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Concluding Remarks

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Concluding remarks

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The discussion has shown that plasticity in the nervous system is now a topic that is actively investigated by physiologists and psychologists. When I gave the Ferrier Lecture on the subject 25 years ago it was little understood and what was known was mostly about the peripheral nervous system. We now also have a considerable body of knowledge about plasticity in the central nervous system, even in mammals, which is welcome both for its importance in medicine and for our understanding of the fundamental problems of neuroscience. The brain depends upon different channels responding to different items of information, so the key to understanding it is to find out how the channels become connected.

The conference has shown that, as in all developmental problems, heredity and environment both play their part. Every aspect of the brain is 'doubly dependent', on genetic influences from within and environmental ones from outside. The capacity to respond during development is presumably itself programmed in the genome. Keating showed how adaptive changes are needed in *Xenopus* to make the receptors and the nervous system keep pace with the changing pattern of behaviour.

Rakic suggests that the plasticity of the adult nervous system may be a 'vestige' of the neuronal modifiability that is essential for proper development. But natural selection tolerates few wholly useless 'vestiges' and, as Wall showed, plasticity *was* useful in the past of each organism, *is* useful now and *may be* needed later. When we know more of its mechanism we may find that it also serves for what we more ordinarily call memory.

Unfortunately we still understand very little of this mechanism. Biochemical work such as that of Horn & Rose suggests that protein synthesis is involved, but this is no great surprise. What we need to know is where it takes place and how it alters connectivity. Few contributors to the discussion were able to deal with possible changes in the details of neuronal organization. There was hardly a mention of growth of synapses or dendrites, or of synaptosomes, axonal transport or tubulin, nor of the place of specific molecules on the pattern of immunology. Gradient fields were often at the back of our minds but no one suggested detailed mechanisms for them.

Situations in the peripheral nervous system provide experimental possibilities that may help us to find the mechanisms. Buller showed how nerves can influence the contractile properties of muscle and Mark how one set of nerve fibres can suppress the effect of others that are present. Perhaps the most novel finding to emerge was that excess innervation may be very prevalent, in a masked or inhibited state, and that it can provide the basis for rapid changes of function. If some nerve fibres are removed from an area, the actions of others may begin to appear. This was shown explicitly by Wall and may well be at the basis of the striking developmental phenomena shown by Le Vay, Wiesel & Hubel and by Blakemore. Wall is inclined to think that the changes do not involve actual growth of new terminals, but Raisman showed that this does occur in the septum.

The presence of a superabundance of fibres and of possible connections may well prove to be a fundamental feature of the more complex parts of the nervous system. In contrast to more hard-wired systems they would thus be programmed to be ready to react to functional determinants. Indeed the presence of many possible alternative pathways is almost certainly an essential of a good neural memory. The mechanism by which appropriate paths are selected is not known but may involve an action of the short axon cells, perhaps by inhibiting unwanted connections. Cajal long ago emphasized the prevalence of such cells in the more modifiable parts of the brain. Investigation of their actions may be one of the next important tasks for physiology.

Presumably the human brain is especially rich in possibilities of connection. There are almost certainly critical periods in children as in kittens, when particular types of connections are especially readily made if stimulation is adequate. Knowledge about such periods and their physiological basis may be of great help to pediatrics and indeed all education.

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