

k6 Kelvin's criticism of geology is negated < perpetual motion, Earth's minimum age >

That fellow seems to possess but one idea, and that is a wrong one.
—James Boswell.¹

Baron Kelvin (from the name of a small river that flows beside Glasgow University)² of Largs (William Thomson (**Figure k6.1**) (1824-1907) knighted 1866 for overseeing the first laying of a transatlantic cable, raised to the peerage 1892), codiscoverer (separately in 1851, from Rudolph Clausius in 1850) of the second law of thermodynamics, was naturally offended by the hint of perpetual motion (an impossibility according to the first law of thermodynamics) in the Huttonian-Lyellian vision of a steady state Earth (in which chemical reactions were supposed to continually produce heat). Even more upsetting for Kelvin was Darwin's proposal that life has evolved to its present state from simple forms by the process of natural selection (with its heavy emphasis on chance). The time required for that to have occurred was, at best estimate by Darwin and persuasive to Lyell, a minimum of 200 million years. Kelvin with prejudice ("the argument of design has been greatly too much lost sight of in recent zoological speculation") took it upon himself, beginning in 1862,³ to show (in what amounted to a footnote to his paper "On the age of the Sun's heat")⁴ by an "unassailable" scientific calculation of Earth's maximum age, that geology had it wrong.

Kelvin's starting hypothesis was that Earth has cooled to its present condition from an initially molten state (correct). Measurements, in mines, of how fast heat is escaping from the Earth's interior, allowed Kelvin to reason, after three and a half decades of committed whittling, that Earth is little more than 20 million years old: "To form a closer estimate of the time which has passed since the consolidation of the earth ... experimental investigation has supplied much of the knowledge then wanting regarding the thermal properties of rocks to form a closer estimate of the time which has passed since the consolidation of the earth, we have now good reason for judging that it was more than 20,000,000 and less than 40,000,000 years ago, and probably much nearer 20 than 40."⁵

Quick to be unimpressed was skeptical Huxley. In his inaugural Presidential Address to the Geological Society on 19 February 1869 he rallied geologists to their observational evidence for the greater age of Earth with the reminder that: "Mathematics may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends upon what you put in; and as the grandest mill in the world will not extract wheat-flour from peascods, so pages of formulæ will not get a definite result out of loose data."⁶ The tension in the audience is given by Adrian Desmond in *Huxley*, 1994:⁷

In his address Huxley defended Darwin against the holier [-than-thou] physicists of Scotland. Darwin had reckoned on hundreds or even thousands of millions of years for natural selection to work in. ... And that was 'preposterously inadequate' for Darwin's higgledy-piggledy build-up of chance variations, added Thomson's cable-laying partner Fleeming Jenkin.

Huxley revelled in his role of defence counsel. 'Biology takes her time from geology', he retorted. Whatever the earth's age, and the accumulated rock strata suggested that it was immense, Nature has worked her results in it. His air infuriated another Thomson colleague, Peter Tait. The 'dashing' Huxley was like his 'Trades Unionists', with a 'handloom-weaver's' hatred of the machines brought in to help him. His 'crab-catching' science should welcome the data-crunching might of the physicist. And so saying, Tait dropped the earth's age to a trifling 'fifteen millions'. That, at least, made Darwin realize 'how devilish a clever fellow Huxley is', for goading the engineers into refuting themselves.

Lyell's reaction to Kelvin, to quote from *Great Geological Controversies* by A. Hallum, 2001, was "to invoke the possibility of divine laws at variance with the discovered laws of nature," and to wish "that some unknown energy source would eventually be discovered, which indeed happened some three decades later" (**Figure k6.2**).⁸ Darwin deleted from the third edition of *Origin* any reference to an absolute age for Earth and later edited the phrase "incomprehensibly vast" to "how vast."

Kelvin did face the problem that, starting with a molten world, life could live on it only when it had cooled enough. And how did life appear? Kelvin in 1871 begged the question by proposing that, like a volcanic island, Earth had been colonized. The alien arrivers were organisms drifting through space inside rocks that had fallen as meteorites.

In numerals haughty for their implied plus or minus of nothing of significance, Kelvin's final estimate for Earth's age in 1897 was 24 million years. Publications of his conductive-cooling calculations during the time of their issue had a chilling effect on geology. Evolutionary palaeontologists coped by lessening their notion of how much time was needed for evolution but stratigraphers at the beginning of the past century were persuaded to absurd conclusions in their explanations of the rock record of the Precambrian which they compressed into a few million years. That was to leave as much time as possible for evolution, on the supposition that life had originated at the beginning of the Cambrian.

By 1892, "Lord Kelvin is willing, I believe, to grant us some twenty millions of years, but Professor [physicist, P. G.] Tait would have us content with less than ten millions ..." observed Archibald Geikie and demurs: "After careful reflection on the subject, I affirm that the geological record furnishes a mass of evidence which no arguments drawn from other departments of nature can explain away, and which, it seems to me, can not be satisfactorily interpreted save with an allowance of time much beyond the narrow limits which recent physical speculation would concede."

