[SLICE OF MIT THEME MUSIC]

ANNOUNCER: You're listening to the "Slice of MIT Podcast," a production of the MIT Alumni Association.

JOE MCGONEGAL: This is the "MIT Alumni Books Podcast," and I'm Joe McGonegal.

Rob Wesson, class of '66, is the author of *Darwin's First Theory,* published in April 2017 by Pegasus Books. For non-scientists, I'll say that the book is a very accessible page turner looking into Darwin's first love, geology, and its influence on the arguments he would make about biology and evolution later on in life. Wesson is a Course 12 graduate and scientist emeritus with the USGS Geologic Hazards Science Center in Golden, Colorado.

Well Rob, thanks for patching in to talk about this book. Congratulations, it's a fantastic read. Tell me what inspired it.

ROB WESSON: Well, a whole bunch of different things, Joe. After spending my career writing scientific papers and bureaucratic memos and so on, I really wanted to try my hand at a different kind of writing. And I wanted to try and outreach beyond the scientific community to see if I could do something that tried to explain a little bit of what scientists do and how they think. And especially geological scientists, because we have a little different way of thinking than a lot of other people.

I was drawn to the story of Charles Darwin, first of all, because I didn't realize before I had 20 years ago first read *The Voyage of the Beagle,* that Darwin had actually been a geologist. I always considered him a biologist. Upon learning he was a geologist and learning about how he thought about things, I was just fascinated by his thought process. He was just a brilliant observer. Once I put these two ideas together, then I wanted to write something about how scientists think and then learning about Darwin and how he thought, especially about geologic processes, I just leapt to the challenge.

The other thing, of course, is that Darwin is such almost a demigod among scientists, and a little bit of an antichrist figure, at least in some circles. Very interesting person, I thought that would be a draw to interest people in the book.

MCGONEGAL: And Darwin is well studied and well-chronicled, but you layer on to the book your own intellectual journey with a lot of the terrain Darwin covered, and do your own research interests.

WESSON: I thought that would also add some interest to it. So I wanted to fast forward the science from Darwin's day into the present. And to show that Darwin's contribution continues in geology, because of the problems he thought about in terms of geology are still being thought about today. Of course, we've made lots of progress, and some of his ideas have been passed by the wayside, but others are still active and people are still thinking about them.

MCGONEGAL: Talk about some of the tools Darwin brought with him on the trip. What are the basic tools of a geologist? You write about these early on the book.

WESSON: Well, his fundamental tool were his eyes. He just observed everything visually. And in terms of actual tools, his hammer. Darwin wrote, geology is a wonderful science to begin, because all it requires is a little hammering and a little thinking, something like that.

Anyway, he had a geologic hammer. He had a compass, a special kind of compass, it's a compass that's also an inclinometer so you could measure the strike and dip of rocks. And a telescope he can look through, and a barometer.

And then you know, he was with Fitzroy and officers of the *Beagle,* and their main job was to make nautical charts. And so they had more elaborate tools for mapping, theodolites and sextants. And Fitzroy, of course, on the Beagle, had a whole array of chronometers, so he could measure latitude and longitude by astronomical measurements. In fact, the *Beagle* made the first round the world chain of longitude measurements by a chronometer.

MCGONEGAL: You write about the exhaustive search for finding what is Rio's actual longitude.

WESSON: Right, exactly. You know, we really didn't just totally figure this out with a great deal of accuracy until transatlantic cables, and of course now with GPS. But determining longitude has always been-- well, up until the modern day, has been a continuing challenge.

MCGONEGAL: If you took Darwin into USGS headquarters, what do you think would be most shocking to him?

WESSON: Well, there's so many different things. In Darwin's day, you were walking or riding a horse or sailing in a boat. Some of the biggest advances in geology have really come from synthesizing

a more birds eye view, if you will, of the terrain and of the landscape and the rocks that are on it. And so beginning with the development of aerial photography in the early part of the 20th century, and then satellite photos and lidar, we just have all kinds of different techniques for mapping the terrain.

