After Aesop

The Illusion of Orderly Progress **(Knopf, $20) is a collection of entomological compositions by the artist Barbara Norfleet. In the foreword, E. O. Wilson describes Norfleet's work as part of the tradition of animal fables which allows human nature to be scrutinized dispassionately. In the piece "My tribe is better than your tribe" (above), shining leaf chafer beetles (*Chrysina macropus*) confront metallic wood-boring beetles (*Euchroma gigantea gigantea*). In "The myth of coupling" (right), the two metallic wood-boring beetles (centre) are otherwise engaged while the single shining leaf chafer beetle straddles the stone alone. Norfleet is director and curator of the photography collection at the Carpenter Center for the Visual Arts at Harvard.**

today. His description of the scientific method and the necessary attitude towards experiments and theories, for instance, are enriching for any present-day scientist. Anyone would recognize colleagues in his amusing descriptions of the different "diseases of the will" — sufferers include contemplators, bibliophiles, megalomaniacs and instrument addicts. His insistence that a young scholar should not be put off by the view that in science "the most important problems are solved" is also interesting. After what has happened during the past century in biology, one wonders what Cajal would think about present-day discussions on the 'end' of science.

On the other hand, the book is sometimes deliciously anachronistic. It strongly recommends studying foreign languages, especially German, "because it must be admitted that Germany alone produces more new data than all other nations combined when it comes to biology". And he is completely politically incorrect when he recommends as the ideal wife for a scientist one who "belongs to him, whose best dowry will be a sensitive compliance with his wishes, and a warm and full-hearted acceptance of her husband's view of life". This advice is out of place in our labs full of young women but, from a historical point of view, the whole chapter deserves consideration.

The same is true when he praises patriotism as a source of motivation for the young scholar. Maybe some of these aspects are lost in the translation that converts nineteenth-century Spanish into modern English, and by the deletion of the last chapters, containing his analysis of the reasons for Spain's lack of standing in world science. Many of his comments in these chapters are, unfortunately, perfectly valid today.

The book was written by a person who had to work very hard to achieve an international standing in science, and who came from a country that was struggling to get away from its decadent imperialist tradition. He succeeded in building an easy relationship with the international scientific community and, following a rigorous methodology, he became influential as few other scientists have been.

Bearing in mind the distance in time and culture, you are left with the feeling that a high proportion of his advice is valid. It is written in the candid style of a person devoted to science and willing to help young people on the verge of making a decision that was as difficult a century ago as it is today. □

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Also new in translation

Of Flies, Mice & Men: On the Revolution in Modern Biology, By One of the Scientists Who Helped Make It
François Jacob, translated by Giselle Weiss
Harvard University Press, $24
"It is just wonderful to read about genetics and to be reminded of details from the classics one has almost forgotten. If there were more books like this, genetics might not be under such an attack as it is now. It would be part of European culture".
Benno Müller-Hill, *Nature* **386,** 668–669 (1997)

And some contemporary advice for graduate students

A Student's Guide to Graduate School in the Sciences
by Dale F. Bloom, Jonathan D. Karp & Nicholas Cohen
Oxford University Press, $16.95, £11.99 (pbk)

German science admits to fraud

Der Sündenfall: Betrug und Fälschung in der deutschen Wissenschaft [The Fall of Man: Fraud and Falsification in German Science]
by Marco Finetti and Armin Himmelrath
Raabe: 1999. 261 pp. DM34

Alison Abbott

German science lost its innocence two years ago with the exposure of what is probably Europe's worst case of scientific fraud: the now infamous Friedhelm Herrmann and Marion Brach stand accused of brazen fabrication of data in scores of peer-reviewed publications over many years.

Thirty-something Brach has admitted guilt, but says she was taught to cheat by Herrmann, who had been her mentor, scientific collaborator and lover. The "web of sex, violence and intrigue" that bound her to Herrmann was the breeding ground for the deceit, she claims. Herrmann, 11 years her senior, says Brach had not told him that she was making up results.

The case seemed to release pressure in a fermenting barrel, for German newspapers have since reported a stream of new scientific fraud cases. These include the scientifically important and much-reported case at the Max Planck Institute for Plant Breeding in Cologne, where a technician was able to deceive the scientific world for years by fiddling a key assay, and the curious affair at the University of Giessen where a young veterinary scientist, stripped of his PhD, has been charged with trying to kill his whistle-blower by spiking his tea with digitoxin.

But according to the authors of this fascinating, if somewhat fatalistic book, cheating in German science is not just about the present — it has a long history, and possibly a solid future ahead of it.

Their thesis, coherently argued, is that cheating is both widespread and intrinsic to science, riddled as it is with what they alarmingly refer to as "diseases of science" — the competition for research funds, the pressure to publish and the fight for recognition in Germany's rigidly hierarchical academic society.

They argue, correctly, that the German scientific community had, at least until now, kept its collective mind closed to the possibility that scientific misconduct could exist. 'Idealists' believed that science was too intrinsically pure to allow for cheating; 'rationalists' argued that science must always expose fiction because experiments are destined to be repeated; and 'nationalists' claimed that scientific fraud could never happen in Germany, where scientists have not been exposed to the same pressure as their US colleagues.

