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**Dear Science, How do we know how old the Earth is?**

By Sarah Kaplan March 6, 2017

[1] Here's what science has to say: For millennia, humans assumed that the Earth was about as old as we were. In Roman times, theorists guessed that Earth started around the time of the Trojan war — the earliest event in their historical record. The "begats" in the Bible were another source for estimates: In the 17th century, Ireland's Archbishop James Ussher reconstructed the genealogy of biblical figures and declared that Earth was created at 6 p.m. on Oct. 26, 4004 B.C.

Those dating methodologies didn't hold up to modern science, as it eventually became clear that the birth of our planet far predates the origin of humankind. Scientists now know the Earth is actually 4.54 billion years old, an age built on many lines of evidence from the geologic record.

The modern effort to understand the age of the planet started with Nicholas Steno, a Danish anatomist and geologist who was among the first to realize that fossils are the remains of living creatures. He proposed that geologists might learn about Earth's history by sifting through layers of rock, which were laid down over the course of millennia and provide a backward chronology of our planet.

A century later, William Smith realized that rock layers at distant locations came from the same time period. He created a catalogue of strata (which all got colorful names such as Lias Blue, and Ditto White) and argued that each one represented a distinct time in Earth's history — a principle known as fossil succession.

[5] The accumulating evidence pointed to an extraordinary new idea: that the history of Earth goes back much, much further than any human memory. In 1788, Scottish geologist James Hutton published his “Theory of Earth,” which introduced the world to the idea of “deep time.” The implications of the treatise were revolutionary: Not only was the Earth not young, but it was not static, Hutton said. The same geologic forces that operate today, like deposition, erosion and uplift, have been shaping the Earth for ages with “no vestige of a beginning, no prospect of an end.”

Science provided a new way of thinking about Earth's history; it made the distant past knowable. Rather than assume the planet was the product of bygone catastrophes, such as a massive global flood, scientists could explain the ancient rock record with phenomena that exist today.

This spawned several earnest — if not entirely successful — attempts to determine the age of the Earth based on ongoing natural processes. One calculated how long it would take rivers to deliver enough dissolved minerals to the ocean to give it its current saltiness (answer: 90 million to 100 million years). Others looked at the average rate of sedimentation and concluded it would take anywhere from 3 million to 1.6 billion years for the rock record to reach its current thickness.

But the big breakthrough came with the invention of radiometric dating. Shortly after radioactivity was discovered in 1896, scientists realized they could figure out how old a rock was by measuring how much of the uranium in it had decayed into lead. Here's how that works: The nuclei of radioactive elements decay — or spontaneously break down — at predictable rates. For example, half of a given batch of uranium will decay into lead every 710 million to 4.47 billion years, depending on the isotope used (this number is termed the element's “half-life"). That uranium, which was created during a supernova that occurred long before our solar system existed, lingers in trace amounts within the Earth. When a rock is formed in the bowels of the planet, uranium atoms are trapped within it. These atoms will decay as the rock ages, and by measuring the ratio of radioactive isotopes within the rock, scientists can figure out how long it has been around.

In 1913, geologist Arthur Holmes published “the Age of the Earth,” the first major effort to date the planet using radiometric dating. “It is perhaps a little indelicate to ask of our Mother Earth her age,” he wrote in his introduction — then proceeded to reveal that she was roughly 1.6 billion years old.

[10] When Holmes presented the findings at a meeting of the Geological Society of London two years later, he was “violently attacked” by critics. “I found myself an exasperated minority of one,” he would later recall. But time would prove him right. By the 1940s, the geology community had mostly accepted his revised estimate of about 4.5 billion years — a number not far from the one we use today.

Modern geologists date minerals called zircons, tiny crystals that form in volcanic eruptions and that are hardy enough to survive for billions of years. Zircons consist of silica, oxygen and the element zirconium, but are occasionally contaminated with uranium as they form. Because of the structure of the crystals, zircons never include lead when they are forged inside the Earth. This makes them, as this University of California at Berkeley webpage put it, “nearly perfect clocks.” Any lead that scientists find in the crystals must come from radioactive decay.

To do this, scientists use a technique called mass spectrometry. Put simply, they excite atoms from zircons or other materials, then expose the charged particles to a magnetic field. This allows researchers to sort the atoms by mass and charge, so they can detect the signatures of particular isotopes.

But even the oldest zircons are not as old as the Earth itself. Everything on our world eventually is eroded or subsumed back into the crust. To get a truly precise date for the origin of our planet, scientists have to look beyond it. Meteorites offer exactly what they need. The asteroids that meteorites come from are some of the most primitive objects in the solar system. They were formed at the same time as our planet and everything else in our solar system, but they have not been changed by the tectonic processes that shape Earth, so they're like time capsules.

Our first really solid estimate of the planet's age was obtained from radiometric analysis of the Canyon Diablo meteorite, a giant iron rock that blazed through Earth's atmosphere from space 50,000 years ago and was found by American scientists in 1891. (Native Americans had known about and utilized the iron fragments since prehistoric times.) Researchers used uranium-lead techniques to date the meteorite back 4.54 billion years, give or take about 70 million — the best age for our planet so far, according to the U.S. Geological Survey.

[15] But scientists will keep trying to shave down that degree of uncertainty in their estimate by analyzing every ancient Earth rock, meteorite and solar system sample they can get their hands on. As the U.S. Geological Survey explains: “The best age for the Earth comes not from dating individual rocks but by considering the Earth and meteorites as part of the same evolving system.”

**DISCUSSION AND GROUP ACTIVITY:**

1. Is the modern scientific community dispassionate in its search for truth, or biased against traditional Christianity?
2. Why do so many evangelicals now embrace evolution?
3. Agree or disagree true science will never discover anything that contradicts the Bible.
4. Has anyone hear heard evidence for a young earth that you found convincing?

Group activity: check out an article from one of the following websites and be prepared to summarize and evaluate it for the class:

* Creation-based science organizations:
	+ Answers in Genesis
	+ The Institute for Creation Research
	+ The Creation Research Society
	+ The Lutheran Science Institute
* “Evangelical” Creation website
	+ Biologos.com
* Evolution-believing Intelligent Design Website;
	+ The Discovery Institute