NEUROSCIENCE

Treasures from a Golden Age

Robert Wurtz

The cerebral cortex performs the highest level of processing in the brain, and the last half century has seen a revolution in our understanding of this superficial gray matter. David Hubel and Torsten Wiesel played a major role in this revolution, one that they chronicle in *Brain and Visual Perception*.

Brain and Visual Perception
The Story of a 25-Year Collaboration
by David H. Hubel and Torsten N. Wiesel
Oxford University Press, New York, 2004. 737 pp. $49.50, £29.99. ISBN 0-19-517618-9.

We can best understand the excitement generated by the authors' work by remembering how little was known about cerebral cortex in the 1950s, when they started their research. Anatomical studies using stains of fibers and cells had divided cortex into discrete areas. Measurements of the electrical potentials evoked by stimulating peripheral nerves had mapped the cortical regions related to touch, hearing, and vision, and stimulation of the cortex itself had revealed the areas related to movements of the body and eyes. Clinical neurology, brain stimulation during human surgery, and ablations in experimental animals had identified additional regions of cortex related to such higher functions as speech, attention, and memory. Whereas localization of function was firmly established, what remained a mystery was the production of something as complex as visual perception from the activity of individual cortical neurons.

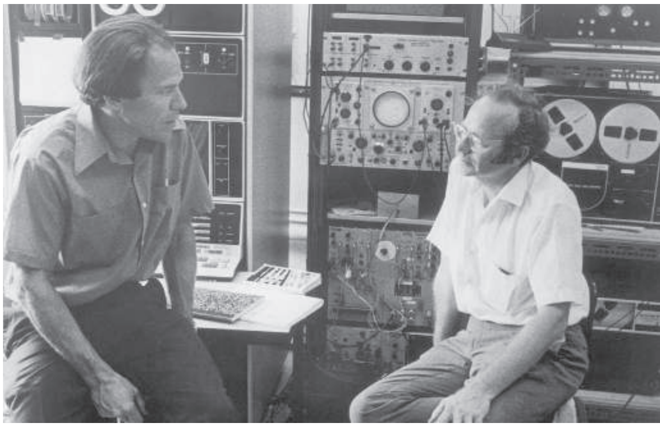
Hubel and Wiesel's first experiments, reported in 1959 and 1962, provided initial answers by demonstrating a plausible hierarchy of visual processing from "concentric cells" to "simple cells" to "complex cells," with each level's output being the input to the next level. The authors went on to identify a columnar organization in visual cortex, the organization Vernon Mountcastle had found in somatosensory cortex (*1*); cells in each column required the same stimulus orientation, and different orientations were represented in different columns. This organization was complemented by an independent one for the inputs from the two eyes. Their experiments led Hubel and Wiesel to the concept of a cortical module (hypercolumn) that did all the processing needed for one region of the visual field—the most complete description of a functional unit in cerebral cortex. Intertwined with this work on organization, they completed striking experiments exploring the development of the system, the alterations with visual deprivation, and the importance of critical periods. Research continues to this day on all these topics, but Hubel and Wiesel provided the first insights.

Brain and Visual Perception recounts this sequence of experiments and much more. The book begins with autobiographical sketches and the authors' descriptions of their research background and the environment of their collaboration (at Johns Hopkins and then at Harvard). Hubel and Wiesel include fond and grateful recollections of their mentor Steve Kuffler, who played a critical role in their research careers and whose work (*2*) was the inspiration for theirs. In the book's epilogue, the authors reflect on the current state of neurophysiology and comment that their 25-year collaboration lasted so long because, in analogy to Gilbert and Sullivan, they were equals with different talents.

The bulk of the book comprises a selection of research papers from the authors' enviable series of elegant experiments, with a foreword and afterword for each. The papers are grouped around the two major contributions for which Hubel and Wiesel received the 1981 Nobel Prize in physiology and medicine: "Normal Physiology and Anatomy" (14 papers) concentrates on the experiments that provided the first insights into the nature of transformations of visual information in cerebral cortex. "Deprivation and Development" (10 papers) centers on how the system forms and the consequences of disruption, topics of considerable clinical relevance. The book's final section supplements the research reports with three appropriate summary articles: the authors' individual Nobel lectures and their joint Ferrier lecture (published in 1977). If one wants to read a single paper to grasp the totality of their work, the Ferrier lecture should be it.

The book's glory is that the commentaries sandwiching each paper illuminate the workings of one of the most productive collaborations in the history of biology. Hubel and Weisel describe the joy of mom-and-pop science where the collaborators do the work and weigh what to do next. One cannot help but feel nostalgia for their model of doing science with infrequent but well-wrought papers that can be profitably read after almost 50 years. The original papers provide an unvarnished report, and the commentaries offer pithy insights into the why and the how of the experiments. For those of us who think that the best way to understand the principles of our field is to read the original scientific reports, the book brings their work all together—complete with the authors' retrospective evaluations of their work.

Mixed among the comments on the authors' many successes are remarks on disappointments and omissions. Hubel and Wiesel had hoped to find progressively higher orders of processing beyond the primary visual cortex (V1), but did not. They missed the structural feature referred to as blobs within V1, and they did not pursue in detail color vision or depth perception. Their comments on roads not taken emphasize the critical role of experimental strategy, one that in their case let them concentrate on the organization of V1 and on visual development. Even with the benefit of hindsight, few would contest their decisions.



The Gilbert and Sullivan of visual cortex (1970).

