sense of the observed motions of planets and to allow predictions, such as the existence of the planet Neptune or when Halley's Comet would return.

A few additional dragons are worth discussing. The authors actually tend to drop the direct mention of dragons in the later sections of the book, but the theme of discussing changes in scientific understanding that required significant rethinking remains strong. A geological and paleontological issue that many readers may be familiar with involves the great extinctions (times when many species died quite rapidly), especially the demise of the dinosaurs about 66 million years ago. Most have probably read articles or seen documentaries blaming an asteroid impact for killing off the dinosaurs, and there was definitely a major impact at the right time. Although that is certainly the best publicized explanation for that extinction, there is another explanation that is less commonly mentioned: very extensive volcanism. This is less dramatic than an asteroid impact and has received less publicity. There were enormous volcanic events in south Asia for an extended period including the time of the asteroid impact, and there is some controversy over how sudden the extinction was. If it was not sudden, then the volcanic explanation fits better. Furthermore, there were other periods of great volcanic activity that match up with the times of other great extinctions. The jury may still be out on this issue. Anyone wanting to know more about this is encouraged to read the book.

Although slightly off the topic of dragons, the authors also discuss people who were not honored with Nobel prizes, but should have been, as well as some who should have been co-authors on significant papers but weren't (or whose work was ignored until far too late). Unfortunately, women have too often been the ones ignored, but men have also been passed over. Among several others, the book discusses the frequently cited case of Jocelyn Bell (now Dame Jocelyn Bell Burnell) and her discovery of pulsars (astronomical objects with short period radio pulses, which she discovered as a grad student in 1967). Two more-senior men received the Nobel prize in 1974 for their contributions to radio astronomy, including specifically this discovery.

The last section of the book contains considerable discussion of modern views of cosmology, including the apparent discrepancy between the results of two different methods of measuring the expansion rate of the universe. The discrepancy between the results may be due to underestimated random errors, or systematic errors in one or both techniques, or new physics yet to be understood (another dragon?). Necessarily included as part of cosmology, the authors discuss dark matter and dark energy. Dark energy is the label given to whatever unknown mechanism is causing the observed acceleration (discovered ~30 years ago) in the expansion of the universe, and should certainly be considered a dragon, since it is a term invented out of ignorance. Dark matter is a different story. For several decades we have known of rapid motions of and within galaxies that are best explained by something that has gravity similar to that of normal matter, but has not yet been detectable otherwise, hence dark. Some think the observed data require a need for modification of the law of gravity, but no proposed modification has yet been successful in fitting all of the data. A clear discovery of dark matter particles, or a successful modification of gravity, will slay the dark matter dragon. Cosmology, including the dark side, is a very active area of current research.

Why should this book be of interest to readers of *PSCF*? Besides the fact that many of us are interested in history and philosophy of science, we should think about whether there are other dragons to deal with. For example, many of us may think of "god of the gaps" as a dragon that has (mostly?) been slain, though its head pops up occasionally. Readers may want to ponder whether there are other dragons in our own science, or our theology, or how we relate these areas.

Reviewed by Kyle Cudworth, former director, Yerkes Observatory, Williams Bay, WI, and professor emeritus of astronomy and astrophysics, The University of Chicago.

DOI: https://doi.org/10.56315/PSCF9-25Bashford

THE HUXLEYS: An Intimate History of Evolution by Alison Bashford. University of Chicago Press, 2022. 423 pages plus 60 pages of notes, 75 figures, index. Hardcover; $30.00. ISBN: 9780226720111.

Alison Bashford is laureate professor in history and director of the Laureate Centre for History and Population at the University of New South Wales in Sydney, Australia. She has held prior positions at the University of Cambridge and Harvard, and served as a trustee of Royal Museums Greenwich. Prior publications include a coauthored biography of Thomas Malthus; in 2021, she received the Dan David Prize for her contributions to the history of health and medicine.

The Huxleys represents an ambitious project: an intergenerational history of the Huxley family, 1825–1975, with major emphases on the biologists Thomas Henry Huxley (1825–1895), hereafter, "Thomas"; and his grandson, Julian Sorell Huxley (1887–1975), hereafter, "Julian." Other Huxleys are essential to the narrative, and these include Thomas's beloved wife, Henrietta Heathorn (1825–1914), and their son Leonard Huxley (1860–1933). Leonard and his wife Julia Arnold (1862–1908) were the progenitors of Julian and his acclaimed novelist brother, Aldous Huxley (1894–1963). Many other Huxley children and cousins populate the book. Julia Arnold, as daughter of Thomas Arnold and niece

to Matthew Arnold, brought to the family a potent intellectual impetus of her own. Notable biologists who make appearances include, of course, Charles Darwin and Richard Owen; also Ernst Haeckel, J.B.S. Haldane, Hermann Muller, and Francis Galton. H.G. Wells figures prominently and, a revelation to this reviewer, also David Attenborough.

