BOOKS: NEUROBIOLOGY

A High Point for Evolution

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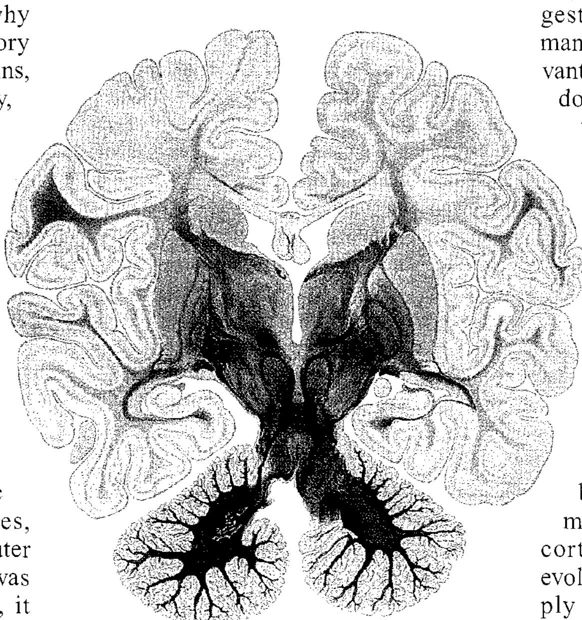
In recent years, the study of brain evolution has shifted from comparative studies of anatomy, which have provided an immense catalog of similarities and differences among the brains of many species, to the molecular mechanisms that drive brain development. In *Evolving Brains*, Caltech neurobiologist John Allman shows how these remarkable discoveries at the molecular level provide new insights into such fundamental questions as why species differ so greatly in their sensory and mental abilities, and how large brains, with their high requirements for energy, could evolve. He tells the story in an engaging, clear style, with copious, high-quality illustrations. In addition to integrating literatures as diverse as paleontology and molecular genetics, Allman provides fresh views of the evolutionary landscape and our understanding of human evolution.

Evolving Brains
by John Morgan Allman
Scientific American Library, New York, 1999. 238 pp. $34.95. ISBN 0-7167-5076-7.

Evolution tends to build on the past. Allman illustrates this by recounting a visit to the boiler room of an old power plant, where he noticed an intricate array of small pneumatic tubes next to a bank of vacuum tubes, alongside several generations of computer control systems. Because the plant was needed for continuous power output, it could not be shut down and retrofitted with each new technology, so the old control systems remained in place and the new ones were integrated into the existing system. So too with evolving brains: Nature cannot afford to throw out an old brain system, but makes do by tinkering with the existing developmental plans and occasionally adding a new layer of control. Gene duplication is a favorite route for achieving large changes.

The neurotransmitter serotonin is one example of an ancient biochemical control system. It is found in neurons in roughly the same location of every vertebrate brain, suggesting the system's presence in the first chordates, 500 million years ago. The serotonin-containing neurons project throughout the brain, profoundly influencing nearly every brain process through over 14 different types of serotonin receptors. Among the behaviors affected by serotonin are the male dominance hierarchy in vervet monkeys and the risk of violent death by accidents or suicide in humans, which is linked with low serotonin activity. The dopamine system could have been offered as an equally interesting example of an ancient neuromodulatory system: Dopamine-containing neurons are important for predicting future rewards (essential for all animals) and for the mechanisms underlying addictive behaviors.



Baby brain. In this brain of a 7-week-old infant, the neurons that lead to the cerebellum and the motor and sensory cortices, are already insulated with myelin (stained blue), which allows these long nerves to conduct information rapidly. The nerves leading to the frontal cortex, the site of higher order planning and reasoning, have not yet been myelinated.

CREDIT: P. FLECHSIG, *ANATOMIE DES MENSCHLICHEN GEHIRNS UND RÜCKENMARKS AUF MYELOGENETISCHER GRUNDLAGE, V. 1* (GEORG THIEME, LEIPZIG, 1920), PLATE X, FIG. 4

A book on brain evolution could easily become a long list of brain systems and the events in evolutionary history that are thought to have shaped them. But Allman has organized his book in ways that make it read more like a mystery story than a catalog. First, the narrative focuses on the evolution of visual systems, starting with the modified ciliated hair cells that became ancient photoreceptors. Various visual systems are discussed, from the frontal eye spot in amphioxus through to the multiple visual cortical areas of primates, which were first described by the author and Jon Kaas.

Second, Allman develops his narrative on an interesting evolutionary framework, one based on the need for large-brained animals to have reliable high-quality food supplies. The metabolic demands of big brains have far-reaching consequences for the evolution of the parts of the brain involved in social activities. The energy demands in developing brains are so large, and childhood in humans so extended, that a stable family and social structure are needed to ensure survival and successful reproduction. In one of the most intriguing parts of the book, Allman suggests that the ancestors of modern humans may have gained a competitive advantage over their Neandertal cousins by domesticating wolves. The social system of wolf packs may have been sufficiently similar to that of our ancestors to allow wolves' cooperation in human hunting and surveillance. Perhaps it was not just tools but also such social skills that made it possible for our ancestors to radiate throughout the world.

Homeostasis provides a third theme running through the book. The evolution of the capacity to maintain a constant high body temperature improved the efficiency of brain function, but at the expense of a much higher energy demand. The neocortex, unique to mammals, may have evolved in part to help ensure a food supply in an uncertain environment. The rapidly changing climactic conditions in which the ancestors of humans lived may have similarly shaped the evolution of adaptive brain functions and led to a larger neocortex and cerebellum. Curiously, the sizes of human brains have been steadily decreasing over the last 35,000 years, for reasons that are unclear.

The book is exceptionally well produced, with particularly fine original drawings by Joyce Powzyk. Unfortunately, this title will be one of the last in the Scientific American Library series. The trend in publishing is away from small, high quality imprints and toward large conglomerates that demand higher profits. The evolution of book publishing, as with brains, is marked by both high points and extinctions. *Evolving Brains* is a high point that that will be of general interest to a wide audience.

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