Astronomy Cast Episode 258 for Monday, March 26, 2012: Viking Landers

Fraser: Welcome to Astronomy Cast, our weekly facts-based journey through the Cosmos, where we help you understand not only what we know, but how we know what we know. My name is Fraser Cain; I'm the publisher of Universe Today, and with me is Dr. Pamela Gay, a professor at Southern Illinois University – Edwardsville. Hi, Pamela. How are you doing?

Pamela: I'm doing well. How are you doing, Fraser?

Fraser: Good, so apologize to everyone for the big delay between this episode and the previous episodes, but we're backdating because I was away on a European trip with my family, so… We had hoped to record a bunch of episodes in advance, and ran out of time and so that had to wait, but we're going to catch up really quickly and get back into a regular schedule as soon as possible. So look forward to more Astronomy Cast goodness shortly. Do you have any news on your path? You've got a million crater challenge going on, right?

Pamela: [laughing] We have a million crater challenge going on. Fraser and I, as you may have heard, are part of a new project called CosmoQuest at cosmoquest.org, and this is a research facility for the public, and one of the science projects that we're encouraging you to help us with is an exploration of the Moon, where we're trying to figure out what is the most effective way to map the Moon, pitting your skills against those of computer algorithms, and we're challenging you during the waxing period of the Moon for this Global Astronomy Month in April to mark 1,000,000 craters. So we launched in on Saturday, we're up over 50,000 craters already, but we've got a long way to go by that May 5 full moon, so join in, register for the site. If you don't register, your craters don't count, and there's prizes for people who hit the 100,000, 200,000, 300… and so on mark, and then 10 random people will also get prizes, and prizes range from Surly Amy pendants to posters to lunar lithographs. So get involved, help us accomplish science and maybe get a warm fuzzy. When my researchers do good work for me I feed them donuts. Shipping donuts doesn't work so well; we'll ship you lithographs instead.

Fraser: Right, but the key is: for science.

Pamela: It's all for science.

Fraser: This is real science. This is not just some fake "make work" project. You will be doing actual science identifying craters.

Pamela: We've already published our first initial results, so it's a matter of let's keep going; let's discover as much as we can.

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Fraser: Alright, so last week, we talked about the orbiter portion of the Viking missions, but that was only half the adventure. Each Viking spacecraft carried a lander as well, which touched down on the surface of Mars searching for evidence of past and current life. What they discovered then is still up for debate now. And what's really great about this episode, I think, is that there's been a lot of recent controversy (well, there's already been lots of controversy, but now there's been even more recent controversy) about the Viking mission and whether or not they discovered life. So this one really truly is ripped from the headlines.

Pamela: It's actually kind of a good thing that you went on vacation when you did…

Fraser: I know!

Pamela: …because if you hadn't, our entire podcast would have been entirely different, and that would have just been embarrassing.

Fraser: I know, and then right after, there would have been some really interesting stories. So then let's before we kind of explain everything, why don't we go back then and talk about it. So what was the…last week we talked about how the Viking missions had this orbiter portion that circled around and made some amazing discoveries and contributions about identifying landforms that looked something like…like water was active in the past, but the coolest part really was these landers that dropped to the surface of the planet. And so how did that whole part of the mission work?

Pamela: Well, it's a lot like you say. They had landers, they dropped them, they had parachutes, they had retro rockets, and it was kind of neat because they looked a bit like beetles or turtles with their legs tucked in, and as they descended and fired their retro rockets, their little legs came out and they landed securely on the surface just like every science fiction movie ever trained us to imagine.

Fraser: And this is a very familiar landing system. I mean, the one that was very different was what happened with Spirit and Opportunity…

Pamela: And Pathfinder…

Fraser: And Pathfinder, right, when they had these airbag systems, and they would come down by parachute, and they would slow down, and they would drop and bounce along the surface. But the Viking one is very similar to what we saw with the Polar lander where it actually gently touched down on the surface of the planet.

Pamela: And it's a matter of difference in weight (which costs money), difference in, well, what's required in order for the mission to succeed. Pathfinder was basically the size of a Tonka toy you might give your two-year-old to play with. It was a robust little rover, and dropping it and letting it bounce – it was fine with that. The Viking experiments, however, they had to have the correct orientation. They had a lot of delicate experiments on board, and they just weren't ready to be dropped. They also weighed more. At the end of the day, well, you don't fall faster when you weigh more; you do have a whole lot more energy that you impact the surface with. When that $\frac{1}{2} mv^2$ hits the surface of the planet and with the parachutes and the retro rockets, they were able to dump that energy into friction, get rid of that energy by expending their retro rocket fuel, and it just led to a safer, safer landing for these heavy-weight and very delicate instruments.