The other tool that Darwin actually had on the *Beagle* was a blowpipe that he could use to melt minerals. And if was one of your fused minerals, that was one of his techniques for identifying them. And of course now, we have all kinds of things like mass spectrometers and spectroscopes and all sorts of things. So we can analyze the chemical composition of rocks and make very detailed matches. And we can match rocks by matching the chemical signatures, chemical composition.

Then of course, the one thing that bedeviled Darwin a little bit was the age of the Earth. And he knew the earth was very old. He realized that to create topography through erosion would take a long, long time.

This is one of the main ideas that Darwin championed following Charles Lyell that things hadn't been created all at once, they were really the result of ongoing processes. He was comfortable with the idea that the world was millions of years old. But he didn't have very good proof. And in fact, he got in an argument with Lord Kelvin, the famous physicist from England, British physicist, who made calculations of the age of the Earth based on the idea that it was an iron sphere and that it had initially been very hot and was cooling off. Darwin didn't believe either geologic processes or evolution could have occurred in that time period. So it was a problem for Darwin.

But in any case, now with the advanced chemical techniques of understanding radioactivity using a variety of different methods, I think that would be very satisfying to Darwin that we've demonstrated that there is something like 4.6 billion years old. And there was plenty of time for evolution and for the development of geologic structures and terrain and so on.

MCGONEGAL: The book's titled *Darwin's First Theory.* If we can tease it out a little bit, he's seeking to answer the question behind seismic plates, right?

WESSON: At Darwin's time, they had two ideas. One is Lyell had thought that the continents must have been places where the crust of the earth was rising and the ocean basins were places where the crust of the earth was sinking. Darwin had basically incorporated that thought into his processes. And the second is that most geologists at that time had the idea that mountains

had been formed catastrophically by some remote period in the past.

So when Darwin got going on the *Beagle,* he really had not before been exposed to Lyell's ideas. What training he'd had in geology was kind of more from the catastrophist school. As he was on the *Beagle,* Fitzroy presented him with a first volume of Lyell's *Principles of Geology.* And Darwin quickly came around to the idea that Lyell was quite right.

And so Patagonia, especially on the eastern coast of Patagonia on which is now Argentina, he found a sequence of terraces that he interpreted as reflecting the gradual uplift of South America. These terraces were basically shorelines formed when the continent was lower relative to sea level. As the continent rose up, it formed successively lower terraces.

And then he saw the same thing in Chile and in the Andes. Of course, Darwin wasn't certainly the only one nor the first one to realize this, but he found shallow water fossils at 14,000 feet or so in the Andes. So it was clear that things had gone up.

The question that Darwin faced was how and why did these uplifts occur? And was there evidence? What was the evidence that was actually going down today?

Well, earthquakes provided a possibility. Before he even got to the South Pacific, he had turned this idea around and realized, he realized that corals only grow at very shallow water, shallow depths in the water. So therefore, if you had a big thickness of coral, it meant that the island or whatever the coral reef had been sinking and the coral had to gradually grow up. This developed into his theory of how the coral islands were formed in the South Pacific and indeed in the Indian Ocean and around the world. So he had his tectonic ideas basically, in a way, it was proof that the continents had been, in fact, rising and the sea floor had been sinking.

What Darwin didn't have at that time, nor did anyone, was that continents and in fact, the crust of the Earth had been moving around laterally on the surface of the Earth. And this was what really, eventually led to the idea of continental drift and seafloor spreading and plate tectonics.

MCGONEGAL: And talk about some of the places you've visited where Darwin collected this proof.

WESSON: I went to the eastern Patagonia. And one of the interesting things we did with the individual from the University of Washington, David Catling, we kayaked down Santa Cruz river in Patagonia. And this river basically flows from the Andes to the east across Patagonia and

empties into the Atlantic.

