HISTORY OF SCIENCE

Belief, Reason, and Insight

Steven A. Frank

The way a scientist chooses problems and interprets nature can be deeply influenced by political views or religious beliefs. At the same time, the scientific truths that last the centuries have a coldly inhuman, rational purity beyond the motivations and beliefs of their human authors. George Price's story brings us up against these alternative traces of history.

The Price of Altruism
George Price and the Search for the Origins of Kindness
by Oren Harman
Norton, New York, 2010. 461 pp. $27.95, C$35. ISBN 9780393067781. Bodley Head, London. £20. ISBN 9781847920621.

Price made three profound contributions to evolutionary theory. First, the Price equation for the effect of selection on a trait (*1*) provided the foundation for the modern analysis of social evolution. W. D. Hamilton completely reworked his famous theory of kin selection after Price explained to him the severe limitations of his original formulation and the need to use Price's equation. The equation also gives the most general understanding of natural selection, transcending genetics to include cultural change, learning, and all forms of dynamical change arising from transmission and biased success. Second, John Maynard Smith's interest in the application of game theory to evolution came directly from Price's original formulation of ritualized combat in animals. In Price's work, mutually armed détente in animal combat arises from the Nash equilibrium of game theory. The first general expression and application of the widely used evolutionarily stable strategy concept in evolutionary games came from Price's work. Third, Price's analysis of R. A. Fisher's fundamental theorem of natural selection cleared up four decades of confusion. Establishing the generality of Fisher's theorem, Price's insight opened the way for a fully realized understanding of natural selection as a central process in all types of evolutionary change.

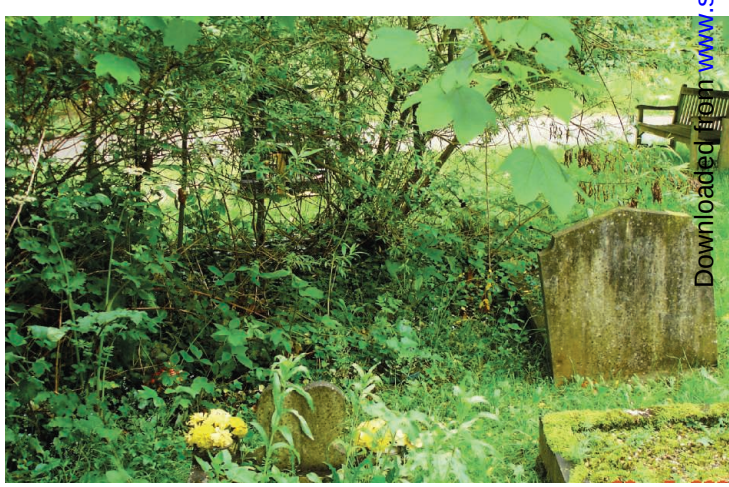
Each insight was so different from the common thought of its time. How did Price do it? Who was he, and where did he come from? Pieces of the story have been known among evolutionary biologists, just enough to make clear that the history was very strange and in the end very sad. We now welcome Oren Harman's deeply researched life of Price. Harman, a historian of science at Bar Ilan University, tells Price's story well.

Price was born in New York in 1923. His father died early, and the family fortunes crashed with the stock market in 1929, leading to much stress in family life. Price's personality developed early: vain, brilliant, difficulty relating to others, but somehow always secure in his own independent ability to see problems clearly. He obtained a Ph.D. in chemistry at the University of Chicago, working as part of the Manhattan Project. His secret research won a competition for the best method to detect radiation exposure by fluorescent analysis of urine samples. He moved from one science job to another—always recognized for his outstanding ability to solve problems but never staying long with any particular work. He was married, had two daughters, became restless, and was bitterly divorced. Moving, studying, and seeking, he published articles in leading journals and magazines about extrasensory perception, methods for the rapid design of new machines, and the arms race. He had ideas and often real insight on seemingly everything. But after his initial success, he rarely finished anything. Usually alone, he took lower-status jobs or did not work at all.

Price had health problems; a botched surgery caused partial paralysis. He obtained some insurance money in a settlement and, at 44, set off for England to begin again, to focus his mind, to make his reputation. Ambitious, certain of his ability, painfully aware of his failure, he increasingly felt the need to do good the only way he knew how—by his belief in clarity of analysis above all else. Day after lonely day in London libraries, Price slowly moved toward problems of evolution, altruism, and game theory. Maybe he could understand the biological roots of kindness, and do so more deeply than others ever had. By some internal story, he perhaps felt that a success in such studies would assuage his prior failings, make his mark in life, and turn things around.

Just as Price succeeds against all odds, making his three great contributions and touching on other topics, he starts on a series of religious conversions. Having scored, by pure reason alone, a triumph on biological altruism and the most abstract theories of natural selection, he loses faith in science and begins to study scripture with a zeal and analytical power that scares his religious mentors. Then even the scriptural analysis wanes, and he turns to help the downtrodden. Not just to help but to give all he has of his time, possessions, and love—to the point that he becomes as downtrodden as those he sought to help. Struggles and depression follow; at last, suicide.

Harman takes us through all of this. But the book is much more ambitious than just a story of Price's life and work: "Our tale teaches that the people doing science, their backgrounds, historical context, family histories, education, political views, religious affiliations, temperament—all play a role." Harman supports this view by providing vignettes of Thomas Huxley's atheism, Fisher's Anglicanism, Prince Peter Kropotkin's anarchism, and numerous other sketches of the faiths and world views of scientists who touched on problems of altruism and human morality in relation to biology. Each scientist's accomplishments are seen in relation to wider aspects of personal faith and moral outlook. The book's first part jumps between Price's early life and an often dizzying patchwork of disparate scientific and personal biographies. Always interesting, these sketches often leave one off balance as the narrative spins



Unmarked grave. Price's burial site, covered by brush to the left of the tombstone, Saint Pancras Cemetery, London.

