Remote Learning Module for 22 April 2020

Lecture Notes on *The Cerebral Code* – Chapters 3 & 4

Last class we considered the opening chapters of William Calvin's *Cerebral Code*, wherein he proposes to offer an empirical theory sufficient to account for the formation of conscious thoughts on an evolutionary model we can call "Generalized Darwinism." We saw the six essential ingredients any such Darwin Engine must have, as well as the five catalysts that often enhance or accelerate biological evolution, and that we can accordingly look for in neural Darwinism. Today we'll turn our attention to Chapters 3 and 4 of *The Cerebral Code*, where Calvin presents a model for explaining how a compressed code will emerge from the hexagon theory, and how the Darwinian schema can explain the partitioning of cloning competitions in cerebral cortex.

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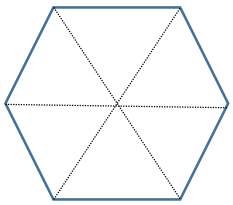
— Chapter 3 —

A Compressed Code Emerges

(1) As we noted at the close of Chapter 2, we are now looking for brain analogs to polyphonic music. Calvin will fill in this analogy on the model of Classical String Quartet. Why? Because this sort of music involves multiple melodic lines presented simultaneously, but without any conductor running the whole show. He will expand on this analogy so that assemblies of cell assemblies will be represented by a *Chorus* of Quartets.

(2) Also recall form last time how triangular arrays among pyramidal neurons, 0.5 mm distant from each other, provides stability of signal via recurrent excitation plus collateral inhibition. While the simplified picture of these arrays lies on a flat plane, a more accurate picture involves minicolumns of neurons; but we can express all the relevant spatiotemporal relations using flat hexagons instead. In other words, as additional arrays of minicollumns are added to a vicinity of cortex, a Hexagonal Assembly will emerge.

(3) Each Hexagonal Assembly is the largest non-redundant collection of points forming a triangular array; and for the memory problem, we find that two adjacent hexagons are needed to form a minimal basis for modeling Hebb's cell assembly—what we need for cloning a pattern in cortex.



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— Chapter 4 —

Managing the Cerebral Commons

(1) The "Commons" refers to the cerebral workspace. This image will introduce us to the fifth Darwinian essential: a biased environment. Our chapter begins with a note on the relative sizes of the cerebral cortices of humans as compared with chimps, monkeys, and rats. If we lay the human cerebral cortex out flat, it takes up about the same area as four sheets of 8.5" x 11" paper. A chimp's cortex, by comparison, has an area roughly the same as one sheet; a monkey's will be about the size of a postcard, and a rat's, the size of a postage stamp.

(2) Calvin surmises that the best evolutionary bet is that mammalian cortices enlarged as wholes, rather than in selected pieces. This does indeed make sense when we examine the overall brain morphologies of the four animals in our sample. In turn, we find two functional results:

(a) *Conversion of Function*: a variety of functions will have been converted from old uses to new ones (a feature we saw first in Damasio's piggy-back engineering model), rather than having been selected directly. You can also think of this as bits of anatomy moonlighting, just as feathers were first selected for insulation, but later came to moonlight, that is, to enhance better flight.

(b) *Coexistence or Cohabitation of Function*: we see this in the areas dedicated to executing language: the same cells involved in the formation of phonemes and morphemes are also involved in hand and face movement sequencing—which may even explain how we are sometimes able to "read" someone's thoughts from their facial expressions (think of a deep frown or a beatific smile).

(3) The Cerebral Commons, then, affords us with an analogy for multifunctionality: various fields and alcoves within a large public park, with children laying down pavers in various regions reflecting their favorite activities, with cats, dogs, and other images serving as our hexagonal images. Now, if a pair of pavers clones a third, we wind up with a triangular array, and thus we set up a *Copying Competition*.

(4) Abstractly, and by abductive inference, we can use this model to explain how the mind moves from *Indecision to Action*; it's a question of whose song can recruit the loudest chorus. Variant patterns appear at the peripheries (joints) of arrays; subsequently (in milliseconds), some will fail to clone new nodes, while others will join the collective voice. So, now we have five of the six Darwinian essentials: Patterns, Copy Mechanisms, Variations, Workspaces, and Environmental Constraints.

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Next time, we'll look to Chapters 5 and 6 of *The Cerebral Code*, where Calvin will further explore the cortical equivalent of a biased environment (Chapter 5), and the analog we'll need for generating selection effects (Chapter 6). Be well everyone, and, although I imagine you are

probably quite tired by now of my continuing to say so, do remember: social distancing continues to save lives, which is presumably why we are still not in JUB 202 presently.