Rather than construct a single linear narrative, the author has split the history along topical themes. Each theme develops the narrative line and integrates it into the prior composite. The result is a multidimensional tapestry, brought to life by the characters themselves and by Bashford's wonderful prose.

Part I, "Genealogies," presents an overview of the genealogy, social milieu, and family tragedies of the Huxley clan from its origins in poverty to its high social status. It begins with a chapter sketching the genealogy of the Huxley lineage, beginning with the parents of Thomas and Henrietta. Thankfully, a genealogical chart is provided. Thomas and Henrietta had eight children. Son Leonard and first wife Julia Arnold (died young, of breast cancer) had four and then Leonard with second wife Rosalind Bruce (1890–1994), another two. Among the latter was Andrew Fielding Huxley (1917–2012), half-brother to Aldous and Julian; Andrew would win a Nobel prize for his research on neurophysiology.

Chapter 2 provides an overview of the biological threads that would be woven into the thought of Thomas and Julian. Charles Darwin and Ernst Haeckel are both introduced as good friends of Thomas and Henrietta. Bashford concludes that Thomas at first accepted Darwinian evolution with certain qualifications, but that it was Haeckel's work which fully convinced him, as well as the data of paleontology. "It was only from 1868 that evolutionary concepts were directly applied by Huxley to his own research, and it was less Darwin than Haeckel's applications of Darwin's idea that finally convinced him … in 1866" (p. 65). The young Julian was tutored in developmental biology and rigorous materialism by Haeckel; both themes were incorporated into his zoological and popular writings. The discoveries of genetics during the 1890s–1930s period are presented well. Notably, Julian worked in both William Bateson's and Thomas Hunt Morgan's laboratories just prior to taking up his first real position at brand-new Rice University in Houston (1912). Julian shortly thereafter recruited Hermann Muller from Morgan's lab to Rice University. They formed a strong friendship which would later yield joint anti-Nazi and pro-eugenics tracts.

The third chapter details the trials and tragedies of the Huxley lineage. The family appears to have been predisposed to depression, which was particularly manifest in Thomas and Julian. Julian exacerbated his instability with protracted episodes of marital infidelity. He underwent hypnosis and Freudian psychoanalysis. "Julian's finely honed self-absorption plus his intelligence and conceptual sensibilities were made for Freud" (p 115). Later, he elected electroshock therapy, which left him unable to concentrate for periods of time. A devout familial commitment to reductionistic materialism, bequeathed by Thomas, left the family without spiritual resources to cope; this lacuna ironically became a trigger for a fascination for Julian with spiritualism late in life.

Part II, "Animals," focuses on zoological achievements. Wonderful subject matter! One could wish for more, especially in view of the author's accessible prose. It details the insights provided by Thomas into such diverse organisms as cnidarians, crayfish, herring, and horses; by Julian into bird behavior; and by both into the biology and behavior of apes. Chapter 4, "Creatures of the Sea and Sky," begins with an overview of Thomas's early research in marine biology. His expertise would earn him deserved positions on British governmental commissions charged with surveying its coastal biota and regulating fisheries. In 1854, Thomas would assume a professorship of comparative anatomy and paleontology at the Royal School of Mines. While there, he undertook signal studies of fossil vertebrates (an aspect of his life which unfortunately receives scant coverage in this book), including one of the first proposals that birds were simply feathered theropod dinosaurs. Julian initially studied ornithology and maintained a lifelong fascination for pied-billed grebes. However, during the late 1920s, he became sidetracked. H. G. Wells (a former student of Thomas), having completed his *Outline of History* (1920), persuaded Julian to collaborate on a sequel of sorts: an introduction to current biological knowledge. Their magisterial product, *The Science of Life*, was serialized and published in three volumes, 1929–1930. The effort was enormously successful, both in distribution and royalties. This marked a profound turning point in Julian's career, to science popularization.

Chapter 5, "Animal Politics," details the involvement of the family, and particularly Julian, in conservation. *The Science of Life* catapulted Julian into the public eye, and he accepted the position of Secretary of the London Zoological Society, which ran the London Zoo. However, German bombing beginning in 1939 forced the relocation (or outright euthanasia) of the zoo's occupants. Huxley was given leave to come to America for a few months. This move resulted in his departure from the organization. Meanwhile, he became involved with many influential conservation groups. He was tapped as the first director-general of UNESCO, where, in 1948, he initiated the collaborative project that became the IUCN (International Union for Conservation of Nature).

