They tentatively suggest that a "commaform" nematode might be phylotypic, but neglect other possible candidates such as the veliger larva of gastropods, or an early segmenting stage of an annelid worm. In accordance with their general case they argue that the conservation of the phylotypic stage is due to its flexibility and robustness, and do not seriously consider the alternative view that it has stayed the same because selective pressures are at a minimum in the middle stages of development.

The most spectacular achievement of molecular developmental biology has been the discovery of long-range homologies between animal groups in terms of things such as the molecular basis of anteroposterior and dorsoventral patterning. These discoveries enable us to reconstruct long dead ancestors in a way that would have been unthinkable a few years ago.

Gerhart and Kirschner use these data to argue that the stem metazoan was a "roundish flatworm" that flourished below the surface of the Vendian biomat. This organism had Hox genes specifying the anteroposterior pattern; *emx/otx* genes to code for the head; chordin/Bmp-4 signalling for the dorsoventral organization; *pax6* doing the photoreceptor; *myoD* doing the muscle and so on. It is tempting to imagine this robust ancestor of ours as being one of the creatures that created the fossilized burrows in the Vendian and Cambrian sediments, some of which can still apparently be found complete with fossilized faeces.

The best parts of the book are those that use information from molecular biology to tell us what actually happened in evolution. For example, milk is a novelty created by the mammals. But the lactose synthetase consists of two components: a galactosyl transferase that was formerly used to assemble glycoprotein carbohydrate chains; and α-lactalbumin, which is a modified version of lysozyme. Similar molecular insight is applied to other examples, such as the origin of myelin, of intermediate filaments, and of lens crystallins.

The lens serves to introduce what must be the most amazing animal in the book. The cubomedusoid jellyfish, *Tripedalia*, apparently has image-forming eyes but no central nervous system to process or interpret the image. Creationists used to tell us that the image-forming eye could not possibly have evolved by chance because of all the coordinated changes that would simultaneously have been required in the brain. So I am left unsure whether *Tripedalia* represents real evidence against the existence of God, or just flexible robustness run riot.

The book is not designed for undergraduate teaching as it lacks the basic descriptive embryology on which to hang the molecular story. It is well written but fairly long and the intended market is presumably graduate courses for students already familiar with developmental mechanisms who want to explore their implications for evolution. It is just the job for students who want to make their debating skills in molecular evolution more robustly flexible. □

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Earthquakes and elephants

Fieldwork: A Geologist's Memoir of the Kalahari
by Christopher Scholz
Princeton University Press: 1997. Pp. 190. $24.95, £19.95

Keith Cox

In 1974 Christopher Scholz and his team carried out a survey of seismicity in the Kalahari Desert in southern Africa, at the request of the United Nations Food and Agriculture Organization. They achieved some decent scientific results, but also had a whale of a time, with experiences varying from the comic through the awe-inspiring to the downright frightening.

Few Earth scientists write anything in the style of their life's memoirs, so this book is doubly welcome. It should appeal to a wide variety of readers, whether fieldworkers or not. The science is accessibly laid out and richly embroidered with tales of the bush.

The scientific problem that the team tackled was to discover whether there is an active extension of the East African rift system into Botswana. Is this the tip of the system propagating itself southward? The question is potentially important because when a fault, such as that forming the edge of a rift, moves and generates an earthquake, there is a change of elevation along the line where the fault-plane reaches the surface. The Kalahari is very flat and the drainage system is in a delicate balance, around the Okavango delta, for example. A large change in the drainage pattern could easily be induced by only a minor movement, and lead to profound ecological consequences.

Botswana is not noted for big earthquakes, but any seismically active area produces many small earthquakes. So the survey had to deal with micro-earthquakes which, predictably, would turn up in sufficient numbers during the few months spent in the field. The technique is to install an array of three or more seismometers with recording devices, leave them for a day or several days, and then see what you have caught. Then the array is moved somewhere else, and so on.

But much of the Kalahari is covered with more-or-less unconsolidated sand, about the worst possible material through which to try to detect micro-earthquakes. As a result, much time had to be devoted to the search for areas of solid bedrock. This travelling about, setting up camp, overcoming obstacles, coping with the wildlife and, not least, confronting officialdom, forms the substance of the book. It is rich in accounts of the incidents that such a mode of life throws up.

It was necessary, for example, to set up camp in thick bush half a mile from the only watering hole for miles. The only clear strip of bush to camp on turned out to be the main route used by elephants at night on their way to have a drink. Add a few thousand nearby antelopes, lions, hyenas and so on, and the night becomes alarmingly noisy.

In the end, the party managed to observe a sufficient number of micro-earthquakes to confirm their hypothesis. The author comments that when the work was published, it did not cause a great stir, but he regards it as an honest and useful job well done.

Although much of the book is devoted to the sheer joy of life in the bush (and its per-

New in paperback

The Lives to Come: The Genetic Revolution and Human Possibilities
by Philip Kitcher
Penguin, £8.99
"Stimulating, informative and courageous.... Kitcher's arguments are always compassionate, always ingenious and always worth pursuing", wrote John Harris in a review in *Nature* **380,** 591 (1996).

The Value of Life: Biological Diversity and Human Society
by Stephen R. Kellert
Island Press, $16.95
"Immensely stimulating, tending to inspire new questions with every one it answers". Thomas Lovejoy, *Nature* **382,** 594 (1996).

