useful situations that might be encountered by human beings while exploring their environment.

I should add that while the book defends these four research strategies, it also covers alternative arguments (both philosophical and scientific) in great detail, so this book is not just a list of the author's own ideas, it also serves as an introduction to consciousness studies as a whole. I personally feel that the coverage of consciousness studies as a whole is a bit too much; the book would have been about half the length, and the main argument easier to understand, if the author had stuck to his own ideas. Then again, since one of the author's stated aims is to lay out a roadmap for the field as a whole, he is within his rights to point out the pitfalls along the way, while leading us via the one true path. The novice reader will quite possibly benefit from these digressions.

Like every other book on a topic as controversial as consciousness, this book also has some flaws. For one, the book does not address the hard problem of consciousness. Why is there anything like phenomenal experience at all? No known physical or biological processes can plausibly be the basis for a state for which there is a 'what is it like to be in that state'. VR simulations are no exception – the reason why we experience something in a VR environment is because *we* inhabit those environments and not because VR computers secrete conscious experience. Why should the brain be any different? Secondly, even if we set aside such metaphysical puzzles, even a biological realist can quibble about brain centrism. Here is an alternative – the brain itself is given to us as an object via our experiential contact with the world, just like flowers and trees and umbrellas. Indeed, one could *define* objects, including the brain, as (geometric and material) invariants of our experience. Objects are shapes that remain constant while we move around in this world. If we accept this 'invariant' reasoning, then from symmetry considerations we should not make a distinction between the brain and other objects, so why privilege the brain?

Keeping the shortcomings of the book aside for the moment, a field as wide open as consciousness studies needs several research programmes, some biological, others physical and yet others metaphysical. Our knowledge of consciousness is bound to increase when these programmes compete in the public domain. For these reasons, I commend Revonsuo for sticking his neck out and stating his views about the geography of consciousness.

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Handbook of Virology. Jawaid A. Khan and Jeanne Dijkstra (eds). The Haworth Press Inc., 10 Alice Street, Binghamton, NY 13904-1580, USA. 452 pp. Price: $69.95.

This book is very handy and provides up-to-date information on different aspects of plant virology in a very concise form. The book includes selected topics in both basic and applied aspects in plant virus research that are written by experts in their own field of research. The book therefore can serve as a useful guide to students, teachers and researchers in plant virology.

Descriptions on symptomatology would have been clearer with more illustrations. The chapter on architecture of plant viruses is rather brief and the assembly pathways for TMV and bromoviruses could have been described in some more detail with illustrations. The replication and gene expression of both RNA and DNA viruses are described in detail. This is followed by a brief description of viroids. Transmission of plant viruses, which is a very important aspect of plant virus research in the management of the disease, is covered in three chapters. The chapters on serology, detection and identification of plant viruses provide up-to-date information on various methods of disease diagnosis and are very useful to researchers in the field. The book also deals with the more contemporary topics such as recombination in plant viruses, virus variability and evolution. The chapter on recombinant DNA technology could have been presented soon after the chapter on isolation and purification of viruses. This chapter seems to be out of place although it describes the various techniques. Resistance to viral infection and control strategies are described rather briefly.

The most useful information for researchers in the field is provided in the appendix, which describes each family of viruses. The book would be of use to both graduate and undergraduate students of plant pathology.

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Annual Review of Neuroscience. Steven E. Hyman *et al* (eds). Annual Reviews, 4139, El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, USA. 2006. Vol. 29. 914 pp. Price not stated.

Although intuitively it would seem that reviewing a set of reviews, a meta-review of sorts, would appear not too demanding (which is probably the reason why I accepted the offer so quickly), perusing through the twenty reviews that comprised the 2006 edition of the *Annual Review of Neuroscience* made me quickly realize the challenge at hand. Because the editorial committee of the Annual Reviews mainly chooses the topics based on their current relevance, the annual reviews series are not thematically organized. Added to this, the reviewer's job is particularly exacerbated by the scope of modern neuroscience that encompasses varied technical and conceptual approaches, all well motivated and necessary, but nonetheless difficult to be digested by a single brain (at least mine). This confession notwithstanding, in putting this review together I have taken the liberty to re-organize the presentation of chapters, emphasizing functional links where possible. I hope this approach might be of greater value to a reader of this meta-review interested in getting a gist of the breadth of issues being examined in the 2006 edition, rather than just evaluate the reviews in their order of presentation in the book, or segregate the reviews into areas such as molecular, cellular, systems, behavioral/cognitive and computational neuroscience as is typically done in many neuroscience journals these days.