"Of all orders of animals, primates were core Huxley business, their appreciation stretching from the wild to the captive, from the historical to the filmic" (p. 198). Chapter 6 focuses on primates, principally apes. Thomas was instrumental in applying Darwinian themes to the origin of humans, especially in his 1863 volume *Evidences as to Man's Place in Nature*. There were few fossils available for him to discuss, so his emphasis lay on the anatomy of contemporary monkeys and apes. Julian, in turn, became entranced with apes and particularly gorillas while with the London Zoo, and was in turn a tutor and promoter of the work of primate ethologists George Schaller and Jane Goodall. His collaborative work with the latter included publicity trips to East Africa to advocate for conservation of primates in the wild.

Part III, "Humans," examines Thomas's and Julian's evolving perceptions of the role of humans in the history of life. Chapter 7 carries the story of the Huxley family's contributions to paleoanthropology forward, and the following chapter reviews the involvement of Thomas and then Julian in politics. Notably, Julian was a member of a select committee of geneticists, including Hermann Muller, J.B.S. Haldane, C.H. Waddington, and Theodosius Dobzhansky, who issued a (1939) manifesto controverting the overt racism of the Nazi regime and its purported biological basis. This manifesto for racial parity would later become known as the Humanist Manifesto. When Julian took on the directorship of UNESCO, in 1946, it became the template for its foundational document, *UNESCO: Its Purpose and Philosophy*. Julian made sure that the underlying philosophy was areligious, monistically evolutionary, and Freudian.

Chapter 9 tells a sad tale, interweaving the Huxleyan family preoccupations with Malthusian biology and with mental illness. Julian pondered what likely was a genetic predisposition to his own temperament, even as he took on leadership roles in the British and international eugenics movement. Along with geneticist R.A. Fisher and others, he served on the Committee of the Eugenics Society for Legalising Eugenic Sterilisation. He praised the efforts of states like California to implement mandatory sterilization policies.

Part IV, "Spirits," is a dénouement of sorts, documenting the paradoxical return to a vague spiritualism on the part of Julian, prodded by his brother Aldous's experiments with mind-altering drugs and the research of his son, the ethnologist Francis Huxley (1923–2016).

This book comprises a magnificent narrative of a family marked by brilliance, accomplishment, and tragedy, and is highly recommended. It is symphonic in scope. Sadly, an underlying dirge is audible within the Huxleyan polyphony; perhaps it is a product of an insistent turning of the face away from the Almighty.

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Physics

DOI: https://doi.org/10.56315/PSCF9-25Hossenfelder

LOST IN MATH: How Beauty Leads Physics Astray by Sabine Hossenfelder. Basic Books, 2020. 304 pages. Paperback; $19.99. ISBN: 9781541646766.

DOI: https://doi.org/10.56315/PSCF9-25Hossenfelder2

EXISTENTIAL PHYSICS: A Scientist's Guide to Life's Biggest Questions by Sabine Hossenfelder. Atlantic Books, 2023. 248 pages. Paperback; $19.99. ISBN: 9781838950385.

"I invent new laws of nature; it's what I do for a living." This is the way German physicist Hossenfelder begins her 2020 book, *Lost in Math*. She goes on, through ten chapters, to explain why particle physics is at an impasse. Particle physicists have been unable to improve upon their "Standard Model," which goes back to the 1970s, largely because experimentation has become so expensive. The $6 billion Large Hadron Collider (LHC) is a prime example. It confirmed, as expected, the existence of the Higgs boson, but otherwise its results have been disappointing. So, Hossenfelder laments, "The LHC hasn't seen anything that would support our newly invented laws of nature" (*Lost*, p. 5).

By her account, contemporary particle physicists have little to work with besides their imaginations and mathematics. Driven to make progress, but without experimental data to guide or constrain them, physicists increasingly rely on aesthetics, on an unreasonable quest for beauty and mathematical simplicity, to theorize. The result: mathematical constructs—new and imaginary particles, string theories, and the multiverse—that pose as science, but are neither testable nor useful. In other words, anyone hoping for an overarching theory of everything is at a dead end. Disaffected with both physics and academia, Hossenfelder's attention has shifted to writing and a popular YouTube channel, "Science with Sabine."

As an engineer, I was barely able to follow Hossenfelder's story since several sections were beyond me. What drew my attention was her honesty and provocative style. She is not a religious person but, like some other scientists, she understands that studies of the fundamental properties inherently involve discussions of God. She acknowledges that religious faith can be consistent with science, while scolding scientists who are dismissive of religion since their criticisms are ill-informed and harmful.