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Published by AAAS

in another direction or back to Price's emerging story. The thesis does not come until the epilogue: "[O]ur story holds a deeper moral that may not be so easy to fathom: One of the pressing challenges of our times is defining the boundary between questions that can be addressed meaningfully by science and those that are outside its purview." I do not find that moral hard to fathom. Personal meaning and scientific insight are distinct.

Perhaps more interesting, Harman's telling of Price's life implicitly but very strongly takes a stand on the origin of scientific insight. In Harman's view, Price's fundamental scientific work followed from his deep humanistic desires to contribute to the greater good. Similarly, Harman views Fisher's great contributions to evolutionary theory through his reactionary Anglican social views. There can be no question that personal outlook can strongly influence a scientist's work. But that humanistic perspective fundamentally misses an important component of scientific insight and accomplishment. To consider the complementary humanistic and coldly scientific perspectives, let us turn to Newton, perhaps the greatest of all scientists.

John Maynard Keynes, who collected many of Newton's manuscripts on alchemy and religion, saw Newton as "the last of the magicians" rather than "the first of the age of reason":

> [Newton] looked on the whole universe and all that is in it as a riddle, as a secret which could be read by applying pure thought to certain evidence, certain mystic clues which God had laid about the world to allow a sort of philosopher's treasure hunt to the esoteric brotherhood. He believed that these clues were to be found partly in the evidence of the heavens and in the constitution of elements … but also partly in certain papers and traditions handed down by the brethren in an unbroken chain back to the original cryptic revelation in Babylonia. He regarded the universe as a cryptogram set by the Almighty …. By pure thought, by concentration of mind, the riddle, he believed, would be revealed to the initiate. (*2*)

One could say that Newton's mad, lonely pursuit was all about his dreams of the glory of his Christian god. But how much does that matter? In the personal history, in understanding motivation, it matters a lot. But whatever Newton thought he was doing, that has no bearing on the truth of force equals mass times acceleration, the bending of light, the calculus, or the foundations of modern science. Anyone who has suffered the hard work of science knows of the duality of mind required. Motivation, personal belief, whatever it may be, is ephemeral and ultimately independent from the impersonal hard evidence and critical testing that determine lasting scientific truths. It is a fine part of history to reconstruct researchers' personal dreams of glory or god. Scientists may need such dreams to keep them going through the long, hard hours. But after the discovery, it is only the outed secret of nature that matters. Or so the scientist may feel. Whereas the historian, the humanist, will perhaps care more for the faith, the loneliness, the personal story of pain and ultimate victory against all odds. In those very human aspects of science, one may choose to see a mirror that reflects back meaning to one's own personal story. Nonetheless, all great scientists have a second, independent core of rationality that dominates in the long run. Despite the complexities of the tormented life that Harman recounts in *The Price of Altruism*, Price's scientific contributions had that purity of complete and rational order—an austerity and abstractness from all humanistic consideration so complete that it stands alone in the history of evolutionary theory.

References

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2. J. M. Keynes, *The Collected Writings of John Maynard Keynes*, vol. 2 (Macmillan, London, 1972), pp. 363–364; www-groups.dcs.st-and.ac.uk/~history/Extras/Keynes_Newton.html

10.1126/science.1193026

HISTORY OF SCIENCE

Imagination in Chemistry

Peter J. Ramberg

Modern chemists routinely shuttle between the immediate empirical, sensual characteristics of substances in the laboratory and the invisibly small world of atoms and molecules. Like mathematicians, chemists do much of their thinking on paper, doodling chemical formulas or tinkering with hand-held molecular models. They think in a highly visual, nonverbal way. The origin of this way of thinking lies in the middle of the 19th century, when an extraordinary group of chemists, most of them in Great Britain and Germany, developed productive techniques for revealing the invisible world of the molecule. By 1890, nearly all chemists could "see" what molecules looked like at the microscopic level, meaning they had access to the explicit connections between atoms in the molecule and how those atoms are arranged in space. The ability to elucidate the structure of molecules down to the atomic level by purely macroscopic manipulation of chemicals is arguably one of the greatest intellectual accomplishments of 19th-century science. Yet in crafting their generalized accounts of past science, historians of science have largely ignored this achievement—equal in its importance to Darwin's theory of natural selection. For example, two recent and prominent surveys of the history of modern science do not discuss chemistry after the introduction of John Dalton's atomic theory in the very early 19th century (*1*, *2*). Reading such histories, uninformed readers would get the impression that the science of chemistry was completed by 1810, when in fact, it was just getting started in visualizing the microstructure of our world.

Image and Reality
Kekulé, Kopp, and the Scientific Imagination
by Alan J. Rocke
University of Chicago Press, Chicago, 2010. 401 pp. $45, £29. ISBN 9780226723327. Synthesis.

In *Image and Reality*, Alan Rocke (a historian of science at Case Western Reserve University and the author of several previous works on 19th-century organic chemistry) offers a masterful account of how chemists crafted a unique visual language of the microworld. The book spans the 50 years from 1840 to 1890 but concentrates on the period between roughly 1855 and 1865, when chemists developed the structural theory of organic chemistry. Rocke has previously described that period as a "quiet revolution," because the change happened relatively quickly and without much controversy (*3*). *Image and Reality* highlights another extremely important dimension of the quiet revolution, demonstrating that it was during the development of the theory of chemi-

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