

main thesis any further. The insights gained are certainly no easier to interpret than Galileo's work and can be of value only when seen in relation to this work.

But the overriding contradiction in Segre's view is this: if Galileo's copious writings, notes and correspondence cannot yield reliable evidence, why should we expect the work of his critics or disciples to do so? Where in fact would the corrosive effect of such scepticism end?

Segre concludes that "throughout we have seen that it was Galileo's critics who employed an empirical discourse", from which he deduces that it was they, rather than Galileo, who were the real empiricists. Alone, however, this argument can prove very little — one needs to be rather cautious about the idea of 'empirical discourse' and enquire a little into the motivation of those employing it. Several of Galileo's contemporaries were so struck by his proposal of mathematical-empirical laws that they became obsessed with his idea of empirical verification. But rather than roll smooth spheres down a gently inclined plane as Galileo had done, they decided to study the vertical fall of spheres from high towers. Naturally, because they did not conduct their experiments under the carefully controlled conditions recommended and used by Galileo (as the manuscripts now confirm), they insisted his law of fall was not quite correct and proposed some 'empirical' improvements to it. Others challenged the accuracy of his claim that the pendulum was isochronous. All of them implied that they were the better 'empiricist'.

So Galileo's critics tended to become bogged down in empirical trivia, mainly because their use of experiment did not form part of a directed research programme. Indeed, they wrote a great deal about their empiricism — in relation to Galileo's ideas it should be noted — because that was all they were capable of doing. They failed to see how empiricism could be used to develop physical theory. Certainly they did find some flaws in Galileo's empirical claims, but his theory of motion was so sound overall that these criticisms had little effect.

That Galileo's critics had a notably inferior grasp of the use of experiment, yet stressed how 'empirical' they themselves had been, is no basis for dismissing Galileo's actions and words. In reality, the very inability of his rivals to distinguish the wheat from the chaff demonstrates his superior empirical abilities in comparison. □

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Before or after?

Lynn Bindman

Long-Term Potentiation: A Debate of Current Issues. Edited by Michel Baudry and Joel L. Davis. MIT Press: 1991. Pp. 454. £62, \$70.

A PRIME candidate for the neuronal basis of learning and memory is a phenomenon called long-term potentiation. This is an increase in the strength of synaptic transmission following increased activity at a synapse that lasts for hours and possibly weeks. It has been produced in the hippocampus, cerebral cortex and cerebellum, all areas of the brain that are important for learning and memory.

The explosion of interest in long-term potentiation (LTP) is illustrated by the fact that four sessions of the Society for Neuroscience meeting in November 1991 were devoted to the phenomenon. I feared that this book, arising from a conference held in 1990, would seem outdated and be merely another collection of symposium papers. Instead, I found it to be compelling reading and a most worthwhile compilation of information and references (updated into 1991). This is due as much to the way in which the editors have organized the book as a debate of five controversial aspects of LTP, ensuring that each author addresses the debated issue and arranging a discussion chapter at the end of each section, as to their choice of distinguished contributors. In most places, the excitement of the debate and current research shines through.

The five themes of the book are: first, whether the maintenance of LTP depends on presynaptic or postsynaptic mechanisms; second, the role of different calcium-dependent enzymes; third, the biophysical and structural changes that underlie different stages of LTP; fourth, the relation between LTP and learning and memory; and fifth, the rules for LTP in neural networks. The book therefore encompasses experimental approaches that range from the cellular to the behavioural.

The presynaptic versus postsynaptic question is the dominant one in the debate, and so it is appropriate that both here and in the book it receives the most attention. Evidence from more than one laboratory indicates that the maintenance of LTP in the hour or so after induction results from an increase in neurotransmitter (glutamate) release. Because there are two main classes of glutamate receptor, the AMPA (α -amino-3-hydroxy-5-methyl-4-isoxazole-propionate) and the NMDA (*N*-methyl-D-aspartate) classes, increased glutamate

release should enhance both the AMPA- and the NMDA-mediated components of the postsynaptic potential. But in 1988, J. Kauer and associates, and D. Muller and G. Lynch found that the enhancement of excitatory postsynaptic potentials in LTP was mediated by only the AMPA class. In the book, though, Z. Bashir and colleagues, and R. Malinow and R. Tsien present convincing evidence that the NMDA receptor-mediated component is also enhanced in LTP. It is still unclear why these contradictory findings exist, although Malinow and Tsien have tested various possibilities and proffer a still untested explanation.

Quantal analysis of transmitter release is another tool for differentiating between presynaptic and postsynaptic maintenance of LTP. Three groups assess different methods of quantal analysis at synapses in the central nervous system. The interpretation of the results of these analyses is controversial because such synapses have different characteristics from the neuromuscular junction where the technique was first applied. The results using quantal analysis of transmitter release in LTP are also not in agreement, favouring either a primarily presynaptic or a mainly postsynaptic change.

It is obvious from the work reported in the book and at the Society for Neuroscience meeting that both presynaptic and postsynaptic changes can occur in LTP. The debate must now focus on the circumstances under which these changes are produced, and the time over which they are expressed.

What are the new findings and issues that are missing from the book? Since it was written, associative, synapse-specific LTP has been induced in single cells of the motor cortex of awake cats; nitric oxide has emerged as a candidate for the retrograde messenger in the induction of LTP; a form of LTP not involving NMDA receptors has been induced in area CA1 of the hippocampus; microfluorimetry has shown increased concentrations of calcium within dendritic spines after afferent tetani; and the mechanisms underlying the obverse phenomenon of long-term depression are being identified. But these omissions — inevitable when book publication takes many months, and most obvious in a fast moving field such as LTP — should not deter libraries and laboratories from purchasing this excellent book. □

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■ *Excitatory Amino Acids and Synaptic Transmission* edited by H. Wheal and A. Thomson is a comprehensive reference text that includes a section on LTP and an extensive glossary. Published by Academic, £65.