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MEDIA REVIEW

An Introduction to Nervous Systems

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If Rudyard Kipling had been a neuroscientist, less whimsical, and interested in teaching neurobiology to undergraduates, he might have written a book similar to Ralph Greenspan's "An Introduction to Nervous Systems" (Greenspan, 2007). This new book reminded me of the "Just So Stories" (Kipling, 1996) I read as a child. Greenspan hooks the reader with interesting animal behavior "stories," mostly from invertebrates, and then explains the neural mechanisms underlying the behaviors. Two reviews of this book have appeared recently, including my brief general description of the book (Johnson, 2007), and an insightful review from a research perspective (Pulver and Griffith, 2007). Here, I address Greenspan's book as a resource for teaching undergraduate neuroscience.

Greenspan points out that nervous systems evolved to produce basic behaviors shared by organisms from protozoans to humans: finding food, avoiding being food, mating, and moving and navigating our way in the world to do these things. He suggests that an understanding of the neural strategies animals evolved to accomplish similar life tasks will enrich our understanding of how our own nervous system operates. Even if neural problem solving strategies are similar across animals, we may find different physiological substrates for behavior that teach us about the molecular and cellular mechanisms underlying our actions.

The first four chapters use the behavior "stories" to teach classic neurophysiological principles for understanding signal transmission in nervous systems, such as the ionic principles of electrical excitability and synaptic transmission. Rather than marching through topics step by step like a traditional textbook, the important concepts of cellular neurophysiology are brought up as needed to explain a behavior. With behavior the focus, the molecular and cellular neuroscience material, the "hard stuff" for our students, weaves in naturally as part of the story.

In the first chapter, Greenspan sets the stage, similar to Hille's approach in his advanced text (Hille, 2001), that ionic mechanisms responsible for the electrical excitability that underlies environmental sensing and movement are evolutionarily ancient. He uses the swimming behavior of *Paramecium* to show that the ion channels in our big brains are not so different from those coordinating the appropriate responses of a protozoan (a "swimming neuron") to attractive and aversive stimuli. The following chapter introduces us to photoreception, chemical synaptic transmission, and the evolution of eyes through a story of the barnacle's response to shadows that indicate a nearby predator. The organization of neural timing and pattern generation is introduced first with jellyfish swimming. The description of jellyfish swimming behavior and the ionic mechanisms of its plasticity is my favorite example of story telling as a tool to introduce students to the "hard stuff." This story leads to an interesting discussion of the interaction of different types of ion channels to produce different locomotor patterns. There is even a brief digression on the evolution of sodium and calcium channels from potassium channels that might seem out of place, but makes sense in the context of the story. The last chapter in this physiology foundation explicitly, and refreshingly, introduces neuromodulation as a major player in nervous system function and evolution. Starting with a story of defensive responses in *Aplysia*, we learn that, like ion channels, neuromodulatory chemicals are also ancient, integral components of nervous systems. For example, serotonin and dopamine are already present in the primitive nervous systems of jellyfish. Greenspan discusses neuromodulators as the source of plasticity in neural networks. They can reduce variability in network output, and contribute to learning and to decision making by biasing networks towards particular outputs. Teaching the dynamic plasticity of nervous system function earlier rather than later in an introductory course might enliven the basic cellular material for students.

The next four chapters shift focus to examine specific behaviors in more detail, and what is known about their underlying neural mechanisms. The daily timing of activity patterns, movement and navigation in a world full of obstacles to avoid, mate attraction and recognition, and the adaptation of innate behavior to the environment through learning are explored with insect model systems, mainly *Drosophila*. Amazing commonalties of neural strategies are highlighted. For example, it appears that flies and mice use the same proteins for similar molecular clockworks; dopamine is involved in fly decision making; and bee experiments suggest that these insects might have cognitive abilities that allow abstract categorization! Not being a drosophilist, I appreciated the condensed background in these chapters on aspects of fruit fly behavioral and neural genetics. I feel more comfortable now teaching the power of the fruitfly model system with this book as a resource. Excellent opportunities for extended student discussion are suggested by questions in these chapters: How do nervous systems integrate stereotypical behaviors with appropriate responses to environmental novelty? Could thinking have evolved from temporally accurate planning of motor programs without movement? What do we really know about the physiological substrates of memory storage and retrieval?

The last chapter of the book sums up its comparative and evolutionary messages, and leaves us with questions that could keep students talking the whole semester. How do the divergent neural anatomies in invertebrate and vertebrate animals produce similar behavioral strategies? Is neuromodulation a key general principle underlying nervous system flexibility across species? How is attention focused and how are decisions made in different neural networks? Finally, what can we learn about the nature and distribution of consciousness by studying the higher level cognitive abilities of invertebrates?

Obviously, I liked this book and see excellent potential in its use for undergraduate neuroscience teaching. To be fair though, many small mistakes and poor attention to details, especially in the figures, sometimes detract from the book's messages, and some messages could be strengthened. A lot of material is covered in 145 pages of text. Consequently, some explanations are shallow, and sometimes interesting ideas are only mentioned in passing. Some figures and text need closer editing. For example, Fig. 1.4 is a plot of voltage vs. time and not distance as suggested in the text, Fig. 2.1 is a figure of a barnacle's nervous system and not of a barnacle, Fig. 2.9 is a micrograph from a horseshoe crab and not a barnacle, and Figs. 5.3 and 5.9, 6.8 and 7.7, and 7.2 and 8.2 are repetitive to each other. A little more confusing for me was Fig. 2.6 where it is not clear why the first order visual interneuron should hyperpolarize to a depolarizing current injected into it. According to the cited reference this interneuron does hyperpolarize when light reaches the photoreceptor and when depolarizing current is injected into the photoreceptor pre-synaptic terminal. Fig. 3.13 didn't quite make sense until I realized that the y axis is mislabeled voltage and it should be current. On page 26, it is suggested that electricity can not move directly between neurons, but then electrical junctions are discussed on page 47. To stress their evolutionary utility and homology, I think the point could be made more strongly that similar ion channel classes are found in organisms ranging from plants, protozoans, jellyfish, and insects to humans. A short paragraph in chapter three could mention that the concept of central pattern generating networks for rhythmic motor activity in invertebrates is a guiding principle for vertebrate research on walking and breathing. This would emphasize a common evolutionary theme in neural network organization.

Criticisms aside, this is an excellent book, well written with a sense of humor. It will introduce students painlessly to major concepts and questions in neuroscience. The bibliography is comprehensive and up to date to be a resource for faculty lectures and further student exploration. This short book will not stand alone as the main text for a majors' introductory neuroscience course, but it could be a supplemental text. In this role, Greenspan's book should broaden students' perspectives on nervous system structure and function. It should excite them to consider that all nervous systems evolved to solve similar problems. They may appreciate Greenspan's message that an understanding of different neural strategies fills our intellectual tool box with more resources to understand how our own brains work. With some skillful lecturing to enhance some of the basic neuroscience material, this book could be a main text for a non-majors' neuroscience course.

On a final side note, the comparative neuroethological perspective of Greenspan's book can also set the stage for a discussion of evolution in the neuroscience classroom. Bill Pizzi's recent 'Call to Action" (Pizzi, 2007) pointed out our societal responsibility as educators to help create citizens who will think logically and critically about the evolution-creationism debate. In addition to the references in Bill's article, other sources I find useful for teaching evolution include the Federation of American Societies for Experiment Biology website (www.evolution.f.org), and Ernst Mayr's book (Mayr, 2001). Mayr was one of the great modern evolutionary thinkers and his 2001 book is an accessible primer on current evolutionary thinking.

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