

know, the precise lineage details may significantly affect each individual's prospects.

In fact, the miracle is that isogenic animals are as similar as they are. Developmental canalization is a very powerful force, which becomes apparent when normal development is perturbed by experiment or mutation. A clone of animals carrying the same single deleterious mutation will sometimes exhibit startling variability in phenotype, while the parental line remains conspicuously uniform. This uniformity is the result of canalization: developmental processes use many error-correcting devices, operating at every level from enzymes to whole organ systems, in order to create highly invariant final structures. The book touches on error-correcting mechanisms, but does not treat them extensively, nor adequately consider what factors may limit their operation. In some situations, as in the immune system, chance may even be retained as a selectively advantageous factor.

Conversely, there are all kinds of possible epigenetic mechanisms that can turn an initial fluctuation into a long-lasting and even permanent change in the life of a cell or an organism. Finch and Kirkwood refer briefly to the possible role of mitochondrial variation as an epigenetic mechanism, but do not explore other possibilities. Their timing is unfortunate, as they discuss the famous cloned sheep Dolly without referring to the recent demonstration that she has a different set of mitochondria from the udder cell that contributed her nuclear genome.

The book ends with various recommendations. One of these is that the familiar partitioning of phenotypic variance into one part attributed to genotype and one part to environment should be extended to include a third part attributed to chance. However, it will be a tall order to separate the contributions of environment and chance. Most biologists will be content simply to remember that 'environment' will always include some uncontrolled variables.

Much of the book's remaining agenda concerns general current research on development and ageing. Perhaps their most salient point is to emphasize the importance of very early developmental events, some of them probably due to chance, in determining the life-history traits of long-lived animals such as humans. To this end, the authors are keen to see the development of technologies for assessing variation in organs such as ovary and prostate at birth, since these seem to have significant long-term consequences for fertility and lifespan. Overall, *Chance, Development and Aging* contains much interesting material, but it could have been distinctly better. ■

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Science in culture

Wozzeck, an opera by Alban Berg based on the prophetic play by Georg Büchner

John Carmody

Science is not the only aspect of human creativity that seeks to be experimental and prescient. This ought to be an enduring aspiration of art, too. And opera — notwithstanding Dr Johnson's denigration of it as "an exotic and irrational entertainment" — has that capacity in full measure. Mostly, though, opera has neglected science and trivialized medicine. But there is one chilling exception, that twentieth-century masterpiece, Alban Berg's *Wozzeck*. It was based on Georg Büchner's prophetic play of 1835–37, a work that was the more telling because it was loosely based on real events.

Büchner, the son of a Darmstadt doctor, graduated in medicine in 1834 but was as dedicated to social and literary reform as to medicine: had he not died of typhus in 1837, while a young lecturer in comparative anatomy in Zürich, he may well have outstripped Goethe in literary achievement. His *Wozzeck* (or *Woyzeck*, in the manuscript of the play) is the model of the anti-hero we know so well in modern literature, the archetype of the hapless, poverty-stricken common man; in particular, he is exploited by medical science. There is, therefore, a timeliness in the new production, under the illuminating direction of Barrie Kosky, which has been at the Sydney Opera House — we have, again, a vantage point for reflection on the role of science and medicine in this century, our retrospect to complement Büchner's prospect.

"We poor people," *Wozzeck* laments to his regimental captain. "If I had a hat, a watch and an eyeglass ... I would be virtuous, too. Folk like us are always unfortunate in this world." Unfortunate, indeed for *Wozzeck*, forced by the need to support his bastard child to participate in the town doctor's bizarre dietetic experiments, to be the victim of a *parvenu* scientist who likens *Wozzeck* to a lizard. The doctor is irritated that this benighted Everyman — a mere experimental subject — is not strictly adhering to his unvaried diet of beans and, worse, urinates in the street rather than into the doctor's collection flasks.

The doctor is hostile to the notion of an individual nature. "Mere superstition. Have I not proved that the diaphragm is subject to the Will? Individuality is sublimated into freedom." Have there been repeated echoes (from scientists and doctors) of that philosophy in our century? The doctor, obsessed with his own importance — "Oh, my hypothesis! Oh, my fame!" — glibly redefines *Wozzeck*'s yearning to express his humanity as a psychiatric disorder, "an excellent *aberratio mentalis partialis*, second species", and later he reveals himself to be equally callous with his patients.

Here we have an allegory of what science would do to our world, not in a detached way,



through weaponry and technology, but face to face with people — the betrayal of medical and scientific trust in the horrible experiments of the Nazi era; the complicity of doctors in torture and murder (and not only in Germany, as Neil Bolton's recent biography, *The Good Listener — Helen Bamber: A Life Against Cruelty* [Weidenfeld & Nicolson], reminded us); the perfidy of medicine in the abuse of psychiatry for so many years in the Soviet Union. It is no exaggeration to say that they are all presaged in Büchner's play; he was describing inhumanity to come, abuse of hapless Everyman and Everywoman on an unprecedented scale.

The extra twist in *Wozzeck* — and Berg's colourful, controlled music makes it more telling — is that the doctor's parasitic indifference to the human values that ought to underpin science and medicine applies to the higher levels of his society no less than to the common soldiers and their women. The doctor almost gloats at the prospect when he warns his friend, the captain, "You might well have an *apoplexia cerebri* someday ... I can assure you that it will be a most interesting case. If God wills it, your tongue will be partially paralysed and we'll be able to do immortal experiments."

In such a society — in *our* society, which Büchner foresaw — every stratum exploits whatever lies beneath it. If art — opera most potently — seeks to "hold the mirror up to nature", *Wozzeck* should compel all of us scientists to look deeply into that reflection of our true souls. ■

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