Neural development. Since the pioneering work of Spemann, Waddington and others, it is now well established that adult morphology or patterning is specified by the spatiotemporal gradients of certain molecules. One such class of molecules referred to as Wnt are known to be critical regulators of neural development such as neurulation and neural tube closure. The review by Montcouquiol *et al.* (Non-canonical Wnt signalling and neural polarity; pp. 363–386) focuses on the differences between the so-called canonical (beta-catenin mediated) and non-canoncial pathways of Wnt signalling during neural development, with an emphasis on the role of the latter in generating polarity and cellular asymmetry. Because of their critical role in development, abnormalities in pathways specifying pattern formation are likely to result in deficits or diseases that are sometimes revealed in the adult organism. This theme is the focus of the article by Dellovade *et al.* (The Hedgehog pathway and neurological disorders; pp. 539–564) who discuss the role of another molecular pathway (hedgehog), a major regulator of development, mutations of which are known to be associated with abnormal development of the nervous system. The authors also summarize recent efforts at characterizing the role of hedgehog in the adult nervous system, and their connection with certain diseases such as Parkinson's disease and some forms of brain cancer, and raise the possibility of manipulating this system for therapeutic purposes. The article by Oppenhiem and colleagues (Adaptive role of programmed cell death during nervous system; Buss *et al.*, pp. 1–36), draws on specific examples from the animal kingdom to illustrate how active genetically programmed cell death (PCD) may be used to regulate development. In relation to neural development they also provide evidence of PCD in events such as neurulation and synaptogenesis, to the elimination of adult-generated CNS cells.

Sensory-motor processing. In order to be sensed, stimuli need to be converted into electrical activity. Specialized cells or receptors containing channels, which conduct electricity when they are activated by particular class of stimuli, do this job. While the molecular events that transduce light, sound, chemical and mechanical stimuli into electrical activity are better known, our understanding of the process underlying thermal sensation is still at its infancy. The article by Dhaka *et al.* (TRP ion channels and temperature sensation; pp. 135–162) reviews the extent to which ThermoTRPs, a subset of the transient receptor potential family of ion channels expressed in sensory nerve endings in the skin, are responsible for transducing thermal information into electrical activity. The molecular basis of another closely related sense, the sense of pain is discussed by Pezet and McMahon (Neurotrophins: Mediators and Modulators of Pain; pp. 507–538). Although the neurotrophin family of neurotrophic factors are better known for their role in neuronal survival and growth, Pezet and McMahon review evidence of the role of one neurotrophin, nerve growth factor (NGF), as a peripheral pain mediator, particularly in inflammatory pain states; as well as the role of another neurotrophin, brain derived neurotrophic factor (BDNF) as a central modulator of pain. The evidence presented raises the possibility that inhibitors of this pathway may provide a fruitful approach to alleviate the effects of chronic pain that has thus far proved resilient to standard anti-pain medication. In addition to conveying impulses from the periphery to central nervous system, the spinal cord has intrinsic neural networks known as central pattern generators (CPGs), that control complex rhythmic movements such as locomotion. The review by Kiehn (Locomotor circuits in the mammalian spinal cord; pp. 279–306) focuses on the anatomical and physiological, and molecular genetic approaches to the identification of CPG neurons in the spinal cord that generate rhythms such extensor-flexor contraction, and left-right movements. At a higher level in the motor hierarchy, Graziano (The organization of behavioural repertoire in motor cortex; pp. 105–134) reviews evidence primarily based on microstimulation experiments that argues for a more complex role for motor cortex in the coordination of ecologically relevant categories of behaviours. The implications of these results are profound as they suggest a radical departure from the dominant view of the primary motor cortex as being a 'simple' map of body muscles.

