Second Nature: Brain Science and Human Knowledge
Gerald Edelman
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Reading this book is, I imagine, very much like having a conversation with—by which I mean listening to—Gerald Edelman on topics of great interest: evolution; the brain; consciousness; and the nature and limits of human knowledge. Normally, this would be a great recommendation for a work, as one would assume the informality of style and intimacy of tone would make more accessible the ideas being conveyed. In this case, however, there are a couple of problems. The first is that, at any point in this particular conversation, at most one person understands what is being said; the other problem is that it isn't always Edelman.

This is to say, there are difficulties here with *both* style and content; indeed, each difficulty is presumably related to the other, and both to the breathtaking ambition of this work. The project of *Second Nature* is twofold: first, to give the reader a picture of how the brain functions, and how it gives rise to consciousness, and second to discuss the implications of this picture for various topics of general interest, such as how we come to know what we do, whether the arts and humanities will (as many humanists fear) eventually be reduced to a branch of physics, whether humans are truly free, and the like. This is a tall order for any work, and one that is perhaps impossible to fill with a composition as short as this one. As it is, in a scant 157 (small!) pages of text, Edelman discusses no fewer than 61 major figures, from Giambattista Vico to E.O. Wilson, Plato to Quine, Freud to Piaget. Any one of these could merit a few dozen pages of discussion; here they are lucky to get a few dozen words. The trouble with this is Edelman has left himself room to do little more than mention (but not explain) some of the main contributions of each thinker, and declare (but not argue for) his dissatisfactions with their accounts. In this way, the book risks missing *both* of its potential audiences. It is too allusive to be illuminating for the general public, and too elusive to be of use to the scientist or scholar.

Edelman is apparently aware of the second risk, as he continually reminds the reader that he has little time for argument and detail, which can be found in his several other works. It is of course perfectly acceptable—even welcome—for an author to provide an accessible guide to his otherwise dense and difficult thinking. But the success of such a project requires that the overview, shorn of obfuscating detail, be sound and coherent enough to stand on its own. Sadly, that is not the case here. Let us consider the first aspect of his project first. Edelman's picture of brain function consists of an argument of roughly the following form: (1) The brain is composed of "functionally segregated" components, dedicated or devoted to tasks like visual processing, (or, more specifically, like determining the orientation of a visual stimulus); (2) These components need to be coordinated, but the brain has no central clock or control system; (3) Instead, long-

distance feedback connections ("reentrant connections") allow for the emergence of coordination, because Hebbian learning ("neurons that fire together wire together") ensures that connections between correlated components are strengthened (thereby further increasing their tendency to fire together) and those between uncorrelated components are weakened (thereby releasing them to act independently). From this (along with the premise that "the brain does not operate by logical rules"), Edelman concludes that the brain is not a computer, but is instead a "selectional system". This forms the basis of his theory, which he calls Neural Darwinism because some connections "survive" this process, and others do not.

As an aside, and speaking only for myself, I am not enamored with the current fashion, whereby every system in which the relative mix of items changes over time (genes, species, neural connections, ideas, societies, galaxies(!), consumer products) is understood by analogy with Darwinian evolution. Each such system has a distinct set of rules that govern its change over time, and one would think that recognizing the differences between these sets would contribute more to understanding these systems than making the connection with biological evolution. Still, if in a particular instance such an analogy leads to insight, who am I to object? In any case, it is not the Darwinian analogy (suspect though it seems) that causes the real problems here.

So, what *is* wrong with his picture? For a start, premise (1) is probably false, as can be seen, among *many* other places, in work on the role of "visual" areas in noun understanding (Martin, et al, 1996; Barsalou, 1999); on the importance of "motor control" regions in verb processing (Damasio & Tranel, 1993; Pulvermüller, 2005); or in my own work on circuit redeployment in the evolution of the cortex (Anderson, 2007). The brain's components are not functionally segregated, but are instead used and re-used in many different cognitive functions in a variety of domains. This probably doesn't matter much to his overall argument, but it risks perpetuating an outmoded view of the basic functional structure of the brain. In a work at least partly about how the brain works, that's a significant problem.

Equally misleading is the argument that the brain is not a computer. The brain may or may not be a computer. I think it probably is, in some important sense, but I don't know this. What I *do* know is that the fact that the brain lacks a central clock, and does not operate by logical rules—premises cited several times by Edelman to support his claim—has nothing to do with whether it is a computer. It is true that typical desktop computers have a central clock and—at least in so far as they are ultimately based on Turing machines—can be said to operate according to logical rules. So Edelman's argument *might* show that the brain is not a desktop computer, but I am guessing you knew that already. What it does *not* show is that the brain is not *some* kind of computer. Not only are there computers without central clocks (Sutherland & Ebergen, 2002) and computers based on formalisms other than logic (Maass, Natschläger & Markram, 2002), even single neurons have been fruitfully understood as simple computers (Koch, 1999). The problem is more than Edelman's apparent lack of understanding of the nature of computation; his dismissal of the analogy between the brain and a computer threatens to cut the reader off from some of the most important and innovative work in neuroscience.