The authors efficiently dispense with these arguments. Some German scientists worked on Mengele's experiments in the Nazi era, so science is not intrinsically pure; experiments can lie dormant in the literature for years before they are repeated, if at all; science is global, so there is no such thing as a national scientific culture.

They applaud the way research organizations responded to the Herrmann and Brach affair by designing codes of good scientific practice and efficient mechanisms for handling fraud within the research institution where it occurs, and by limiting damage done to the research community at large. But they fear that the unwillingness of universities to adopt the new rules will allow fraud to continue in a new regime of complacency: "*Problem erkannt — Gefahr gebannt*" (problem recognized, danger eliminated).

This judges too quickly. It is true that universities and research institutes initially displayed innate hostility to guidance from above — guidance, moreover, which seemed to demand a public acknowledgement that they could, in principle, harbour cheats. But universities are already accepting that rules must be set, if only because this is now a condition for eligibility for most sources of public research funds.

Der Sündenfall's message may err on the side of alarmism, but it is certainly a good read, even though the science behind the scientific fraud is not always clearly described. It is expertly researched and its raw material has, by its very nature, a potent human element.

The book includes numerous case studies, beginning in the 1920s with Ernst Rupp, a physicist with the AEG company in Berlin, whose burning ambition to become a university academic, through fair means or foul, turned him into Germany's first known perpetrator of scientific fraud. Rupp claimed that he had carried out an untested experiment designed by Albert Einstein in 1926 to investigate the properties of light.

Showing (apparently) the interference of electron beams, he (apparently) demonstrated the particle–wave dualism of light and matter. His claim precipitated scepticism among the academic community he sought to woo, since the technological hurdles to such an experiment were, at the time, immense. Over the next few years other German physicists were able to prove that he had lied. In his defence, Rupp produced a psychiatrist's report saying that he suffered phases of "psychogenic trances combined with spiritual weakness", during which "he unconsciously published reports about physical phenomena which had the character of fiction".

It is interesting to note that in the good old days fraudsters, however bizarre their excuses, always admitted their guilt when overwhelmed by evidence. Their modern counterparts usually obey their lawyers' advice to deny it to the bitter end. □

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A further string to the believers' bow

The Elegant Universe
by Brian Greene
Jonathan Cape: 1999. 428 pp. £18.99

John Maddox

A year ago, I fell into conversation with a young woman just embarked on a PhD stint at a British university. Her thesis adviser had assigned her a project in string theory, and I asked whether she believed that string theory would indeed answer all the questions of fundamental physics. "I don't think so," she said, "but the mathematics is interesting."

Agnosticism such as this (and worse) is rife. For much of the past 15 years, almost the only rejoinder to scepticism has been the observation that Ed Witten, the Princeton theorist who has stepped into Einstein's shoes at the Institute for Advanced Study, "is a believer". But now the agnostics can read Brian Greene's remarkable book as well.

Greene is a regular physicist at Columbia, a practitioner of string theory of distinction and a proselytizer of the cause. (He is not to be confused with his near namesake, Michael Green, who with his colleague Julian Schwartz of Caltech caused a stir in 1984 by demonstrating that strings can reconcile quantum theory and relativity.) Greene's contention is that the account given by string theory of the properties of the particles of matter is too good not to be true.

To be fair, Greene repeatedly acknowledges, although with decreasing frequency as the pages turn, that his high hopes for string theory may be disappointed. Perhaps he has shrewdly calculated that the sceptics will either have been won over by the repetition of the refrain "Strings are the cat's whiskers!", or that they will have fallen by the wayside before they reach the end — which is a long way from the beginning.

Greene starts with the frank declaration that quantum mechanics and general relativity are incompatible. That, in itself, is not a radical revelation: people have been trying to 'quantize' Einstein's equations for a quarter of a century without success. Greene prefers to explain this failure qualitatively: Heisenberg's uncertainty principle requires that quantum fluctuations increase without limit as the space accessible for the specification of physical variables shrinks indefinitely. That means that space itself, which is smooth on a macroscopic scale, is microscopically far from smooth — or "differentiable", as mathematicians would say.

How does string theory resolve the difficulty? Elementary particles are no longer point-like objects, but tiny one-dimensional strings (which may be open with two loose ends or closed, like rubber bands) which, having tension, vibrate like piano strings. The energies of the normal modes of vibration then correspond to the masses of elementary particles (by the familiar rubric $E = mc^2$). They are all there. Electrons, quarks and the particles that transmit the various forces — photons, the heavy bosons of the electroweak theory and the gluons that mediate the strong nuclear force. And then, magic upon magic, there are also gravitons — the massless particles of spin 2 that are supposed to be the quantum particles of the gravitational field. That is how string theory unites gravitation with the other forces.

This picture, for outsiders, is also the stumbling block to understanding. A real string could not yield the riches of the known elementary particles. External disturbance of a vibrating string, perhaps by collision with another, would change a pure vibrational state into a mixture of all others, but photons do not turn into gravitons or into quarks of different kinds. Why do events of that kind never happen? Because the strings of particle theory vibrate in 10