Many of us now investigating the visual system were attracted by the beauty of the organization Hubel and Wiesel laid out and by the hope of exploring higher levels of cognition through the window they opened into the visual system. *Brain and Visual Perception* consolidates the basis for this surge of interest. The book is not intended for the general

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reader curious about perception, because it presents the original scientific reports in all of their technical detail. But for neuroscientists interested in vision, it is a gem in the history of the field and a core resource for understanding the roots of what we now know about the mammalian visual system.

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MARINE ECOLOGY

Toward Ecosystems Oceanography

Philippe Cury

In ecology, stimulating fields of research can emerge from observed patterns. Analyzing the very irregular numbers of young herring and cod in the North Atlantic, the Norwegian marine biologist Johan Hjort noted that "the renewal of the [fish] stock…must depend upon highly variable natural conditions" (*1*). With those words in 1914, fisheries oceanography was born. Since then, the discipline has made considerable progress in relating environmental processes, and the spatial scales at which they act, to fish recruitment and the success or failure of fisheries. In their summary chapter in *Marine Ecosystems and Climate Variation*, the Norwegian ecologists Nils Chr. Stenseth and Geir Ottersen remark that "although the variation in North Atlantic cod stocks throughout the last decades is reasonably well known, the possibly major *indirect* community effects of the varying abundance of cod have not been studied with equal intensity." Their statement reflects the book's ambitious objective: to explore a wide range of ecological patterns in the North Atlantic driven by climate and involving phytoplankton, zooplankton, benthos, and seabirds as well as fish.

Disentangling the consequences of climate variation at an ecosystem level is not a simple task. We lack a general ecological theory that can adequately elucidate the functioning of marine ecosystems. But we ecologists can track patterns and processes. The book presents numerous examples that highlight apparent links between climate and marine ecology. It also elaborates concepts, models, and statistical and simulation techniques for quantifying species interactions. Readers are treated to an overview of what happened in the North Atlantic during the last decades of the 20th century and of our current understanding of the causes of those changes. (The authors also include insights from the Pacific as well as from freshwater and terrestrial perspectives.)

The volume contains 16 chapters, with contributions from 40 authors. One might therefore worry about a lack of homogeneity in both presentation style and content, but the editors and authors have succeeded in producing a coherent, integrated treatment rather than a collection of disjointed chapters. An introduction effectively links the chapters to one another, and a unified conceptual framework structures the entire volume. This structure is grounded in the argument that large-scale climate indices (e.g., the North Atlantic Oscillation or NAO) may serve as simplified proxies that capture the essence of the overall physical variability better than the complex of local observational details—the "package of weather" sensu Stenseth (*2*).

Marine Ecosystems and Climate Variation
Nils Chr. Stenseth, Geir Ottersen, James W. Hurrell, and Andrea Belgrano, Eds.
Oxford University Press, Oxford, 2004. 266 pp. $124.50, £68. ISBN 0-19-850748-8.

Nature is intricate. The effects of climate fluctuations on ecology may be nonlinear, can act with time lags that are difficult to detect, and may have both direct effects on life history traits and indirect effects through the food web. The contributors disentangle many ecological interactions in rather simple and convincing ways, producing what I consider to be ecological enlightenment.

The fish that changed marine ecology. Atlantic cod (*Gadus morhua*).

The book focuses quite naturally on cod, a key predator species that has a central role in the ecosystem dynamics of the North Atlantic. The authors show how a given NAO pattern can correspond to varying levels of cod recruitment (good or poor) in different areas, which yield apparently contradictory results. Comparative analysis of the factors (e.g., air and water temperatures, ice cover, and winds) that appear to control cod recruitment at an ecosystem level among the different environmental settings of the Barents Sea, the North Sea, and Canadian waters offers an elegant approach to unraveling this paradox. The chapters on phytoplankton, birds, and benthos offer intriguing insights into the subtle balances among direct and indirect environmental effects on species abundance.

The approach elaborated in the book supports the idea that the environment exerts significant controls on ecosystem dynamics. On the other hand, it is also abundantly clear that by greatly reducing the abundance of large predators such as cod, fisheries can have major direct effects on the structure and functioning of ecosystems—the resulting ecological patterns of such "top-down control" can be found in Daniel Pauly and Jay Maclean's recent book (*3*). I believe that future work on the North Atlantic will benefit from a synthesis of these two viewpoints (climate change and overexploitation), presented as a unified treatment and not separately. However, the present book certainly kick-starts the process.

Recently the world ocean was subdivided into 64 large marine ecosystems (www.edc.uri.edu/lme), and the book's conceptual framework should help stimulate research in these ecosystems. The book should also contribute to the efforts of several current international programs that address ecosystem integration (e.g., Global Ocean Ecosystem Dynamics and the European Network of Excellence for Ocean Ecosystems Analysis). In addition, the book provides a comprehensive approach to acknowledging ecological interactions between exploited and nonexploited species in the context of climate change. This is an important step, particularly given the recognized need to move toward an ecosystem approach to fisheries (*4*).

Will the book's ecosystem oceanography become a new field of research? Time will tell. What can definitely be said is that *Marine Ecosystems and Climate Variation* excellently illustrates the issues of controls in marine ecosystems, addressing them in a convincing and organized manner. "Who controls whom" in marine ecosystems is a stubborn and intricate issue, but potentially solvable. At least that is the message of the Norwegian scientists and their colleagues.

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