were full of sound and fury, but his ideas were of unknown and untested (some would say untestable) significance. Colleagues distanced themselves from him. His wife, who was taking vitamin C, died of cancer. The first paper of an academician to be refused by the *Proceedings of the National Academy of Sciences* was his. He dismissed his colleagues. Instead of seeing tragedy in all of this turmoil, Serafini tries to hold out possibilities that Pauling was always right in the way he attacked problems. How could things be otherwise if he was an intuitive genius?

In my opinion, the greatness of Pauling as a scientist lay in his ability to use facts imaginatively and constructively, with considerable theoretical insight but in at best a semi-quantitative manner. It is the way in which many great chemists and biologists work, and it succeeds as long as there is a sufficiency of fact to guide and limit the imagination. Where the method fails is when the facts are few and one's choice of hypothesis cannot be much more than speculation. The only proven scientific method then is to construct a quantitative theory, to get more facts and to prove the theory valid. When Pauling drifted away from his detailed physico–chemical background towards biology he had already built his belief in his intuition, but afterwards he had too few facts to support his thinking. He made errors in the structure of DNA and the atomic nucleus, and, I believe, in his views on preventive treatment for certain diseases. Often his approach can only be described as a consequence of a reckless wish to be in the picture. The flaw of self-belief, perhaps even a cult of personality, enveloped him.

Scientists appear to need the image of 'intuitive genius', as espoused here by Serafini, and many propel themselves towards this reputation. Rather than believe in steady progress, which is the principal characteristic of science if its quantitative methods are applied thoroughly and with skill, they think of their individual 'breakthrough' as having been generated by some personal artistic insight. This is an illusion encouraged by the modern theatre of prizes and conferences, created by scientists and loved by the media. Only too often the very best of those who are imaginative and hard working rise to the top only to become in later life dreamers attempting conquests in areas outside their skills. Much though Serafini tries to promote the image of the scientific genius, there may be no such thing and this very image may well have been the trap into which Pauling fell. Pauling, in my opinion, was for quite some time just the best of us. I know of no higher praise. □

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Flaws of nature

John D. Barrow

Reading the Mind of God: In Search of the Principle of Universality. By James Trefil. *Scribner's, New York: 1989. Pp. 232. $18.95.*

MIND-reading is a racket. By foreknowledge and subtle suggestion one can peddle one's own thoughts as those of the subject. Reading the mind of God is therefore likely to be an exceptionally tricky business.

Perhaps the fact that the enterprise is doomed to failure from the outset is reason enough why this book fails to live up to the author's intentions and those of the publisher. It claims to be a popular study in the philosophy of science focused upon the 'principle of universality' (that is, the principle that the laws of nature which we discover here and now hold sway in the Universe everywhere and everywhen). But at one level I found the book to be a mystery, the mystery being the whereabouts of any real discussion of its stated subject. Occasionally, after a description of a piece of physics — the behaviour of light, the saltiness of the sea or the age of the Earth — the author remembers what he had hoped to write about and adds a few sentences of homespun philosophy about the laws of nature. But that's about it.

Because of this idiosyncracy, I suggest that the prospective reader should wipe clean any thought of the subtitle and simply enjoy the separate chapters. They are accurate and interesting in their explanation of scientific ideas, some of which rarely find their way into popular science books.

Particularly engaging is the story of Fraunhofer's early life as an industrial glass caster, which culminated in his becoming the most skilled nineteenth-century manufacturer of precision scientific instruments. This account leads naturally into the birth of spectroscopy, new astronomy and the discovery of helium in the Sun (in which, incidentally, Sir Joseph Norman Lockyer, the founding editor of this venerable periodical, had a part). Similarly there is a successful cameo about the turn-of-the-century dilemmas regarding the age of the Earth and battle between the physicists, biologists and geologists over the relevant evidence. We learn about Kelvin's genius for practical things, and his design of the modern fireplace, but all too little about the influence of his religious views and the role played by attitudes towards darwinian evolution.

Here, and elsewhere in the book, Trefil has one eye upon modern creationist arguments about the antiquity of the Earth and the uniformity of nature. What could have been made clear is that the point of disagreement is a subtle one for the layperson. The creationists interpret the uniformity of nature to mean a constancy in the events of nature whereas Trefil, like most other scientists, lays stress upon the constancy of the underlying laws of nature. This constancy does not require any uniformity in the outcomes of those laws. Indeed, in some of his passing comments on universality Trefil fails to appreciate the importance of this point. It is not enough, as he argues, to know the laws of nature in order to understand the structure of the Universe and reconstruct its past from the present. Even if we knew the initial conditions, we would still be faced with restoring the past symmetry-breakings which determine the particular outcomes of the laws of nature that we witness. Knowledge of the laws is necessary but not sufficient to understand the structure of the Universe.

Another point that would trouble the alert reader is what to understand by the much-vaunted invariance of the laws of nature. If Trefil has in mind the 'real' laws (assuming that such things exist) then by definition they cannot be changing — one can always re-express a proposed law of change as the constancy of some higher derivative of it. If, on the other hand, he simply means our current theories, then these 'laws' can of course be proven wrong. Quantities that are supposed to be constant may be found to change. These are not changing laws, of course, simply wrong laws. In a book for this sort of audience it is necessary to make clear which picture one is adopting — are the laws of nature descriptive accounts of what has always happened (and so cannot by definition be broken, as the creationists' defence of the miraculous sometimes argues), or are they prescriptive (and so can be found to be 'broken', but only in the undramatic sense that they were not the correct laws).

The closest Trefil gets to tackling questions of this sort is in his helpful demarcation of the scientific method into the two processes of theory creation and theory verification or falsification. Sociologists of science lay great stress upon the former element, which is partially subjective and influenced by all manner of extracurricular prejudices, whilst the exasperated scientist invariably points the sociologist towards the objective and hard-nosed activity of theory testing.

Reading the Mind of God exhibits good small-scale structure. The individual sections and even chapters are stimulating and will be instructive to students and non-specialists alike. But the book possesses no coherent large-scale structure that relates in any helpful manner to its title and the author's overall intentions. God can rest easy. □

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