Fraser: And both landed successfully.

Pamela: Both totally landed successfully.

Fraser: The technology…again, you think about the kind of technology they had available to them at the time…

Pamela: This was '75 when these things launched! We were little kids!

Fraser: And the list of failure of these Mars missions just goes on and on and on -- that landing a spacecraft on the surface of Mars is an incredibly difficult process, and it's a place where your dreams go to die. And yet these two spacecraft landed safely and did some science -- one more then the other, but yeah.

Pamela: And what was amazing was, like, Viking I refused to die.

Fraser: Yeah!

Pamela: It was the little mission that kind of like Spirit and Opportunity just kept going and going and…yeah! So for six years and 116 days this spacecraft sat on the surface, digging, looking up, watching the weather, just being a happy little robot, taking scientific readings…and I'm sure there were a lot of scientists that were frustrated that it didn't have more data that it could take because it only carried so many…there were a lot of biology experiments on board, and they could only do so much, but yeah, it was just really kind of awesome. And part of the reason that I'm saying Viking I lived forever wasn't that Viking II wasn't as good as Viking I, but they landed in different places. So Viking I landed much closer to the equator, and that meant it had a lot more direct sunlight. Direct sunlight means charge the batteries faster, you get a little bit of dust on your solar panels, you're fine, but Viking II it was twice as far north. So with Viking I it was at 22.48 degrees north, with Viking II it was up at 48.3 degrees north, so that's significantly further. That's like you're in Canada if you want to be on the planet Earth thinking about it.

Fraser: And on Mars, which is extra cold.

Pamela: Right. And it's not just extra cold, I mean, cold matters -- they do have to keep the electronics warm, but the sunlight's just coming in at that much steeper of an angle, and it's not going to illuminate your solar cells as efficiently, and it's not going to charge your batteries as quickly, and the batteries just eventually died, and that caused the one Viking mission to just not quite last as long as the other one did.

Fraser: And so what was the main objective with these [missing audio]? Again, it was very ambitious.

Pamela: This was the set of missions that were going to figure out if there was life on Mars. This was back in the days where NASA was still allowed to be looking for life. There was an actual a political moment in the '70s where, kind of, the mandate came down that NASA was not going to expend its energies and resources looking for life, but this was prior to that when looking for life was still cool. And so there is a whole series of different experiments onboard each of these exactly identical twin rovers, and these two pairs of experiments were going to sample in two different locations: does the soil have carbon-based molecules in it? Does the soil have stuff in it that metabolizes just the…does the soil have stuff in it that exhales? Does it…just all these little, tiny experiments, and when I say little, tiny, I mean, literally little, tiny because they had to get carried all the way there, and unfortunately, we didn't fully understand the chemistry of Mars' soil at the time and it's only now with Phoenix lander and we'll hopefully learn even more. With Mars Curiosity Science Laboratory, we just didn't fully understand the chemistry of the soils, and without understanding your starting point, it's hard to design experiments that will get you to a specific end point -- and this has led to controversy.

Fraser: Right, and this is the big controversy, right? And again, the whole process was just so ambitious, right? Let's send a spacecraft that's equipped with enough experiments inside of it, and then let's give bacterial life whatever it wants. If it's there, we should see some kind of output. Let's give it water, let's give it warmth, let's give it potential food sources, and all that kind of stuff, and the right gases they might require, and hopefully, the bacteria will do whatever it does in response, and I guess…and what was the result? Back in the day, they performed the experiments, and what did they find?

Pamela: That they were confused.

Fraser: They were confused. Really? Is that what they said? No, they didn't. They didn't say, "Oh, we're confused," they said, "something's happening here."

Pamela: So it's always been *as a community* we've been confused. With specific individuals, "We did," or "We didn't," and then many of us in the middle going, "We don't know. We don't know." So they had four different experiments onboard, and the first one was a very simple we-don't-necessarily-know-if-we're-going-to-inadvertently-kill-life-with-the-nutrients-we've-brought-so-let's-just-look-for-organic-molecules, so the gas chromatograph experiment got a sample of the soil, heated the soil up and through heating it, broke it into its different constituent pieces and used a gas chromatograph and mass spectrometer to measure what are all the different constituents of the soil. Now, the fact that they heated it up is the key clue for understanding these results because it turns out that there are certain chemistries that when you heat them up, break down any organic molecules that might be present. When they ran this experiment back in the 1970s, the result of the experiment was there were fewer organics than like a scoop of sterile soil here on Earth, and that was sort of a no-life-on-Mars result, but it turns out there was a chemical present in Mars soil: perchlorate, and this particular chemical, when heated and mixed with organics, breaks down all of the organics, so even if there had been organics in the soils, this particular experiment turned out to be precisely designed to destroy them. So that's a null result.