Our Evolving Universe
by Malcolm S. Longair
Cambridge University Press, £14.95
"A beautifully produced book, in an oversize format, with an elegant typographical design, clear diagrams and many colour illustrations... the text is unflinchingly direct and accurate.... Its content is that of a first-rate introductory course". William Press, *Nature* **382,** 220 (1996).

ils), and is written so that you can almost smell the smoke of the camp-fire, the descriptions of occasional trips to town are just as evocative of Africa. We meet a rich array of ramshackle bars with ramshackle customers, we play plenty of darts and hear many a comic or curious yarn.

Perhaps the best is the one about the Afrikaner who, at a time of severe floods, managed one moonless night to drive across a bridge that not only had no handrail but was under two feet of water. On being asked how he managed this, he replied: "What bridge?" □

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Fringe maths

Fermat's Last Theorem: The Story of a Riddle that Confounded the World's Greatest Minds for 358 Years

by Simon Singh

Fourth Estate: 1997. Pp. 362. £12.99

Keith Devlin

On 23 June 1993, the world of mathematics was electrified by the news that the British mathematician Andrew Wiles had proved Fermat's last theorem, a problem in number theory that had resisted numerous attempts at solution for more than 350 years.

Within a few months of that dramatic announcement, an error had been found in the proof. Although everyone agreed that Wiles had produced some of the most remarkable mathematics of this century, he had not, as he had first thought, solved what was almost certainly the most famous open problem in mathematics.

Then, in October 1994, Wiles announced that he had corrected the mistake. This time, the experts agreed that his proof was correct. The complete argument was published in *Annals of Mathematics* in May 1995.

That, in a nutshell, is the story. John Lynch, editor of the BBC 'Horizon' series, sensed a good television documentary and was on to the story from the first announcement. As his co-producer and director, Lynch chose Simon Singh, a physics PhD who had worked in television for five years. The resulting programme was broadcast in 1996. This book is a spin-off from the programme. It comes close on the heels of another book of the same title, by Amir Aczel, which was reviewed in *Nature* last October (**383,** 774; 1996). That review applies virtually word for word to the Singh book.

Both books adopt the same overall approach. They offer plenty of discussion of the early history of Fermat's last theorem, a selection of mathematics' most durable and oft-repeated anecdotes and examples, many of them having little connection to the theorem (such as sphere packing, the four-colour theorem, the Galois saga), capped off with the briefest of thumbnail sketches of Wiles's proof.

The similarity is an inevitable consequence of the difficulty facing anyone who sets out to write a popular account of Wiles's solution to the problem of the theorem. The problem itself is easily understood, and the human drama that surrounds it has all the elements of good drama, from the problem's origin right up to the final acknowledgment that it had indeed been solved. But the solution is something else. There are probably only a dozen mathematicians in the world who are sufficiently knowledgeable to follow Wiles's proof fully, and maybe a few hundred who can, with difficulty, struggle through it.

Fermat's claim was that for no whole number n greater than 2 can the equation $x^n + y^n = z^n$ have any whole number solutions for x, y, z (except where one of the numbers is zero).

Wiles's proof involves building a bridge to connect two areas of deep mathematics that had hitherto been regarded as entirely separate, the theory of elliptic functions and the theory of modular forms. As long ago as 1954, two Japanese mathematicians, Yutaka Taniyama and Goro Shimura, had suggested that these two areas were connected. But, although over the years an increasing number of mathematicians had come to accept the possible truth of the Taniyama–Shimura conjecture, most thought that a proof was many decades away.

In 1986, Ken Ribet proved the surprising result that Fermat's last theorem is a consequence of the conjecture, providing Wiles with a possible way to attack a problem that had fascinated him since childhood.

By proving a special case of the Taniyama– Shimura conjecture, Wiles not only proved Fermat's last theorem, he opened the doors wide to an entirely new era in number theory. His proof was both an end to a 350-year-old riddle and the beginning of an era in which we will learn much more about those oh-so-familiar counting numbers that lie at the heart of mathematics.

For a would-be author of a book that sets out to explain the story of the last theorem, the only viable approach is to provide mathematical detail around the edges, where its only function is to put some mathematical content between the book's covers, and to concentrate on the human drama when it is time to describe the problem's final resolution. Although I think Singh's book would have been better had he included less of the peripheral 'popular mathematics' dressing, his treatment of the human drama is well done, and as a result the book succeeds.

Non-mathematicians should get something of the flavour of the way mathematicians work, while mathematicians will enjoy learning some of the human details surrounding the eventual solution. □

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Money in the equation

Wiles's proof of Fermat's last theorem is also now described in the paperback edition of Keith Devlin's *Mathematics: The Science of Patterns* (W. H. Freeman/Scientific American Library, $19.95, £14.95). The book was originally published in 1994, shortly before the proof's discovery, and was reviewed in *Nature* 373, 206 (1995). As Devlin points out, the offer of various awards to the first person to find a proof has added to the theorem's allure: in 1816, the French Academy offered a gold medal and a cash prize; and in 1908 the Royal Academy of Science in Göttingen offered another cash prize, the Wolfskell Prize, now worth £30,000. Wiles, pictured here announcing his solution at the Newton Institute in Cambridge on 23 June 1993, receives the latter award tomorrow (27 June).