reviews of specific and non-specific immunotherapy suggest that these approaches in animal tumour systems are still ill-defined and unproven. Yet these same approaches are being tested against a wide range of human cancers, often in conditions that would be considered unacceptable in the model animal systems. These contrasts between the experimental animal work and the application to human cancer surely point to the need for a more critical approach to this important aspect of cancer research.

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Function of the cerebral cortex

The Mindful Brain: Cortical Organization and the Group-Selective Theory of Higher Brain Function. By Gerald M. Edelman and Vernon B. Mountcastle. (MIT Press: Cambridge, Massachusetts and London, 1978.)

THIS book of 100 pages consists of two papers given in June 1977 at an Intensive Study Program of F.O. Schmitt's Neurosciences Research Program (NRP). They are here published separately from the main volume of that meeting, "The Neurosciences: Fourth Study Program" (in which they will also appear), because it is thought that they are closely interrelated; and F.O. Schmitt claims in the Introduction that the two papers represent the "convergence of theory with experimentally established facts".

Vernon Mountcastle comes first with the facts. It was he who discovered that cells in the somatosensory area of the cerebral cortex were grouped according to the modality of cutaneous excitation that excited them. These groups or clusters of neurones are called columns because they run through the depth of the cortex perpendicular to its surface, and their discovery represented the first evidence for microstructure within the topographical mapping of the cutaneous surface on to the cortical surface. This chapter provides an excellent review of the anatomy of the cerebral cortex. According to Powell the basic element is a cylinder 30 μm in diameter containing 110 neurones; Mountcastle calls these "minicolumns" and regards them as the repeating module from which the cortex is constructed. He estimates there are about 600 million minicolumns in the human cerebral cortex. They are actually smaller in diameter than the functional groups that were first described as columns in the somatosensory and visual cortex, which Mountcastle now calls "macrocolumns". According to Hubel and Wiesel's work on visual cortex there must be just under 1000 minicolumns in a macrocolumn, and just under a million macrocolumns in the human cortex. The remarkable feature of their work on visual cortex is the high degree of regularity and order they have revealed in the arrangement of minicolumns within the macrocolumn.

It is hard to find a good account of the anatomy of the cortex, and this is a most useful review. One does not, however, emerge with much idea of what these repeating modules actually do, so one plunges eagerly into the theory that is said to converge with the facts. Gerald Edelman is best known as an advocate of the selectionist theory of the immunological response, and he here proposes a "group selectionist theory of higher brain function". It is always interesting to see what a distinguished visitor from another science makes of one's own subject. But alas it is often disappointing, and for me I fear it was so in this case. Edelman starts by postulating that "The main unit of function and selection in the higher brain is a group of cells . . .". No serious attempt is made to justify this: why not take a single cell as the unit, or a single synapse? This theoretical postulate of the group is probably the main "convergence" with Mountcastle's facts that Schmitt claims, but there is nothing at all to indicate that the group postulate is the result of a convergence; instead, it is, more likely, simply the natural starting point for someone who has been associated for many years with the NRP, and hence with the work on cortical columns. At any rate, a much better theoretical case would have to be made for postulating the group as a unit before any weight could be attached to the claimed convergence with anatomical and physiological facts.

In Edelman's theory the cell groups are selectively activated by patterns of excitation. He attaches great importance to "degeneracy", by which he means that they are excited by a range of patterns, and the range for one group overlaps that for another cell group. This is probably thought to correspond to the "partially shifted overlap" in Mountcastle's account of cortical colums. The cells of one column have some but not all properties in common with those of neighbouring columns; for instance, they respond to the same modality of excitation, but come from a slightly different area of skin. At a much higher level this "degeneracy" may correspond to the fact that the units of thought and language have both specific and general attributes; a horse is a highly specific object in the sense that there are millions of other species of living things and nameable natural objects, but it is a general term in that it includes all individual horses. It is interesting to link these facts under the term "degeneracy", though it might be premature to start a search for the "horse" column in the cortex! To be serious, what seems to me to be missing in Edelman's theory is any recognition that sensory stimuli are themselves structured, and the lack of any attempt to account for the structure in the way we classify our sensory stimuli. Why pick on horses as a class of nameable objects, and for that matter why are cutaneous stimuli grouped by modality in the somatic cortex? The term degeneracy does not explain nearly enough.

My disappointment with the book as a whole stems from the fact that both authors approach the problem of higher nervous function from the same, rather narrow, viewpoint. After all, the cortex of man is responsible for his intelligence, his social behaviour, his language and, to some extent, his history. You will find little mention of the remarkable things the human brain does in these two chapters. An imaginative engineer who watches a tennis player return a service must be filled with amazement and admiration for what goes on in his brain, but these authors show no such respect for their subject matter, though to be fair they show no signs of disrespect either. Instead, they both just blandly attempt to explain consciousness; indeed they write as if this is the main problem of higher nervous function that requires explanation. I would be accused of poking fun at them if I were to quote what they have to say on the subject, but it leaves no doubt in my mind that attempting to understand the mechanisms of tennis-playing would have been a more fruitful, less premature, objective than trying to explain consciousness.

To summarise, the book contains a first rate and valuable review of cerebral neuro-anatomy, and a theory that I hope gives more insight to others than it did to me. It is safe to say that we still have much to learn about the function of the cerebral cortex.

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