Biographical Encyclopedia of Astronomers

Darwin, George Howard

Born Down House, Kent, England, 9 July 1845

Died Cambridge, England, 7 December 1912

The details of the Moon's evolutionary history were most clearly elucidated not by the students of its surface features but by mathematicians who built on the recognition that tidal forces had retarded the Earth's rotation. These same forces, it was realized, would have slowed the Moon's rotation into synchrony with its period of revolution. The mechanism and the stages of this process were most elaborately worked out by Cambridge mathematician George Darwin

The second son of the great evolutionist Charles Robert Darwin, George attended Trinity College, Cambridge University, graduating as second wrangler in 1868. Afterward, he studied law and was admitted to the bar but never practiced. In 1883, Darwin was appointed Plumian Professor of Astronomy at Cambridge University, a post he held for the rest of his life. There, he became a junior colleague of the most influential British physicist of that time, William Thomson (Lord Kelvin). Lord Kelvin's calculations of the Earth's lifespan (from considerations of its rate of cooling and the lifespan available to the sun if gravitational contraction were, as Kelvin thought, its only source of energy) had been an "odious spectre" for Charles Darwin's theory of biological evolution (which seemed to require hundreds of millions of years). Ironically, it was at Lord Kelvin's behest that George Darwin adopted the theory of tides as his own special subject on which he was destined to leave his mark Darwin married Maud du Puy of Philadelphia in 1884; the couple had four children.

Darwin first announced his theory in 1878 and published a long memoir on the subject a year later. Because of the gravitational attraction of the Moon, the liquid masses of the oceans are slightly bulged on the near and far sides of the Earth relative to the Moon. In effect, the Moon holds in position a portion of the oceans. Beneath these tidal bulges, the globe of the Earth rotates. Although water is a reasonably good lubricant, particularly when it is deep, it is not altogether without friction when dragged over shallow seabeds (like the Irish and Bering seas) by the Earth's diurnal rotation. Because of this tidal friction, the Earth suffers a braking action that slows its rate of axial rotation, lengthening the day by a miniscule fraction of a second per century Moreover, since action and reaction are equal, as the Moon pulls on the bulging oceans, the oceans tug in return on the Moon, imparting energy to it and causing it to spiral slowly outward as the Earth's rotation slows.

Darwin calculated that after the lapse of indefinitely long ages, a stable configuration will be achieved when the Moon revolves around the Earth in about 55 days. In that inconceivably distant future, the Earth's axial rotation will also have been slowed to 55 days. But one could equally well run the cosmic clock backward. In the past, the Earth must have spun more rapidly on its axis, and the Moon must have circled much closer than it does now. At some point, the Moon's period of revolution becomes equal to the Earth's period of rotation. Near that point, Darwin wrote, the solution to the equations became unstable, "in the same sense in which an egg when balanced on its point is unstable; the smallest mote of dust will upset it, and practically it cannot stay in that position."

What had preceded this unstable condition? "It is not so easy," Darwin admitted, "to supply the missing episode. It is indeed only possible to speculate as to the preceding history." Darwin

suggested that the Earth and Moon had once been part of a common molten mass that broke up due to the combined action of the tides raised by the Sun and the primordial object's rapid rotation. He attempted to estimate the minimum time at which the Moon had undergone "fissi-partition" from the proto-Earth.

At the present time, friction in the shallow seas is the most efficient mechanism of dissipating tidal energies, but when the proto-Earth was hot and plastic, tides in the body of the Earth itself would have been far more pronounced. From his belief in the "prepondering influence of the tide," Darwin found himself able to account for many peculiarities of the Earth-Moon system

While Darwin himself believed that the cavity left behind when the Moon fissioned from the Earth would have quickly closed up, the Reverend Osmond Fisher, rector of Harlton near Cambridge and author of *The Physics of the Earth's Crust* (1881), disagreed. Most of the material shorn off to form the Moon would have been of the lighter continental variety, he argued, rather than the denser oceanic crust. Its departure would have left scars, including the Pacific Basin. Among the most ardent early supporters of Fisher's theory was American geologist Clarence Dutton.

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