Fraser: Right, because the perchlorate is not good to life, right?

Pamela: No, no. Well, it just breaks down; it's a dissolvent, essentially, for organic molecules, so it's sort of like washing everything in acid is the best way to think of it.

Fraser: Right, dropping your soil in bleach and seeing what you find.

Pamela: Yeah. No, all the bacteria are dead, thank you very much.

Fraser: Who can find the live bacteria in this bleach? What's going on?

Pamela: So the perchlorates, when heated and mixed with the soils, would have quite happily destroyed any and all organic molecules – no life for you. So that counts as a null result, but we didn't understand it was a null result until Phoenix got there, and Phoenix found the perchlorates that we didn't know were going to be in the soils. So at the time, it was a "there are no organics" was the way to read that particular experiment, which was frustrating. Now, the second experiment was a gas exchange experiment, and this was another one that took a sample of the soil. In this case, when they say heating, they say incubating, they're trying to inspire life to do its normal thing, and so they scooped up some dirt, they added a bunch of organic and inorganic nutrients, mixed it up, and then they looked for respiration. They looked to see what are the concentrations of things like oxygen, CO_2, nitrogen, hydrogen, methane -- things that you would expect that the ratios of these different atoms in the atmosphere of the container would change as you have life forms respirating. And how they would change would depend on the life form. So, they didn't go in with a "we expect to see carbon dioxide exhaled; we expect to see methane exhaled." They went in saying, "We're going to look at all the things we know life inhales and exhales and see how it changes."

Fraser: Right, you can imagine, right, the surface of Mars is such a toxic environment with the radiation blasting down and the cold temperatures, the lack of liquid water, and perchlorates in the soil (which we now know) -- all these things that are counter to life. But you can also imagine that life, as they say, always finds a way that it can last in these really extreme environments. Maybe it just hibernates and waits for periods when the soil is a little damp, or maybe the sand covers it up a little and it gets a chance, briefly, to do some more living. I guess that was the goal, right, that you would start to give it some of the ingredients that it might require and see what happens.

Pamela: And we know there are examples here on Earth where there's various bacteria, there's various parasites, there's various fungi spores, that when the conditions get too dry, they just basically ball up into these inert balls. That's a boring way of putting it, but that's what happens.

Fraser: They hibernate; they wait. They wait for whatever it is they require to come out.

Pamela: And all it takes is a very brief smattering of millimeters of rain, and suddenly everything is able to complete its entire life cycle before the water dries up again. And they were kind of hoping that maybe there was that sort of life form that all it takes is that moment of being warmed with nutrients, and life would spring back into existence, but no. No life for them, again. So we have one null result, we have one no result…

Fraser: Right, so the first result being "We screwed up the experiment,"

Pamela: "We killed anything."

Fraser: The second one being "We didn't find what we were looking for," so negative result.

Pamela: So the next experiment was a Labeled Release (LR) experiment, and the idea here was we're going to feed anything that might be in the soil sample carbon 14, which is a radioactive form of carbon…carbon 14-based nutrients. So they took a soil sample, they dropped in the solution of nutrients that were tagged with the carbon atom, and then they looked to see if there would be respiration that would cause the amount of carbon 14 in the atmosphere of the chamber that this is going on to change. So the idea is that if you consume radioactive carbon, you're going to excrete radioactive carbon, and exhale radioactive carbon, and what goes in has to come out, and so they looked for that over time.

Fraser: Poor little bacteria, you know? They should have been a little more careful at this "never look free nutrient soup in the mouth," but yeah…

Pamela: Well, you're tagged with carbon 14 as well. This is how we figure out how long things have been dead on Earth …

Fraser: It's just more, you know, it's more. Let's just mix in a little carbon 14, a little radioactive carbon 14 in your meal. Yeah, soup's on!

Pamela: It tastes good with your Wheaties.

Fraser: Yeah, yeah, they loved it. It's delicious…spicy.

Pamela: Well, and the thing is, they seem to have loved it and thought it was delicious. Well I can't speak for spicy – they're molecules, but this was the most intriguing of the experiments because they watched it, and lo and behold, everything they anticipated happening happened. There was this gradual systematic build-up of carbon monoxide with carbon 14 atoms in the molecules within this chamber, completely consistent with metabolizing it, and they tried doing the same thing with comparison samples, and all of the results worked out consistent, but then everything else was a mess and so this led to a lot of "Well, maybe it's just a chemical reaction, and the chemical reaction when you dropped this in caused things to happen, and the things that happened just happened to release this gas in a systematic way."

