

of intact cells) requires sophisticated mathematical reasoning and well-planned numerical simulations. Not many molecular biologists are inclined to such rigours, nor are many applied mathematicians conversant with the biological problems.

Albert Goldbeter is one of the few scientists in the world who speak both languages fluently. Here he communicates his style of analysing periodic behaviour of biochemical and cellular control systems. He treats in great detail all the classical cases — glycolytic oscillations, cyclic AMP signalling, pulsatile hormone secretion, calcium oscillations, cell cycles and circadian rhythms — and is a reliable guide through the intricacies of the biochemistry and mathematics. The great strength of the book is his unshrinking dedication to understanding these processes from start to finish. The volume is loaded with experimental data, hypothetical mechanisms, differential equations, numerical simulations and careful comparison between theory and observations. Although the book is conversational, clear and accurate, Goldbeter makes no concessions to his readers. He assumes equal familiarity with metabolic pathways, polyacrylamide gels, Hopf bifurcations and deterministic chaos. Few readers will be able to keep pace as he flips back and forth between biology and mathematics. This is a book to read with a friend who speaks the 'other' language.

My only complaint is that Goldbeter discusses in detail only his own models of each rhythmic process. I can forgive this in a man who practically invented the field, especially in someone as unpretentious and likeable as Goldbeter. But there are other models of some of these processes that are superior to his and should have been given top billing. On the other hand, Goldbeter is generous, thorough and tasteful in his citations to the literature, from which the reader can easily gain access to the best experimental and theoretical work available.

Although it will demand some hard thinking, the book can serve as a reliable and rewarding introduction to mathematical modelling of dynamic processes in living cells for any molecular biologists beginning to see the usefulness of this tool. As Michael Berridge says in his foreword to the book: "I [have begun] to appreciate the value of good modelling, especially now that we have learnt so much more about the basic biochemical details regulating cellular activity. For each system now being investigated, there are so many variables that it becomes impossible to use our intuition to assess how each parameter influences the oscillatory cycle. The only way to understand these biological rhythms, therefore, is to become more quantita-

tive and to develop rigorous mathematical models. Albert Goldbeter is at the very forefront of this new approach." □

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Shifting sands

Martin A. Conway

Memory Distortion: How Minds, Brains, and Societies Reconstruct the Past. Edited by Daniel L. Schacter. *Harvard University Press: 1996. Pp. 417. \$49.95, £31.50.*

A COMMONLY held belief is that long-term memory is like a library, a personal library that we each carry around in our heads. In remembering past events, we take books from the shelves and examine their contents. On other occasions we might misplace a volume. Later we might quite by accident stumble upon it and feel the sense of wonderment that accompanies the recall of a 'forgotten' event. It is an attractively simple and beguiling metaphor, but one that students of human memory have long known is wrong.

Nor is human memory like a photograph album, a collection of cassettes, compact discs or videos or any other accumulative archive of the past. Rather, memories are fragmentary, condensed, often distorted and inaccurate representations of past experience. This point is made in impressive detail by all the contributors to this excellent collection of essays on memory distortion. Memories carry with them personal meanings and are interpreted in terms of the current knowledge, understanding and goals of the rememberer or, in the case of collective memories, of the group or society. They take effort to construct and are difficult to hold consciously in mind for more than a few seconds: they quickly dissipate from awareness and must be laboriously brought back to mind. In short, they are transitory mental constructions that encompass knowledge at different levels of abstraction — from the specific to the general — drawn from long-term memory and from the current processing environment and held together by control processes in the frontal lobes of the brain.

Patients with neurological damage to the frontal lobes can no longer construct mental representations of the past. Instead, as Morris Moscovitch shows, these patients replace gaps left by their memory disorder with imaginary remembered experiences consistently believed to be true. The mental constructions that must mediate their memory reports are not shaped to give an

accurate account of past experience in even its most general aspects.

Long-term memory is also exquisitely sensitive to cues in the external environment and to knowledge internally generated or activated. We are, perhaps, constantly reminded of the past although we may not be directly aware of this. Control processes in the human brain modulate access to knowledge activated in long-term memory, allowing only some information to enter central processing sequences. Clearly, it would be no good if every cue one encountered led to the eventual construction of a memory (although Proust may have disagreed). On the other hand, being reminded of some relevant past experience can dramatically help in problem solving or achieving personal goals.

Larry Squire examines how the transitory but temporarily stable patterns of activation that make up memories may be distributed over anatomically and cognitively distinct memory systems that represent knowledge in different ways. James McClelland gives a preliminary outline of how memory construction might take place in parallel distributed processing architectures. Within this overall framework it is easy to see how memories can be accurate, inaccurate and incomplete all at the same time. The constructivist account also provides ready mechanisms for the incorporation of false information into memories and even the construction of wholly false memories, not only in patients with damage to their frontal lobes but also in normal people under certain experimental conditions.

In his scholarly and thorough introduction, Schacter traces the history of experimental memory distortion, and Elizabeth Loftus and colleagues and Stephen Ceci describe some recent exciting work on the creation of wholly false memories in normal people. Interestingly, only about a third of the participants in these experiments ever develop false memories, which indicates that there are individual and group differences in memory accuracy.

Arising from a seminar held by the Mind, Brain and Behavior Initiative at Harvard in May 1994, *Memory Distortion* provides an outstanding multidisciplinary perspective on memory accuracy, ranging from cognitive psychology through psychiatry, neuropsychology and neurobiology, to sociocultural analyses. My only reservation is that the book does not deal with the implications of a constructivist account of memory, particularly one emphasizing inaccuracy. If human memory is inaccurate and distorted, what use is it? My own view, for what it is worth, is that memory is primarily a vehicle for personal meanings and for grounding the self, and that accuracy is secondary to this role. □

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