In retrospect

An Investigation of the Principles of Knowledge and of the Progress of Reason, from Sense to Science and Philosophy

by James Hutton
1794
Facsimile edition: Thoemmes: 1999.

Chosen by Paul N. Pearson

Following the publication of *On the Origin of Species* in 1859, Charles Darwin learned (and duly acknowledged) that two previous authors had anticipated the theory of evolution by natural selection. The first account to come to light was by Patrick Matthew, who had briefly outlined the mechanism in an appendix to his 1831 book *On Naval Timber and Arboriculture*. The second was by the physician William Wells, who had speculated on selection and human evolution in 1818.

But some 50 years ago, E. B. Bailey described a still older version of the selection theory from a 1797 manuscript by the geologist James Hutton — now chiefly famous for his early appreciation of geological time. Unfortunately, this work, entitled the *Elements of Agriculture*, never appeared in print. Now a more complete, published account has come to light from 1794.

An Investigation of the Principles of Knowledge is an intimidating philosophical treatise of three volumes, running to 2,138 pages in its original edition. Hutton's friend and biographer, John Playfair, presciently noted: "The great size of the book, and the obscurity which may justly be objected to many parts of it, have probably prevented it from being received as it deserves." The selection theory is the subject of an entire chapter in the second volume (see supplementary information). Hutton mused: *"If an organised body is not in the situation and circumstances best adapted to its sustenance and propagation, then, in conceiving an indefinite variety among the individuals of that species, we must be assured, that, on the one hand, those which depart most from the best adapted constitution, will be most liable to perish, while, on the other hand, those organised bodies, which most approach to the best constitution for the present circumstances, will be best adapted to continue, in preserving themselves and multiplying the individuals of their race."*

The original *Origin*? James Hutton described natural selection as long ago as 1794.

For example, Hutton describes that in dogs that relied on "nothing but swiftness of foot and quickness of sight" for survival, "the most defective in respect of those necessary qualities, would be the most subject to perish, and that those who employed them in greatest perfection would be best preserved, consequently, would be those who would remain, to preserve themselves, and to continue the race". But if an acute sense of smell was "more necessary to the sustenance of the animal", then "the natural tendency of the race, acting upon the same principle of seminal variation, would be to change the qualities of the animal, and to produce a race of well scented hounds, instead of those who catch their prey by swiftness".The same "principle of variation" must also influence "every species of plant, whether growing in a forest or a meadow".

Hutton was no mere armchair theorist. He came to his principle after experiments in plant and animal breeding, some of which are described in the *Elements of Agriculture* manuscript. These experiments led him to distinguish between seminal variation, which occurs in sexual reproduction and is heritable, and non-heritable variation, caused by the circumstances of soil and climate.

It is important to stress, however, that while he used the selection mechanism to explain the origin of varieties in nature, he specifically rejected the idea of evolution between species as a "romantic fantasy". Indeed, he was a deist and regarded the capacity of species to adapt to local conditions as an example of benevolent design in nature.

It may be more than coincidence that Wells, Matthew and Darwin were all educated in Hutton's home town of Edinburgh, a place famous for its scientific clubs and societies. Studies of Darwin's private notebooks have shown that he came to the selection principle independently of earlier authors, as he always maintained. But it seems possible that a half-forgotten concept from his student days resurfaced afresh in his mind as he struggled to explain the observations of species and varieties compiled on the voyage of the *Beagle*.

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Supplementary information The full text of Hutton's chapter from *The Principles of Knowledge* and other relevant extracts from *Elements of Agriculture* are available on *Nature*'s website.

development of the now-preferred scenario for how the Moon came to be. By the mid-1970s the analytical ideas of the Soviet cosmogonist V. S. Safronov about the role of impacts in forming the planets of our Solar System had travelled west, where they were tested and extended numerically by George Wetherill and by the Planetary Science Institute. Bill Hartmann and Don Davis, from the latter group, realized that the final objects to accumulate into the terrestrial planets must have been massive and would have careened through the inner Solar System. They concluded that the Moon could have been born from the final collision of such an object, and argued that the material thrown off proto-Earth would have been from its iron-poor surface layers and that volatiles would have boiled off, explaining the Moon's gross composition.

Independently, Al Cameron and Bill Ward noted that the angular momentum of the entire Earth–Moon system required an impact from at least a Mars-sized projectile, and began to analyse the likely evolution of the flattened, Earth-circling cloud of vaporized material that any giant collision would have generated. The Moon, accumulated from this orbiting debris through much the same processes as the planets themselves, would contain material from both Earth's mantle and the projectile. Despite their plausibility and close match with known facts, these works attracted little attention and languished along with all lunar studies during the early 1980s.

Languished, that is, until a conference in 1984, held in Kona, Hawaii, brought together dynamicists, cosmochemists and geophysicists to consider the Moon's origin. By this time, impacts were accepted as shapers of life, following the proposal of Luis and Walter Alvarez that linked an asteroid collision with the dinosaurs' demise and other mass extinctions at the end of the Cretaceous period. As the conference proceeded, it became clear that a consensus had silently emerged in the various disciplines: each, unaware of the other, favoured a collisional beginning for the Moon.

In the past two decades, there have been increasingly sophisticated simulations of a massive impact and the evolution of the resulting debris disk, and lunar samples and meteorites have been scrutinized. The giant-impact hypothesis does well in explaining the observed physical, thermal and geochemical properties of the Earth–Moon system. Plausible modifications to the original theory may overcome the remaining faults: contemporary models suggest that Earth was not fully grown when it was struck by an even larger projectile than was previously thought.

Besides telling an interesting tale well and elucidating how science progresses, Mackenzie's book emphasizes the fact that impacts have been the primary creative and destructive process throughout the history of the Solar System. Some today wonder whether the final violence that ends civilization will be another such collision — rather than a catastrophe of our own making. ■

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