**The Mindful Brain: Cortical Organization and the Group Selective Theory of Higher Brain Function.** Gerald M. Edelman and Vernon B. Mountcastle. Cambridge, Massachusetts: MIT Press, 1982, 100 pages, $5.95 paper.

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*The Mindful Brain* is really two separate mini-books, each being largely independent of the other and both quite short. They are not completely independent however, since Edelman's theories of organization and function are built to some extent on Mountcastle's discussion of brain structure and neuroanatomy. Neither section is easy reading and cannot be lightly read by anyone but the most sophisticated reader. They are both quite provocative and any reader will find him or herself so intrigued by the facts that his or her thoughts will fast diverge to related ideas of applications.

Because of the difficulty level of both parts, many readers will find it useful to read with pencil and paper—if not an atlas of neuroanatomy at hand—in order to sketch out the relationships that are posited. The effort will be rewarded since both sections are logical, tight and well-grounded in recent research literature. Much of the mystery of "mental" functions is clarified by the combination of these authors. The illustrations are helpful, but it is always difficult to translate ideas into printable format.

Professor Mountcastle's description of cortical organization is embarrassingly simple in a way, since his model is so direct and clear: the cortex is organized by vertical columns, interconnected into "modules" and connected to other groups of columns thereby forming distributive systems. Each module becomes an entity by virtue of functional commonality and connection; but these modules are further interconnected to other modules, thus forming larger systems. Mountcastle emphasizes the connectivity of the modules even to the extent that the extrinsic connections (outside the module) are the most important principal for brain function. He very much emphasizes the input-output processing of the columns, rather than how the column (or cells, for that matter) functions intrinsically. Thus, different areas of neocortex are distinguishable primarily on the basis of different connectivities, and much less on a cellular level. This kind of organizational scheme is consistent with what seems to be known about the structure of cells, and the interconnection of cells, but at the same time this leads into a "higher" organizational system, a system perhaps consistent with "thought". The latter is only briefly discussed in the end of this section, much to this reader's disappointment—almost as if this section provided a tantalizing lead into Dr. Edelman's following section.

Dr. Mountcastle states that "neocortex is everywhere functionally more uniform than hitherto supposed . . ." (p. 15). The existence of the neural module, by offering a model dependent upon interconnections between different areas of the brain, is less consistent with the older models of how the brain functions and much more consistent with the newer models starting as early as the work of A.R. Luria. The results recently obtained by Dr. Patricia Goldman are a good example of a kind of research support that Dr. Mountcastle can bring forth bearing on his theories. Even though we have long since given up the idea of mass action, a model of elaborate and complex interconnectivity of neural modules would explain how the mass action theorist could have been misled in terms of understanding covert behavior. It

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certainly shed some light on how it is possible for similar behaviors to be disrupted by injuries to divergent sections of the brain.

Dr. Mountcastle's system is quite clear with respect to the sensory-motor functions, even parietal functions; but the system is more vague with respect to the higher integrative or planning functions, speech and language or limbic system functions. Even though not explicit, it is likely that this organizational scheme will hold up for these other functions. The reason that Dr. Mountcastle did not discuss them more directly may be due to the state of knowledge about these areas (which is not as advanced as that for sensory-motor functions), or due to his assumptions that the model will fit.

Dr. Edelman's section relating to group selective theory of higher brain function is throughout quite exciting and intriguing; however, it also is not easy reading. It is sometimes difficult to follow Edelman's diagrams. However, with some thought and some care in studying this, the model is extremely provocative.

Edelman postulates that incoming stimulation is processed by cell groups (which might be analogous to Mountcastle's neural module), and groups of cell groups. He relies heavily on the concept of degeneracy; that there are several groups or groups-of-groups that can respond to a given output. Also, any group may respond to many different kinds of stimuli. This offers an overlapping system, but one which has the kind of flexibility and possibility for many permutations that would be required in order to account for how the brain processes complex stimulation.

These groups are widely distributed, not anatomically contiguous, but interconnected in some infinitely varied pattern with other groups throughout the cortex. Once again, this idea fits very well with Mountcastle's structural organization hypothesis. In fact, the notion of groups-of-groups can account for higher order cognition in association processes that branch in many directions.

The degeneracy principle is important to explain the experience of divergent thinking, of what seems like "multi-channel" processing, and for recovery of function after cortical insult: Memory relates to degeneracy, in that there is an increased probability of response with repeated stimulation of a given group or group-of-groups. Thus, fewer cell groups become more likely to respond; the exact mechanism (chemical, physical synaptic, etc.) has not as yet been determined.

Consciousness becomes related to the ability of the cell group (or group-of-groups) to monitor internal states. One can have re-entrant input or self stimulation, with these perhaps recycling in time with slight changes in a-cycle. This is slightly suggestive of the old claim of "reverberating circuits".

Dr. Edelman relies on a not-clearly-developed-principle to explain the initial formation of cell groups. He leans strongly on the belief of diverse associative networks utilizing nearby cells as well as longer association pathways. He utilizes in his theories the neocortex as well as thalamic pathways, brain stem, and limbic system. He discusses the development of groups and groups-of-groups in terms of embryonic development and phylogeny.

The model is complex and difficult to follow in written form—it probably would be much more easily understood from the perspective of a lecture, but the model is exciting because of the scope of phenomena it can accomodate. The reading and understanding of this little book should be required of every psychologist who takes seriously the physiological underpinnings of behavior.