"How long will these lectures [by Kelvin⁹] continue?" asked President Gilman one day of Lord Rayleigh, while walking away from the lecture-theatre"—writes Silvanus Phillips Thompson in *The Life of William Thomson*, and continues—"I don't know" was the reply; "I suppose they will end some time, but I confess I see no reason why they should.""¹⁰

They would.

In 1904, while giving the Bakerian lecture at the Royal Institution, London, Ernest Rutherford made the point, at which Kelvin in front-row attendance, but asleep, woke up ("I saw the old bird sit up, open an eye and cock a baleful glance at me!"), that the energy released in rock by radioactive decay is converted to heat (**Footnote k6.1**).¹¹ In 1905, he demonstrated the relation of radioactivity to nuclear disintegration that produced the energetic particles he called α (*alpha*), β (*beta*), and γ (*gamma*). Emitters of these that significantly heat Earth are the radioactive isotopes of the elements K, U, and Th.¹²

In the year of 1905, Kelvin ceased (without apology) to argue for a young age for Earth. He had learned that radioactivity *would* continually heat Earth's interior and this invalidated the premise of his theoretical model.¹³ He had achieved a calculation of a *minimum* geological age for Earth! And that too little by two orders of magnitude. Thereafter, the 20 million year old age that physicists calculated for a yet incandescent "metal" (*sic*) Sun would be paradoxical¹⁴ (increasingly so as radiometric ages of minerals and rocks became available) until nuclear fusion was elucidated in 1938.¹⁵

Apocrypha: Once during a sermon on *The Second Law of Thermodynamics and the Entropic Heat Death of the Universe*, Lord Kelvin pronounced that our world, but 20 million years old, would end when, after the same length of time, Sun's fuel expires. An elderly woman in the congregation interrupted him and anxiously asked: "How long did you say?" The Lord Kelvin replied, "twenty million years." The woman sighed, "Thank you Lord, I thought you said two million!" □

Figure k6.1 William Thomson (1824-1907). Some pronouncements of Lord Kelvin:



“You, in this country, are subjected to the British insularity in weights and measures; you use the foot, inch and yard. I am obliged to use that system, but must apologize to you for doing so, because it is so inconvenient, and I hope Americans will do everything in their power to introduce the French metrical system. ... I look upon our English system as a wickedly, brain-destroying system of bondage under which we suffer. The reason why we continue to use it, is the imaginary difficulty of making a change, and nothing else; but I do not think in America that any such difficulty should stand in the way of adopting so splendidly useful a reform.” ... “Radio has no future.” ... “I can state flatly that heavier than air flying machines are impossible.” ... “There is nothing new to be discovered in physics now. All that remains is more and more precise measurements”

Kelvin had the misfortune to live long enough to see his “unassailable” proof—that Earth was far younger than geologists had decided—undone upon the discovery of radioactivity. Also, he was almost alone in England (unlike in Europe where too, at the time, only the seeable held sway in science) in his resistance to atomic theory: specifically, the Austrian, Ludwig Boltzmann’s equation, $S = k \log W$ that links the phenomenological science of thermodynamics to the concept of atoms and molecules. This exasperated Josef Nabl to the point that in a letter to Stefan Meyer in Cambridge dated 1900 he described Kelvin, who was crotchety in his old age, as “a silly old idiot.”¹⁶

“OK,” a salient for “satisfactory,” derives from two affirming letters lighted in turn by test swings of Thomson’s mirror galvanometer (patented 1858) in use on the first Atlantic telegraph cable.

In 1906, the Royal Navy discontinued a sustaining source of income for Kelvin, the Admiralty’s adoption in 1889 of his much touted, patented, dry-card compass & binnacle as the Standard Compass for the Royal Navy—despite its wild swings that made it “utterly useless” in a rough seaway during navel bombardments, and in small boats, compared to the steadiness of various liquid filled compasses long in use by other navies and shipping. A perspicacious officer commented: “individuals [are] often pleasant, persuasive, persistent, and perceptive of everything but possible faults in their inventions.”

On the bright side, Kelvin is best remembered for introduction (in 1851) of the absolute temperature scale (his name is the eponym for degrees on it). At its zero all motion ceases.

Figure k6.2¹⁷ In Einstein’s hand written *Special Theory of Relativity* manuscript (1912) is

$$L = \frac{mc^2}{\sqrt{1 - \frac{q^2}{c^2}}}$$

In this equation that expresses the general form of energy associated with a mass m moving with a velocity q as a fraction of the speed of light c , the variable for energy L (the Lagrangian) is edited by being crossed out and replaced by E as (surprise!) L does not tend to zero when q does.

Evidently, for a body at rest, $E = mc^2$.

Footnote k6.1¹⁸ Early in 1903, Pierre Curie, and his assistant Albert Laborde, noticed that radium produces heat and by 16 March could announce that one gram of radium can melt one gram of ice daily.