Darwin and Fitzroy and a good chunk of the crew of the *Beagle* pulled whaleboats. They had three of these whaleboats that they initially tried to sail and then paddle up the river, but the current was too strong. So they ended up dragging these whaleboats by a rope. And they went a couple hundred miles up this river hoping to get to the Andes, but they couldn't quite make it. They ran out of food and time.

And this area is pretty far south and very dry terrain. Darwin interpreted the rocks as being evidence for this region having been below sea level relatively recently. And Santa Cruz River was kind of a channel, much like the Straits of Magellan or that Beagle Channel further south.

It turned out that one of the other geologic problems that confounded Darwin a little bit was continental glaciation. Which just as he was actually on this trip up the Santa Cruz River, Agassiz and Charpentier in Switzerland were coming up with the ideas about continental glaciation, which Darwin was dismissive about initially. But anyway, these deposits actually turned out to be glacial deposits. And so Darwin was a little bit off base on that. So that was one of the interesting places.

But the place that most influenced me, actually, was an island off the coast of Chile just south of Concepción called Isle of Santa Maria. Darwin and Fitzroy felt the earthquake in 1835 when they were in port of Valdivia, which is a couple hundred miles south. And then they proceeded north to Concepción and the place was completely wrecked by the earthquake. The adjacent port city of Talcahuano had been destroyed by the tsunami.

At that time, the *Beagle* had only one anchor left. You need to have an anchor, for sure. So Fitzroy took the Beagle up to Valparaiso to get some more anchors. And that's when Darwin jumped off the ship.

And when they'd been at Concepción initially, they'd seen some dead shellfish and some other indications that there might have been some uplift of the coast in the 1835 earthquake. But when Fitzroy went to Isle Santa Maria, he realized that there was something like 2 and 1/2 to 3 meters of uplift on this island. But there were these areas on rocky flats that had been before the earthquake most likely below low tide line, judging by the shellfish and so on that were there. But these had been uplifted. And when Fitzroy got there six weeks after the earthquake, they were stinking and dying and stinking. And he described the stench as being abominable.

When I first got involved in thinking about this following their course, I really wanted to go to this island. And so the first time I went to Chile I went to this place that Fitzroy described at the north end of the island. And there was no rocky platform above the water line at that point. I realized that either the rocky platform that Fitzroy described had been eroded away or the island had subsided.

And Darwin had used this evidence that Fitzroy collected at Isle Santa Maria is a true cause, or a causa vera. This was something that you could really see that demonstrated the uplift of the continents and islands. And after I saw this, I thought well, you know, is there any way we could see what happened?

And it turned out that I was able to find in the basement of the Library of Congress a chart that the *Beagle* officers had made of Isle Santa Maria and especially of an adjacent bay that's pretty shallow. It was about eight meters deep. And they had sounded in this bay. And so on this chart where all these soundings describing how deep the water was.

So a Chilean colleague and I came up with the idea that we should just go out there with a little echo sounder and a GPS and see if we could redo this survey of the *Beagle* and see if the water was the same depth in 2010 as it turned out as it was in 1835 after the earthquake. And when we did this in January of 2010, it turned out that the water was on average about a meter and a half deeper in January 2010 then in April 1835. So it seemed pretty clear that the island had subsided.

Then six weeks after we were there, there was a magnitude 8.8 earthquake. And sure enough, the island popped up again. This time it only went up about a meter and a half, but you could see it. For me, that was just the most amazing-- I mean, it was a sad earthquake because there was a lot of death and destruction from the tsunami in 2010. But from a scientific point of view, it was just amazing.

MCGONEGAL: You include some figures and photos of the Porto Anglais on Santa Maria.

WESSON: In the book, there's photos taken by my colleague Daniel Melnick, who is the guy who I worked with on the survey. You can see all the sea urchins and kelp. And now, actually in the years since 2010, this rocky platform has been covered with sand and a beach is slowly forming. So it's a really interesting example of how you can see the cycle of elastic strain accumulation and release and what its expression is in the natural environment.