Fraser: Yeah, now you're saying all that in your skeptical voice, right? You know, your grumpy, skeptical voice, but I think, when the experiment turned …showed up exactly what people were looking for, that's the beginning of this inquiry, right? That's the starting point. Again, with the previous one: negative result, then let's agree that nothing happened. But then, this one: positive result, needs more science.

Pamela: Right, and this is the one that has continued to be debated since this, basically, data was taken when we were still in diapers, and so that's an entire couple of academic lifetimes of research that have gone into this and when we do find life – it's not *if* we're going to find life, it's *when* we do find life -- it's going to take extraordinary evidence for people to believe it, unless it walks up to us and pokes us in the face.

Fraser: "Pleased to meet you. Have some radioactive soup."

Pamela: Yes, when they start feeding us carbon 14, we'll believe it.

Fraser: Yeah, yeah, exactly. "Wait a minute. This has a lot of carbon 14 in it." "No it doesn't, Earthling." Right. Yeah, but no…so this is the one that has been debated back and forth for years and years and years, but you said there were four experiments, or do you want to talk about this one some more?

Pamela: Well, so the fourth experiment -- it's another one of those "Huh… OK." So this is another one where they looked at what are the things that go into life. So, in general, you need light, you need water, and we look at carbon being present because we're assuming that the life we're looking for is going to be like the life as we know it, so carbon-based, not silicon-based or something else in that particular column of the periodic table. And so this is another one, again, where they're looking at the radioisotope of carbon 14, and in this case, they're looking to see if there's photosynthesis present. So again, take everything -- and here they were mean. They gathered everything together, and they baked it until all the gases were removed, and then they collected everything and looked to see if the carbon 14 in the atmosphere of the container had been converted into a biomass. So basically, once you bake all the gases out, has the carbon in the atmosphere been respirated into stuff? So think here on Earth of carbon fixation that happens in plants that convert atmospheric carbon into part of the tree. And so when they looked at this one, it was one of these things where it was actually completely inconclusive result. They looked at it, they considered the chemistry that had happened, and it just didn't match anything, so this is the one that gets talked about last because chemistry as we anticipated didn't quite happen on Mars, so neither positive nor negative, simply a "Oh, that didn't behave as we expected," so there were four experiments. First one: if there was life, we killed it by baking it, second one: no evidence whatsoever, third one: total evidence, fourth one: oh, that didn't work as we expected. So four experiments, two spacecraft, confusing results, a lot of people sitting back going, "This isn't sufficient evidence to say there was life. This is sufficient evidence to want to go dig more." And with the funding structure the way it's been, this has become justification to go look for water, and with the Mars science laboratory Curiosity we're not necessarily going to be doing life-specific experiments, but we are going to be continuing to look for the chemistries required for life.

Fraser: Now, doesn't that decision strike you as kind of weird? That, you know, finding life on Mars would be on the pathway to perhaps the most important discovery in scientific history, right? If you discover life on Mars, then maybe that means more life in the rest of the Universe, and maybe if that's completely unrelated life, then that's super- interesting, and if it's related to earth life, that's still really interesting. You have a, you know…and so you get an inconclusive result, but a very interesting result. You know, I think any scientist's first experiment is run the experiment again, you know, let's fix all the mistakes that we made and let's run the experiment again. Let's get another, you know, we've already got a mission, we've already got a blueprint on how to build it, let's just send another couple with some fixes to sort of catch the mistakes or the misunderstandings we had the first time and let's get to the bottom of this. But instead, NASA went in a completely opposite direction. They went, "You know what? Too weird, too hard… Let's go look for ancient water." And then created a completely different mission profile searching for ancient history, you know, ancient water, so I find it…it's a very strange, and I don't want to sound conspiratorial because that's not what it is. It's political.

Pamela: It's Congress.

Fraser: It's a political thing…yeah.

Pamela: And I honestly think with things like Mars Science Laboratory, it's at a certain degree a Hubble-like mission. The Hubble space telescope was launched with two key goals: to measure the expansion of the Universe (Hubble constant), and to figure out what the heck planetary nebulae are. And look at everything else it's been able to do! It's a beautifully built, diverse mission that was funded and launched with a very focused science goal. And Mars Science Laboratory isn't quite that focused, it is a "kitchen sink" mission. It has a ton of different experiments on it, and its goal is to study the chemistry of Mars because you can't say it's going to study the biology of Mars because there's lots of people out there who think looking for life is dumb, and a waste of resources, and a waste of money. But at a certain level, astronomy is physics, which is mathematics. Chemistry is quantum mechanics, which is physics, which is mathematics. Biology is chemistry, which is physics, which is mathematics, and so when we say we're launching the Mars Space Laboratory to study the chemistry of Mars, there's a lot of potential to do a lot of off-label usages.

