**The Quest for the Age of the Earth**

If you were interested in finding out the ages of things, the University of Chicago in the 1940s was the place to be. Willard Libby was in the process of inventing radiocarbon dating, allowing scientists to get an accurate reading of the age of bones and other organic remains, something they had never been able to do before. Up to this time, the oldest reliable dates went back no further than the First Dynasty in Egypt from about 3000 B.C. No one could confidently say, for instance, when the last ice sheets had retreated or at what time in the past the Cro-Magnon people had decorated the caves of Lascaux in France.

Libby’s idea was so useful that he would be awarded a Nobel Prize for it in 1960. It was based on the realization that all living things have within them an isotope of carbon called carbon-14, which begins to decay at a measurable rate the instant they die. Carbon-14 has a half-life—that is, the time it takes for half of any sample to disappear — of about 5,600 years, so by working out how much a given sample of carbon had decayed, Libby could get a good fix on the age of an object—though only up to a point. After eight half-lives, only 1/256th of the original radioactive carbon remains, which is too little to make a reliable measurement, so ***radiocarbon dating works only for objects up to forty thousand or so years old***.

Curiously, just as the technique was becoming widespread, certain flaws within it became apparent. It was also quickly discovered that carbon-14 samples can be easily contaminated with carbon from other sources—a tiny scrap of vegetable matter, for instance, that has been collected with the sample and not noticed. For younger samples— those under twenty thousand years or so—slight contamination does not always matter so much, but for older samples it can be a serious problem because so few remaining atoms are being counted. It is more like miscounting by a dollar when you have only two dollars to count.

Libby’s method was also based on the assumption that the amount of carbon-14 in the atmosphere, and the rate at which it has been absorbed by living things, has been consistent throughout history. In fact it hasn’t been. We now know that the volume of atmospheric carbon-14 varies depending on how well or not Earth’s magnetism is deflecting cosmic rays, and that that can vary significantly over time. This means that some carbon-14 dates are more dubious than others. This is particularly so with dates just around the time that people first came to the Americas, which is one of the reasons the matter is so perennially in dispute.

Because of the shortcomings of Carbon-14, scientists devised other methods of dating ancient materials, among them thermoluminesence, which measures electrons trapped in clays, and electron spin resonance, which involves bombarding a sample with electromagnetic waves and measuring the vibrations of the electrons. But even the best of these could not date anything older than about 200,000 years, and they couldn’t date inorganic materials like rocks at all, which is of course what you need if you wish to determine the age of your planet.

The problems of dating rocks were such that at one point almost everyone in the world had given up on them. Had it not been for a determined English professor named Arthur Holmes, the quest might well have fallen into abeyance altogether.

Holmes was heroic as much for the obstacles he overcame as for the results he achieved. By the 1920s, when Holmes was in the prime of his career, geology had slipped out of fashion—physics was the new excitement of the age—and had become severely underfunded, particularly in Britain, its spiritual birthplace. At Durham University, Holmes was for many years the entire geology department. Often he had to borrow or patch together equipment in order to pursue his radiometric dating of rocks. At one point, his calculations were effectively held up for a year while he waited for the university to provide him with a simple adding machine. Occasionally, he had to drop out of academic life altogether to earn enough to support his family—for a time he ran a curio shop in Newcastle upon Tyne—and sometimes he could not even afford the $10 annual membership fee for the Geological Society.

The technique Holmes used in his work was theoretically straightforward and arose directly from the process, first observed by Ernest Rutherford in 1904, in which some atoms decay from one element into another at a rate predictable enough that you can use them as clocks. If you know how long it takes for potassium-40 to become argon-40, and you measure the amounts of each in a sample, you can work out how old a material is. Holmes’s contribution was to measure the decay rate of uranium into lead to calculate the age of rocks, and thus—he hoped—of the Earth.

But there were many technical difficulties to overcome. Holmes also needed—or at least would very much have appreciated—sophisticated gadgetry of a sort that could make very fine measurements from tiny samples, and as we have seen it was all he could do to get a simple adding machine. So it was quite an achievement when in 1946 he was able to announce with some confidence that the Earth was at least three billion years old and possibly rather more. Unfortunately, he now met yet another formidable impediment to acceptance: the conservativeness of his fellow scientists. Although happy to praise his methodology, many maintained that he had found not the age of the Earth but merely the age of the materials from which the Earth had been formed.

It was just at this time that Harrison Brown of the University of Chicago developed a new method for counting lead isotopes in igneous rocks (which is to say those that were created through heating, as opposed to the laying down of sediments). Realizing that the work would be exceedingly tedious, he assigned it to young Clair Patterson as his post-doctoral thesis. Famously he promised Patterson that determining the age of the Earth with his new method would be “a piece of cake.” In fact, it would take years.

Patterson began work on the project in 1948. For seven years, first at the University of Chicago and then at the California Institute of Technology (where he moved in 1952), he worked in a sterile lab, making very precise measurements of the Uranium-235/Lead-207 ratios in carefully selected samples of old rock.

***The problem with measuring the age of the Earth was that you needed rocks that were extremely ancient***, containing lead- and uranium-bearing crystals that were about as old as the planet itself—***anything much younger would obviously give you misleadingly youthful dates***—but really ancient rocks are only rarely found on Earth. In the late 1940s no one altogether understood why this should be. ***Indeed, and rather extraordinarily, we would be well into the space age before anyone could plausibly account for where all the Earth’s old rocks went***. Patterson, meantime, was left to try to make sense of things with very limited materials. Eventually, and ingeniously, it occurred to him that he could circumvent the rock shortage by using rocks from beyond Earth. He turned to meteorites.

The assumption he made—rather a large one, but correct as it turned out—was that many meteorites are essentially leftover building materials from the early days of the solar system, and thus have managed to preserve a more or less pristine interior chemistry. Measure the age of these wandering rocks and you would have the age also (near enough) of the Earth.

As always, however, nothing was quite as straightforward as such a breezy description makes it sound. Meteorites are not abundant and meteoritic samples not especially easy to get hold of. Moreover, Brown’s measurement technique proved finicky in the extreme and needed much refinement. Above all, there was the problem that Patterson’s samples were continuously and unaccountably contaminated with large doses of atmospheric lead whenever they were exposed to air. It was this that eventually led him to create a sterile laboratory—the world’s first, according to at least one account.

It took Patterson seven years of patient work just to assemble suitable samples for final testing. In the spring of 1953 he traveled to the Argonne National Laboratory in Illinois, where he was granted time on a late-model mass spectrograph, a machine capable of detecting and measuring the minute quantities of uranium and lead locked up in ancient crystals. When at last he had his results, Patterson was so excited that he drove straight to his boyhood home in Iowa and had his mother check him into a hospital because he thought he was having a heart attack.

Soon afterward, at a meeting in Wisconsin, Patterson announced a definitive age for the Earth of 4,550 million years or 4.55 Billion years (plus or minus 70 million years)—“a figure that stands unchanged 50 years later,” as McGrayne admiringly notes. ***After two hundred years of trying, the Earth finally had an age.***