MCGONEGAL: Well, we might as well talk a little bit about evolution while we're talking about Darwin. I found some cool historical reference to William Barton Rogers, the founder of MIT, having debates about Charles Darwin with Agassiz. You know, it's Harvard versus MIT before MIT even existed. Tell me about what you've learned about both academic thinkers and the public's thoughts on Darwinian evolution.

WESSON: Well, this is actually a fascinating story. Darwin was kind of on the wrong side of the glacial debate. And Agassiz was mostly on the right side. Darwin eventually came around to the idea of first glaciers high in Wales and in Scotland. In contrast, Agassiz hated the idea of evolution.

Of course, William Barton Rodgers, and he also had a brother who was also a geologist who ended up in the UK somewhere. So William Barton Rogers-- their specialty was the Appalachian Mountains, actually. And they were trying to explain the Appalachians before he devoted his full time to getting MIT going.

When a lot of people talk about evolution, they're thinking about it as a biological problem, which is totally true. But it was also a big problem for the geologists in that time. They realized that the older the rocks, the simpler the forms of life. These forms of life got more complicated as time went on. So they needed to explain that.

And that was one of the motivations that Darwin had to think about species from a geologic point of view. Initially, there was a lot of opposition to the idea in England. But in England, this got worked out pretty well. But in the US, particularly, we have and still have a pretty significant fraction of our population that chooses not to accept the data and arguments and the analysis that lead us toward evolution.

In the book I actually describe a discussion I had with a person with an unusual point of view, and that is a creationist geologist who continues to believe that the world is 6,000 years old. And as far as I can understand, the arguments that they make for this is that the rate of decay of radioactive isotopes may be steady during normal times, but it was not steady during the seven days of creation nor during Noah's Great Flood.

So it's interesting to try and understand why people can be totally comfortable with using an iPhone that is based on physics that involves quantum mechanics. And they go to radiologists and use physics that's based on understanding of radioactive decay and so on. But then when it comes to thinking about the age of the Earth, they reject this same science.

And that's, honestly, a little troubling to me. One of the best science writers today, David Quammen, wrote in one of his books that faith comforts but data persuade. I'm personally comfortable with the idea of people having faith that meets spiritual needs. I think that's terrific. And in many ways, it helps humans get along together. But it troubles me that they have this disconnect between their uses of science and their acceptance of its consequences.

MCGONEGAL: Well, I think nobody can argue that you haven't done due diligence in this book. Tell me, what else are you reading right now?

WESSON: I wrote about in the book just briefly, but I had to throw a lot of it out, about the French expedition to South America in the 1740s when they were trying to measure the shape of the Earth. And there was this big debate. Newton had come up with the idea that well based on gravity and the rotation of the Earth, that the Earth should be a prolate spheroid. That is a sphere that's a little bit pushed down from the top. Oh, I said it wrong. The Earth is an oblate spheroid, but they thought it was prolate, which is more football shaped.

And so this expedition went to South America to try and measure the length on the surface of a degree of latitude. If it is a oblate spheroid, then that distance would get larger as you move to the poles. And if it was prolate or football shaped, it would go the other way.

So anyway, this expedition ended up taking about 10 years and people got murdered and people got married. And there's two really good books about it. One is called *The Measure of the Earth.* And the other is called *The Mapmaker's Wife,* I think. And I'm reading *The Mapmaker's Wife* now.

And then I'm toying with the idea of whether I could try and do another book. And so I'm reading about sea level and early man, Neolithic man and how people were influenced by changes in sea level and changes of climate over the last 20,000 years.

MCGONEGAL: Rob Wesson is the author of *Darwin's First Theory,* published this spring by Pegasus Books. You can find it online or at your favorite local bookstore. And Rob, thanks for tuning in and talking about the book.

WESSON: Well, you're very welcome, Joe.

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