tion change rather than methodology, but there are some helpful discussions of techniques such as the interpretation of alluvial pollen data in the drier regions, as in New Mexico, and the development of the isopoll vegetation maps in the north-east. The bibliographies supplied with each chapter are extensive and are a splendid point of entry to the relevant literature.

The timing of this volume is somewhat surprising, coming as it does on the heels of the two-volume *Late Quaternary Environments of the United States* (University of Minnesota Press/Longman, 1984). There is obviously a fair degree of overlap with that work, but the book reviewed here is confined to pollen data and is thus more detailed in vegetation descriptions and in its attention to regional variation.

Bringing so much information into one volume must have been a formidable undertaking and it has been brought off successfully only by careful planning and editing. Apart from finding a wide audience in North America, the book will be welcomed by palynologists on this side of the Atlantic who, perhaps, may be inspired to perform a similar service for Europe. □

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Done with a will

Richard Passingham

The Brain Machine: The Development of Neurophysiological Thought. By Marc Jeannerod. Translated by David Urion. *Harvard University Press:1985. Pp.171. $16.95, £14.50.*

THE subtitle of *The Brain Machine* says that it deals with *The Development of Neurophysiological Thought.* It doesn't. In the original French the subtitle is *Physiologie de la Volonte,* and indeed the book turns out to be about the history of neurophysiological speculation about willed movement.

In Descartes' time people were credited with a will but animals were not. Descartes correctly conceived of the brain as a machine, although his conception of its workings was quaint. However, he also believed that by some mysterious process the machine was controlled by an indwelling soul.

Later physiologists, such as Hughlings Jackson, suggested a class division within the brain: based on the observation that damage to the motor cortex interfered with willed movements while leaving many automatic movements intact, the idea was that the lower centres catered for our animal needs, while the higher neocortical centres supervised our voluntary activities. Certainly, it is true that patients with such damage report that it is their subjective impression that moving the affected limb requires them to summon up an effort of will.

Jeannerod argues that "the elucidation of the term 'will', and the multiple concepts it covered, without doubt constitutes the central problem in comprehending the physiologic bases of the different aspects of movement" (p. 20), and in the various chapters of his book he covers some of these concepts. One issue is how a movement is triggered. We carry out some movements in response to external prompts, but there are others that we perform at our own direction and at our own pace. In accounting for spontaneous movement, the author mentions the spontaneous rhythms of the electroencephalogram and the oscillators proposed by von Holst. He also describes studies in which slow potentials are recorded from the cortical motor areas while subjects make simple movements. These potentials differ in their pattern and timing when it is the subject rather than the experimenter who decides when the movements are to be made.

A second idea is that of intention. Jeannerod argues that if a movement is intended the brain knows "what will happen as a result of its own action" (p. 97); that is, the brain is aware of its own commands and can therefore compare what happens with what was intended. A copy of the command to the motor system is sent to other centres, but if a movement occurs which is not intended there will be no such copy.

There is, too, a third notion: "Human action, when it is voluntary, intentional, or propositional, has the distinction of being dominated by language, in the sense that language precedes the action and is an integral part of the representation" (p. 121). More generally there must be a plan; people can try out possible actions in their heads before performing them. Recent technology has allowed us to detect evidence of such planning. When brain regions increase their activity they increase their metabolic requirements, and we can use the flow of blood to an area as a measure of its metabolic activity. It is now possible to take these measurements from the outside of the skull and thus to investigate the activity of brain regions in human subjects while they carry out mental work. If subjects are asked to rehearse mentally a set of finger movements without actually performing them, activity can be detected in the supplementary motor area.

Jeannerod's book gives the history of these and other ideas. He includes chapters on such topics as the natural history of the soul; hierarchy and integration of movements; the motor cortex; the physiology of spontaneity; representation, plan, programme; and action, the force of self-organization. He ranges widely, his theme taking him from animal spirits to electrical conduction, and from spinal reflexes in frogs to apraxia in the hospital clinic, and also into the realms of European philosophers such as Schopenhauer, Cassirer and Merleau-Ponty. Because the thrust of the book is primarily historical, Jeannerod says little of modern experiments in modern physiology. But the history of ideas on this subject is intriguing, and makes an altogether fascinating story.

The book is illustrated with line drawings, some of which are delightful: for example, the author reprints Descartes' splendid drawing of the mechanism for muscular contraction, a naive diagram by an alchemist of mental function and a beautiful drawing of a brain dissection done in 1827. The text has been well translated by David Urion, and it is to his particular credit that if the book were handed to someone who did not know they might fail to guess the language of the original. □

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• Recently published by Raven is *The Citadel of the Senses,* by Macdonald Critchley, a collection of 30 short essays on episodes and personalities in the "prescientific age of neurology". The book costs $32.50, and will be reviewed in a future issue of *Nature.*