons that may have existed before the two moons that are there now. Mars was a very, very different place before this happened.

[29:44]

Natasha: So, for awhile it wasn't spherical?

Charlie: Yeah, it's actually not terribly spherical now. It's like an onion and you know how onions have layers? It's like the top half of the onion is missing it's top layer. It's like a kinder egg or something, I don't know.

Natasha: Right. Wow.

Charlie: And it's totally redefined the planet. It's doing these incredible things so now there's, it's called the dichotomy and a dichotomy just means the difference between two different things and so it's the polar dichotomy that controls the weather because there's a highland and a lowland. It controls the movement of water and carbon dioxide, it controls temperature in various places and so, I think it's pretty amazing. It totally redefined the planet. But, other planets have been entirely redefined by impact events too.

Lissa: Okay, so actually, it turns out Earth got pied in the face too once upon a time. Way, way back when, like 4.5 billion years ago when the Earth was just forming, well, so let me back up. So the definition of a planet, this is very controversial because, you know, Pluto got demoted as a planet, it's not a planet anymore, it's a dwarf planet. So, a part of the definition of a planet is an object that is orbiting around the Sun, it's gravitational cleared it's own path, right. So it's like PacMan, right and like everything that's in it's path around the Sun, each little planet, PacMan has eaten. So, that's the definition of a planet but when the solar system was still forming all of those little PacMan planets were still kind of taking care of all the left over scraps and eating everything that was in its orbit as it went around the Sun. So, it turns out that when the Earth was still a brand new baby Earth and everything was molten and you know, it had just basically formed, there was another little planet in an orbit that crossed what we now think of as Earth's orbit and they actually crashed into each other so this other planet was about the size of Mars and they didn't crash head on, they like whiffed each other and they whiffed each other really slowly. It was kind of like a slow motion, you know…

Charlie: It's like two boys starting a fight in middle school where they hit shoulders against each other.

Lissa: But what actually ended up happening was because, Mars is a pretty big sized planet plant and so, for a planet that size to hit Earth is not something to sneeze at. And so they kind of smashed into each other and broke apart and basically both of their mantles, their outer onion layers got stripped off during impact and the core of the Mars sized planet kind of got assimilated into the Earth sized planet because it was bigger so it had more gravity but both of their mantles ended up getting sprayed out into space but because you know, now there is this little proto Earth there they're kind of gravitationally trapped in this disk so they're kind of like orbiting Earth in this disk, kind of like Saturn's rings right and then over the course of like a few days all of this material that's orbiting around the new earth that kind of has a Mars sized core assimilated into it, all of that stuff re-coalesced and that's what our moon is today.

Natasha: Whoa!

Lissa: So that’s our current working hypothesis of how the moon formed. It was a giant impact between the Earth and a Mars sized planet right when everything was still forming about 4.5 billion years ago.

Natasha: That’s amazing!

Lissa: I know, right!

Natasha: I didn’t know that, that’s great.

[33:02]
Ben: Well that was fantastic! Oh, so good! Thank you Lissa, thank you Charlie, you pleased me! Your efforts have born fruit and that fruit is sweet! Here’s some fruit. Lissa, you get a peach.

Lissa: Yummy.

Ben: And Charlie, you get a plum.

Charlie: Delicious.

Ben: You know what they have in common? They both have pits! Like a crater. I want to thank my guest Natasha Allegri from Adventure Time and all the fantastic cartoons she does. Thank you Natasha!

Natasha: Thank you so much!

Ben: I hope you had fun!

Natasha: I did, that was great!

Ben: Awesome!! Alright, So, to close the show, hey, Tie Fighters, you my fans, listen, I know you love the show and I love hearing from you and lets suppose you want to interact with us, the Titanium Physicists, there are a variety of ways! Why not try following us on Twitter at titaniumphysics or join our Facebook group, if you’d like to hang out with us and socialize, why not join our online forum, the BrachioBoard is a fun place where the fans of the BrachioMedia network gather to chat about science and things. So, let’s suppose you want to send me an email directly, let’s suppose you want to propose a topic or ask me a question, email your questions to barn@titaniumphysics.com or if you just want to tell me nice things email tiphyter@titaniumphysics.com because I’m always happy to hear nice things about the hard work we do, okay so, that’s it for the main part of today’s show. Remember that if you like listening to scientists talk about science in their own words you might also want to listen to other shows on the BrachioMedia Network like the Weekly Weinersmith where Kelly and Zach Weinersmith talk to academics about their research or Science Sort of where Charlie drinks beer. So editing support for the Titanium Physicists podcast is provided by a gentleman named John Heath - thanks John you’re doing a great job! The intro song to our show is by Ted Leo and the Pharmacists and the end song is by John Vanderslice. Thank you my friends and until next time remember to keep science in your hearts.

