Neuroscience: a new era?

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Neural Darwinism: The Theory of Neuronal Group Selection. By Gerald M. Edelman. *Basic Books: 1987. Pp.371. $29.95.*

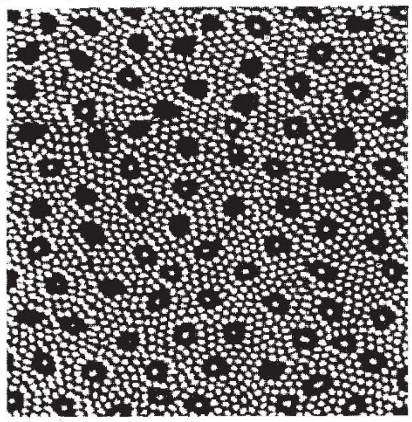
THE power of Darwinian selection is much in the air these days, especially after the success of the clonal selection theory in immunology; it has, for instance, been applied to the travelling salesman problem by Brady (*Nature* **317**, 804–806; 1985) and to the learning of temporal sequences such as bird song by Dehaene and colleagues (*Proc. natn. Acad. Sci. USA* **84**, 2727–2731; 1987).

The basic idea of Gerald Edelman's book is stated in the title: neurons are organized into groups, and these groups are subject to a selection process which forms the anatomical and functional patterns of connection that are responsible for the astonishing performance of the brain. Assessment of the merit and originality of the idea depends upon the specifics of these proposals: what are neuronal groups, what are the selective processes applied to them, and where is the potential for exponential growth that is so essential for a Darwinian process to have the power it does? Finding answers to these questions is not easy, for although the distinguished author has obviously made desperate efforts to explain himself clearly, this is an exceedingly difficult book to read and understand.

One of the difficulties is stylistic. In discussing the localization of function in the brain, Edelman says (pp.141–142): "The position taken here (and the only one consistent with neuronal group selection theory) is that the real basis for overall functional responses is the dynamic interaction of specific individual components arranged in repertoires of neuronal groups or populations within different mapped reentrant structures rather than the fixed assignment of function to anatomically distinct regions". That sentence is hard to understand, and so are many others in the book.

A second difficulty lies in the lack of clarity and completeness in the definitions. For example, it is crucial to understand exactly what Edelman means by the term "neuronal group", which figures so prominently in his thinking. Perhaps the simplest question to ask is: are the groups overlapping, or non-overlapping? If a given neuron can belong to more than one group the number of possible groups is virtually unlimited and it might be possible to devise a rule for group reproduction that would give the potential for exponential growth. Both Darwin and Wallace appreciated that it was the potential Malthusian population explosion that gave natural selection its immense power, and the glimpse of neuronal groups with these properties makes one say to oneself "Aha, this idea might work". If, on the other hand, the groups are non-overlapping, then reproduction and selection can merely shuffle neurons from one group to another, and it is hard to believe that this contains any such exciting potential.

Eagerly turning to the book, one finds the primary definition of a neuronal group on pp.46–47, as follows: ". . . a collection of cells of similar or variant types, ranging in number from hundreds to thousands, that are closely connected in their intrinsic circuitry and whose mutual dynamic interaction may be further enhanced by increases in synaptic efficacy". This does not resolve the issue, and it is not for another 150 pages or so that it becomes reasonably clear that, alas, the groups do not overlap. Such an elementary point upon which so much hinges should have been resolved with the first definition.



Seeing spots — a section through the peripheral retina of a monkey, passing through the layers of rods (small white dots) and cones (black regions with white dots in centre). The picture is taken from Eye, Brain and Vision *by David H. Hubel, recently published in Britain by W. H. Freeman.*

It is disappointing that groups appear to be non-overlapping, but it is hard to see the merit of the overall concept for other reasons as well. Edelman says (pp.164–165): "According to the model, a neuronal group in the cerebral cortex is functionally defined as an ensemble of cohesively interconnected cells, all of which express the same receptive field". In the visual cortex there are no reports of two or more different cells having identical receptive fields. But apart from the lack of experimental evidence for such groups, what theoretical or practical advantage could be conferred by having a set of cells with identical function?

The selection process is the next hurdle. This depends upon synaptic modification according to a Hebbian rule, as in so many current neural network models (for example, Longuet-Higgins *et al. Q. Rev. Biophys.* **3**, 223-244; 1970 and *Parallel Distributed Processing*, by McClelland, Rumelhart and the PDP research group, MIT Press; 1986). What is curious, however, is that in Edelman's version the result of positive selection is to incorporate more and more cells into the same group. What is the benefit of this? It is not like the increase in population of a species, which implies that they have successfully competed for a larger fraction of the available primary resources so that the genes responsible for the success have multiplied. For more and more cells in one group to respond to the same stimulus confers no particular advantage either to the cells, or to the group, and nothing corresponding to the genes has been proposed. Such a process would probably wreck the function of the whole brain, for if the cells in a group respond to a larger fraction of the sensory stimuli being received, this implies that they are becoming less selective: the brain would simply become less discriminating, more muddled. Furthermore this is not what happens in the developing visual cortex (Blakemore & Vital-Durand, *J. Physiol.* **345**, 40P; 1983 and Derrington, *Exp. Brain Res.* **55**, 431–437; 1984) where experience makes the cells become more, not less, selective. Thus Edelman's type of selection does not seem to happen, and it is hard to see how it would confer any advantage if it did.

The book contains an interesting section on cell adhesion molecules and their effects in development, but this is not a complete review of all the work in the field. There are also accounts of two computer simulations of the processes Edelman thinks are at work in the brain, and these have the merit of trying to give greater precision to the ideas that his words leave unclear.

This is not a book for the faint-hearted, because of its difficulty and obscurity, nor is it for the untutored, because it gives such an incomplete and one-sided account of brain development and function. But epoch-making books are often panned unfairly by bigoted reviewers, so readers are strongly urged to study "this magisterial work" (as the publisher's blurb calls it) and decide for themselves whether it ushers in a new era in neuroscience, or whether it's just a hopeless muddle. □

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