The Dating of Fossils

(excerpts from the book The Blind Watchmaker, by Richard Dawkins)

"We have long known how to arrange fossils in the order in which they were laid down. The method is inherent in the very phrase 'laid down'. More recent fossils are obviously laid down on top of older fossils rather than underneath them, and they therefore lie above them in the rock sediments. Occasionally volcanic upheavals can turn a chunk of rock right over and then, of course, the order in which we find fossils as we dig downwards will be exactly reversed; but this is rare enough to be obvious when it occurs."

"Even though we seldom find a complete historical record as we dig down through the rocks of any one area, a good record can be pieced together from overlapping portions in different areas (... paleontologists seldom literally dig downwards through strata; they are more likely to find fossils exposed by erosion ...)."

"Long before they knew how to date fossils in actual millions of years, paleontologists had worked out a reliable scheme of geological eras, and they knew in great detail which era came before which. Certain kinds of shells are such reliable indicators of ages of rocks that they are among the main indicators used by oil prospectors in the field. By themselves, however, they can tell us only about the relative ages of rock strata, never their absolute ages."

"More recently ... [since the turn of the 20th century] ... advances in physics have given us methods to put absolute dates, in millions of years, on rocks and fossils that they contain. These methods depend upon the fact that particular radioactive elements decay at precisely know rates. It is as though precision-made miniature stopwatches had been conveniently buried in the rocks. Each stopwatch was started at the moment that it was laid down. All that a paleontologist has to do is dig it up and read off the time on the dial. "

"Different kinds of radioactive decay-based geological stopwatches run at different rates. The radiocarbon stopwatch ... [see chart below for Carbon 14] ... buzzes round at a great rate, so fast that, after some thousands of years, its spring is almost wound down and the watch is no longer reliable. It is useful for dating organic material on the archaeological/historical timescale where we are dealing in hundreds or a few thousands of years, but it is no good for the evolutionary timescale where we are dealing in millions of years. "

"For the evolutionary timescale other kinds of watch, such as the potassium-argon watch ... [Potassium 40 below] ... is so slow that it would be unsuitable for the archaeological/historical timescale. That would be like trying to use the hour hand on an ordinary watch to time an athlete sprinting a hundred yards. For timing the mega-marathon that is evolution, on the other hand, something like the potassium-argon watch is just what is needed. Other radioactive 'stopwatches', each with its own characteristic rate of slowing down, are the rubidium-strontium, and the uranium-thorium-lead watches ..."

"So ... if a paleontologist is presented with a fossil ... [from a particular layer containing these stopwatches, or very near such a layer] ... he can usually know when the animal lived, on an absolute timescale of millions of years."

A Radioactive "Stopwatch" Chart ...

Parent Isotope:	Half-life:	Final Product of Decay:	Effective Dating of Age Range:
Carbon 14*	5,715 years	Nitrogen 14	0-80,000 years
Uranium 235	.70 billion years	Lead 207	> 100 million years (m.y.)
Potassium 40**	1.26 b.y.	Argon 40	> 100,000 years
Uranium 238	4.5 b.y.	Lead 206	> 100 m.y.
Thorium 232	14.0 b.y.	Lead 208	> 200 m.y.
Rubidium 87	48.8 b.y.	Strontium 87	> 100 m.y.
Samarium 147	106 b.y.	Neodymiun 143	> 100 m.y.

*Carbon is an important element in life-forms

**Found in many John Day Fossil Beds layers

Decay Curve

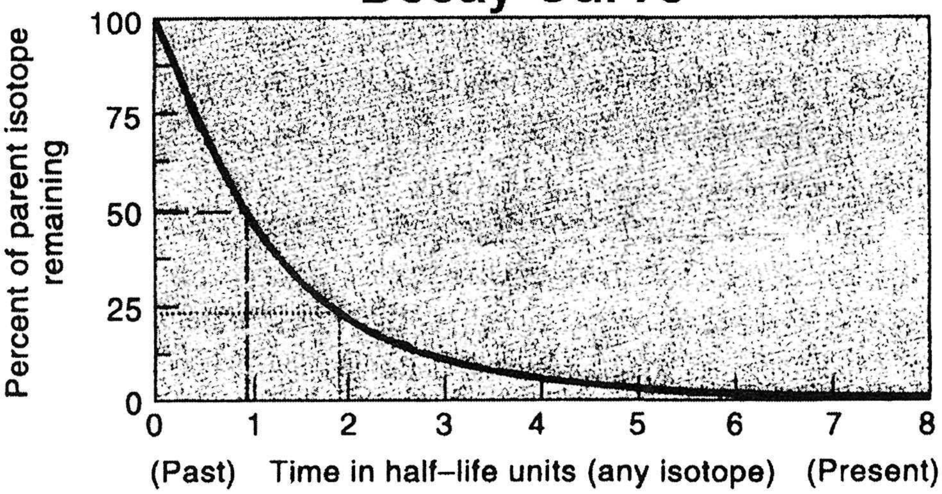

FIGURE 5.5 Simple arithmetic plot of a universal isotopic decay curve. After one half-life has elapsed, 50 percent of the original parent isotope remains; after two half-lives, half of that, or 25 percent, and so on.

(Figure 5.5 from the book Evolution of the Earth, by Prothero and Dott)

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