Fraser: Yes. Yeah, exactly. If you ask a scientist working on that, "Are you guys looking for life?" They're like "Noooo." But, you know – wink, "No, we're not looking for life." But that is such a sophisticated rover with all kinds of amazing scientific instruments on it and the ability to go wherever they want with power to run for a very long time. This is, if not an absolute life finder, it's going to get us pretty close.

Pamela: Right.

Fraser: So where do we stand now? Because you mentioned sort of at the beginning of the show that this is sort of ripped from today's headlines that if we'd recorded the show a week earlier, a month earlier, then we wouldn't have known this stuff, so what's all the most recent stuff that's come up on this story?

Pamela: So that Labeled Release experiment…there have been communities within the astronomy, and astrobiology and planetary science community who've been trying to say "No, no, no. All of that observed metabolism, that was clearly just a chemical reaction." So they've been trying to model what sorts of chemical reactions can produce the carbon 14 release that was observed over time within these chambers, and they've gotten so that they can figure out how you get it released. But people who have recently done what's called a complexity analysis of the data (this is where you look to see if we look at all the fine variables), if we look to see over time: do the ways in which we observe in the laboratory these possible chemical reactions? Do they actually match the systematic results we saw, or not? What we find is the amount of randomness inherent in the carbon release within the laboratory experiments is a much greater amount of randomness than the systematic release that appears to replicate what we see with metabolism. So you can sort of imagine: you take an inert bacterium, get it all happy and respirating, and it's just going to start breathing and it's going to keep breathing, and it's going to do this in a systematic way, but if you've ever done the Alka-seltzer and vinegar experiment, or Mentos and Coca-cola experiment, you know, you drop it in, massive reaction that then tapers off over time, and it varies every time, depending on how things get dropped in. But that little bacteria -- it's just going to breathe, and so what was observed matches the respirating bacteria much more than it matches the random chaos inherent in a chemical reaction that's allowed to just do its happy chemical reaction thing.

Fraser: But does it not necessarily match a starving bacterium that hasn't seen food for 74 million years and is just trying to gobble up as much as it can before the inevitable…?

Pamela: It DOES match the bacteria is the thing.

Fraser: Right, right.

Pamela: It doesn't match the chaos of a chemical reaction, so complexity analysis is now pointing to this, according to one community within the planetary science, astrobiology, astronomy community, according to this one group of researchers, this was evidence for life that we've simply been in denial over for the course of most of my life and yours.

Fraser: But, again, you know, you get to the bottom of it, and you have two groups essentially saying slam dunk, it's life, but it doesn't matter, right? Like, here we are, like, slam dunk, it's life, or is it until the next paper comes out, and the reality is just because we don't have this ability to go and just check soil again, in a comprehensive way, we can't get any further than this. We're stuck at we're pretty sure it's probably life, based on this 35-year-old research, this data that was gathered and it's sitting in a computer tape somewhere, but that's all they've got, and it's the need for ongoing discovery and exploration. Send those kinds of experiments back to the surface of Mars and keep looking.

Pamela: And I really hope that they don't send human beings to Mars until they figure this out because imagine the person who, without thinking, wipes their nose on their hand, grabs their spacesuit, gets bacteria from their nose on the outside of their spacesuit, climbs into their spacesuit, and then gets snot bacteria all over the surface of Mars. We don't want to go to Mars as plague carriers.

Fraser: Yeah, and I know that in recent…some people have been proposing just recently much tougher, more stringent measures on avoiding this biological contamination.

Pamela: Right, and while we'd like to think that most of the viruses and bacteria and prions and everything else on Earth would happily die, or unhappily die as the case may be on Mars…

Fraser: That's what I was thinking "Uh, where am I now? This is awful! What is this place?"

Pamela: But the reality is we have extremophiles on our planet that could probably make it quite easily once they got a foot or so beneath the surface of the planet and so we really do need to be careful not to be plague carriers on other planets.

Fraser: Yeah. Absolutely. Well, I think that wraps up this episode of Astronomy Cast with the Viking Landers, so thank you very much, Pamela. It's great to be back and recording again, and thanks to every body who had some patience. We will be back shortly, and we'll see you all next week.

Pamela: It's great talking to you.