The two never meet — in between lies what Stewart and Cohen call "ant country", the region where the complicit interaction of systems produces emergent phenomena that cannot be predicted by reductionist methods. The 'ant' business comes from a cellular automaton called Langton's ant, which has inexplicably complex behaviour, entirely unpredictable from the moronically simple rules by which it operates.

Pomposity is the peril likely to afflict any book of this sort. The casual chat of *Gödel, Escher, Bach* goes too far the other way. *Figments*, by contrast, is alarmingly, almost full-frontally, direct. Stewart and Cohen assault (that *is* the right word) all the big questions (the origin of life, the nature of progression in evolution, the mind–body problem, the origin of consciousness and so on) with gleeful expedition. For example, their debunking of Roger Penrose's idea of quantum consciousness as hopelessly reductionist is the literary equivalent of being taken round the back of the pub and mugged.

*Figments* even has its own version of Achilles and the tortoise. These are the Zarathustrans, amusing bird-like aliens who operate through an eightfold group-mind. "Octimality" is the watchword of the Zarathustrans: they even have their own theory of everything that fits on a Z-shirt (the equation is E=8). Stewart and Cohen's sidelong looks at life, the Universe and everything are paralleled by interludes in which the eight crew-members of the Zarathustran survey vessel *Watcher of Moons*, orbiting Earth, consider the same points — and reach intriguingly different conclusions. Amusement turns to terror as the Zarathustrans consider, seriously, whether humanity should be destroyed on the grounds of unoctimality.

At every step, *Figments* questions our placidly received wisdom. Its metaphors often come from science fiction. It is sad that many scientists dismiss science fiction as juvenilia. Ninety per cent of sci-fi is daft, naturally — but so is 90 per cent of everything in the end. And the best sci-fi raises the most scientific questions in readers' minds, questions that always start "What if...?".

Like all books, *Figments* has its faults, mainly that the authors tend to get carried away by their own metaphors — something that leads them into a view of evolution that looks suspiciously orthogenetic. Again, if life on Earth is monophyletic, using morphological analogues as a way of predicting alien morphology is suspect. Finally, the word 'oops' has no place outside cartoon speech balloons. Such niggles are unoctimal, as ultimately (and fittingly) *Figments* is a great deal more than the sum of its parts.

*Figments* will not appeal to everyone. It will hold few charms for anyone homozygous for the *humourless* mutagene, or without much imagination. But science without humour and imagination seems rather pointless — just like books without pictures or conversation were to Alice. We need imagination to frame hypotheses, to wonder what is round the next corner, to ask "What if...?". And anyone without a sense of humour should be a merchant banker, not a scientist — the pay is better, for a start.

For the rest of us, *Figments* is frighteningly readable, and a worthy successor to *Gödel, Escher, Bach*. □

*Henry Gee is chief science writer on* Nature.

# A practical approach to bodybuilding

**Principles of Tissue Engineering**
edited by Robert P. Lanza, Robert Langer and William L. Chick
*Academic: 1997. Pp. 808. $125, £90*

**Nicholas A. Peppas**

The design and engineering of new tissue for functional organs has been a fairly recent endeavour of scientists and engineers working on cell growth and proliferation. The term 'tissue engineering' has been around for more than a decade. In 1987, the US National Science Foundation offered the first request for proposals on tissue engineering, and the resulting programme set up not much later supported the research of some of the early pioneers in the field, including one of the coeditors of this volume, Robert Langer.

The premise of tissue engineering is simple: to replace diseased organs with newly grown, functional organs rather than with structured biopolymers and other biomaterials. Naturally, the characteristics of cell growth and differentiation become important in designing a functional organ. Although *in vitro* control of tissue development is necessary for selection of appropriate cells and scaffolds, *in vivo* synthesis is, of course, the heart of the field.

**A bag of silicon implanted in a female chest wall, defying the laws of gravity. From *The Secret Family: Twenty-Four Hours Inside the Mysterious World of Our Minds and Bodies* by David Bodanis. Simon & Schuster, $27.50 (hbk).**

This new treatise on the principles of tissue engineering is essential for anyone working in the field. It is a vast, detailed and beautifully presented analysis of the cellular principles, *in vitro* and *in vivo* behaviour, modelling and applications of tissue engineering. The subject is broader than its immediate application, because successful design and engineering of organs requires an appreciation of peripheral sciences such as biology, materials science, and chemical and mechanical engineering. The book provides sufficient background in all these fields for a reasonably trained scientist to appreciate any problem that may arise in tissue engineering.

The coverage of the subjects is detailed and clearly annotated, with emphasis on the basics of cell growth and differentiation, *in vitro* control of tissue development, *in vivo* synthesis of tissues, the use of biomaterials as scaffolds in tissue engineering, transplantation issues and applications in the cardiovascular system, the gastrointestinal system, the kidney, reconstruction of cornea and pancreas, growth of cartilage and bones, and nervous tissue regeneration as well as dental and skin applications.

With a book this size, one cannot but be impressed by the coverage. Regrettably, the multi-authored approach (88 authors contributing 48 chapters) creates some problems despite the editors' considerable efforts. Stricter editing would have avoided occasional awkwardness, as in oversimplifications about lymphocyte engineering (p. 530), self-congratulatory comments by authors (pp. 371 and 663), repetition of material (pp. 55–57 and 115–116) or narrative-like history provided by some researchers when describing their own work.

Smaller errors, misinterpretations or confusing remarks can be found, as in equation 1 (p. 173), where the surface tension $\gamma$ is misprinted as $g$; equation 9 (p. 200), which is dimensionally incorrect; the oversimplification of the nonlinear viscoelastic behaviour of materials (notably the modulus definition on p. 205); the one-sided statement about methods to characterize protein adsorption (p. 212), which excludes ATR-FTIR, circular dichroism and radioactive labelling techniques; and the assignment of finite molecular weights to insoluble crosslinked gels (p. 681).

Nevertheless, the book achieves its main goal of educating and directing the novice and advanced researcher in the field. □

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