After Song:
[35:51]

Charlie: There's this thing that physicists describe how energy dissipates and it's called a $1/r^2$ rule. And that's just because we live in a three dimensional world so energy dissipates away in this like sphere so the bolide or meteors carrying all this kinetic energy, energy associated with motion and mass and then when it strikes all of that energy has to go somewhere and so it gets transferred into momentum and a shockwave and heat and this shockwave will move away in this three dimensional sphere or hemisphere in the case of a planet. Thats how so many different forms of energy dissipate. They just spread out from a central point.

Natasha: Well, I have these questions but I don't know if it's because I know untrue science facts but they say there's bacteria on Mars, is that true?

Charlie: No.

Natasha: No, okay, then never mind.

Charlie: We don't know yet. There very well could be bacteria. In my mind I could easily see how there could be bacteria on Mars, there's bacteria all over Earth. Ancient Mars had what we call warm and wet conditions, it was above the freezing point of water so there was liquid water all over the surface of the planet that would have been a great place for bacteria to live and under the surface of Mars today, we haven't detected it but all geophysical models point to the fact that there's water underneath the surface, well, there's water on the surface so that means that there's water underneath the surface and the deeper you go into a planet the warmer it gets due to radioactive decay of elements within the crust so that's why if you deep into a mine on the Earth it gets really, really warm down there. And so there will be a point where that frozen water on the surface that then is underneath the surface will then be liquid so there's likely to be aquifers on the planet Mars and then the final line of evidence is that because Mars and Earth are relatively near each other within the solar system rocks from Mars due to impact events and again, this is why impact events may be our friend, can kick rocks from Mars onto Earth and rocks from Earth may have been kicked by impact events all the way to Mars and the one crude analogy that often, people tongue and cheek say that baby Mars and baby Earth were like two toddlers in daycare sharing each others spit so they're going to come down with the same disease, the same disease being life.

Natasha: Right

[38:12]

Ben: Natasha, were you asking about the meteorite where they found bacteria?

Natasha: Yeah. Yes.

Charlie: Oh, Allan Hills

Lissa: Like early 2000…

Charlie: 1998. It was during the Clinton administration because there was a press conference.

Lissa: They found this meteorite in Antartica which is where we find a lot of meteorites. There's actually an expedition every year, it's a group of people and they basically get on these snow machines and they go in a row basically, basic search pattern and they are looking for anything that doesn't look like snow, right because that's the easiest way to find a rock. If there's a rock just laying by itself in the middle of the snow in Antartica then probably it came from outer space. So…

Charlie: Or somebody totally trolling them and just laying them…

Lissa: Or there's some you know, evil alien sorta like planting these little things in Antarctica and laughing at us.

Ben: They'd still come from space if it was aliens.

Lissa: That's true, that's true. So, anyway, every year they look for these meteorites and there's a place in Antarctica called Allan Hills and so they found this meteorite and they determined that it was from Mars and one of the ways to do that is to test the trapped gasses that are in the meteorite, so if you cut it open there are little gas bubbles in the pores of these rocks and you can test those gases and say like hey that matches the atmosphere of Mars which in and of itself is pretty awesome. So, anyway they figured out this thing is from Mars and they were looking at it under some crazy, I guess it was an electron microscope, so, I'm not sure about that, and they found this thing that looked like a little worm. And so, everybody kind of went berserk and it went up and up and up the chain and the thing about it though was that, so it looked like a little segmented worm but it was smaller than bacteria as we know it today. So that if it was life it would have had to be smaller than what we understand the requirements are for life today but it was so very wormy bacteria shaped that it was hard for anyone to believe that it wasn't life.

Charlie: The Jury I guess is still out but yeah, it's so small that the fundamental chemistry of life like things like water and sugars and stuff, proteins, those molecules don't fit in it. Those molecules are too big for the size of this worm and so it's teeny, teeny, teeny tiny and so its a different kind of life if it is life or it's not life or it could be some abiotic, weird mineralogical, formation, whatever.

Lissa: Right. So, kind of the explanation that they've kinda come up with to explain why this thing looks like a worm is that it's like a very weirdly shaped crystal mineralogical thing that formed on its own in the shape of a worm which isn't a very satisfying explanation but thats… it's not like, so it's got to be a rock so let's just say that a rock can form in this shape.