Actually, it's even worse than it sounds, for Edelman spends a whole chapter on some work being done at The Neurosciences Institute (which he heads) attempting not just to model, but also to reproduce the functionality of the brain. The work involves building simple robots able to sense and act in simplified environments: moving about, "tasting" food, categorizing objects, and making decisions about what to do. The brains of these robots are designed based on the principles of Neural Darwinism, including neural networks with reentrant feedback, and with connections between "neurons" that can be adjusted according to simple Hebbian rules, thereby "selecting" some connections over others in light of environmental stimulation. But how do you suppose these brains are actually built? By being implemented in a cluster of clock-having, logic-using computers. So, although the selectional brain *isn't* a computer, it can apparently be implemented in one. Edelman doesn't even have the decency to be embarrassed by this revelation, or its apparent inconsistency with his central conclusions; he just soldiers on to the next topic. It is of course true that bluster, bravado and unselfconsciousness can be useful traits in life, but here they are enemies of enquiry and understanding.

It is just such bluster that causes problems with the rest of Edelman's project, which seems to consist entirely of a series of attempts to make incompatible ideas fit, not in virtue of some illuminating reconceptualization, but by the sheer force of his insistence on their compatibility. Here is a typical passage on the brain basis of consciousness:

"My thesis is that the evolution of a reentrant thalamocortical system capable of giving rise to the dynamic core allowed the integration of vastly increased complexes of sensorimotor inputs. Animals having such a core were therefore capable of refined discriminations. Qualia are just those discriminations, each entailed by a different core state." p. 39-40

Qualia are, roughly speaking, the specific subjectivity of conscious states: the experienced greenness of green, the felt warmth of heat. So, what Edelman is saying here is: the different neural firings that result from exposure to green (as opposed to blue) or heat (as opposed to cold)—the different discriminations your brain makes—simply *are* your experience of green or warmth. Problem solved—or rather, problem ignored. Worried about why or how *physical* events can cause *mental* ones? They don't; these events just *are* your experiences. Worried about why this event should look *green*? Well, it's the one that lets you discriminate green; how else should it look? But, wait what about . . . . Move along now, nothing to see here. Actually good advice: within a page we are on to another topic.

Or consider his answer to a worry about free will—that, if my conscious states are just the operations of my brain, this implies that my mind is as physically determined as my body:

"In the strict recognition that all physical events have causes, one must conclude that core states as physical events are determined. Nonetheless, when not physically bound or in

prison or in the throes of neural disaster, we can honestly claim the ability to do ‘as we like’ or ‘see fit’, illusory or not.” p. 94

I defy anyone to be satisfied by this response. It is as if someone handed you a dollar, which you fear is counterfeit, and to your worry he replies: “Sure, it might be, but still, you have it!” Indeed you do; but is it a dollar?

This pattern repeats with the remainder of the topics treated in this volume. We are offered a series, not of solutions, but of ways to talk as though there are no problems. But there *are* problems—interesting, thought-provoking problems, the serious contemplation of which offers the possibility of genuine insight into the nature of the brain, the mind, and the human condition. In declining to treat these issues honestly, Edelman leaves us instead with counterfeit wisdom—and, as Socrates famously realized, this is worse than no wisdom at all.

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He earned a B.S. in pre-medical studies at the University of Notre Dame, a Ph.D. in Philosophy from Yale University (where he was a Sterling Prize Fellow), and did his post-doctoral work in Computer Science at the University of Maryland, College Park. He was recently recognized as an "emerging leader under 40" by the Renaissance Weekend, and was one of only twenty people world-wide to be invited to attend the McDonnell Project in Philosophy and the Neurosciences workshop for early career researchers.

Dr. Anderson is author or co-author of over fifty scholarly and scientific publications in artificial intelligence, cognitive science, and philosophy of mind. His best-known article, "Embodied Cognition: A Field Guide", was one of the most requested articles from *Artificial Intelligence* for 2003, 2004 and 2006, and has been adopted for courses in computer science, philosophy and psychology in several countries. His current areas of research include using graph-theory based methods to illuminate the functional structure of the cortex, by mining hundreds of brain imaging studies for information about the coactivation of neural components; and an account of the evolution of the brain via exaptation of existing neural circuitry (the "massive redeployment hypothesis").