Neural coding of sensory information. Unlike the peripheral nervous system where the pattern of electrical activity bears a close resemblance to the sensory events that triggered them, the firing properties of neurons in 'higher order areas' are more complex, requiring a conjunction of complex features in the environment to trigger them. As a consequence, our understanding of the relation between the patterns of activity and the features they encode (the neural code) is not clear. The article by Wilson and Mainen (Early events in olfactory processing; pp. 163–202) reviews some of the complex issues involved in sensory coding. They discuss various coding strategies that are evident even at the earliest stage of olfactory processing. The limitations of individual coding schemes are also well highlighted, as is the possibility that the concurrent operation of multiple coding strategies may be essential to adequately represent the richness of odour space. The chapter by Wu *et al.* (Complete functional characterization of sensory neurons by system identification; pp. 477–506) discusses how statistical approaches to hypothesis testing and systems formalisms borrowed from engineering may be used to test different computational models to understand how neurons process sensory information. As one might expect, systems approaches provide a good description of the functional properties of peripheral sensory neurons, but are less accurate at modelling the behavior of central sensory neurons, particularly responses that encode figure-ground segmentation, for example. Such perceptual grouping, as discussed by Roelfsema (Cortical algorithms for perceptual grouping; pp. 203–228), requires the use of top-down (feedback) from higher cortical areas and horizontal connections that provide contextual information to receptive fields, in addition to the better-understood bottom-up mechanisms. For this reason, systems approaches, which rely on relatively simple stimuli sets, may fail to engage contextual responses responsible for figure-ground segregation. Roelfsema discusses a model of visual perceptual grouping containing bottom-up as well as top-down mechanisms, which nicely accounts for the dynamics and the influence of attention, in the context of how perceptual grouping is achieved by the visual system.

Imaging and higher brain function. As with every scientific endeavour, advances in neuroscience are strongly dependent on parallel advances in technology. This truism is most apparent in the field of imaging that has witnessed a revolution of sorts over the last twenty years, enabling neuroscientists to study some of the

highest cognitive capabilities of the human brain such as language and decision making. However, because these studies are mainly based on imaging techniques such at positron emission tomography (PET), and magnetic resonance imaging (MRI), whose signals derive from measures of energy metabolism and blood oxygen levels, it is important for research to provide a clear basis for linking changes in these measures with changes in neural activity. Raichle and Mintun (Brain work and brain imaging; pp. 449–476) review the available evidence and shortcomings of the basis for making these links. In doing so, they suggest a crucial role for astrocytes and the role of aerobic glycolysis in brain energy metabolism. In their review (Imaging valuation models in human choice; pp. 417–448) Montague *et al*. show how the technology of non-invasive imaging in conjunction with computationally motivated models can be used to study higher cognitive functions such as reward valuation and decision-making. Importantly they show that such approaches, in addition to having explanatory power, can be used to generate predictions than can be tested experimentally.

Synaptic plasticity and learning. The molecular and cellular basis for synaptic plasticity, which is widely believed to be the neural substrate underlying cognitive abilities such as learning and memory, figure prominently in the current Annual Reviews. Two articles discuss the basis for postsynaptic and presynaptic changes in synaptic efficacy, while two articles focus on the control of such changes. The article (Organelles and trafficking machinery for postsynaptic plasticity; pp. 325–362) by Kennedy *et al*. reviews progress made in understanding how specific proteins are transported over long distances to selectively target individual synapses along the dendritic arbors of neurons. The spatiotemporal regulation of such trafficking is proposed to underlie the changes in postsynaptic efficacy contributing to plasticity and learning in the brain. The chapter (Endocannabinoid-mediated synaptic plasticity in the CNS; pp. 37–76) reviews research on a type of use-dependent synaptic plasticity that requires retrograde signalling by a class of molecules, endocannabinnoids, that bind to presynaptic cannabinoid receptors, causing transient and long-lasting changes in pre-synaptic plasticity. Because changes in synaptic efficacy provide a powerful way for learning and memory to manifest itself, there must be mechanisms responsible for their control. In his review (Homeostatic control of neural activity: From phenomenology to molecular design; pp. 307–324) Davis motivates the issue of control from the perspective of homeostasis. He proposes that by maintaining neural activity, neurons are able to regulate synaptic efficacy. In the chapter he uses several examples to support his hypothesis. In addition to activity-dependent synaptic plasticity, synaptic plasticity may also be controlled by extrinsic factors such as reward, and may form the cognitive basis of learning and memory. This hypothesis is examined by Hyman *et al*. (Neural mechanisms of addiction: The role of reward-related learning and memory; pp. 565–598) in relation to pathological conditions that occur during addiction, in which normal cellular and molecular processes underlying reward-dependent learning may be usurped by drugs that mimics the effect of natural rewards.

Neurobiology of brain disorders. While not necessarily correct, scientific progress is often judged on the basis of how knowledge gained benefits in the understanding, treatment and eventual cure of diseases. The article by Cao *et al*. (Noncoding RNAs in the mammalian central nervous system; pp. 77–104, 259–278) discusses the role of noncoding RNA in the function of the nervous system, giving specific examples. The article by Ranum and Cooper (RNA-mediated neuromuscular disorders; pp. 259–278) explores how trinucleotide expansions in non-coding regions of RNA can generate gain-of-function mutations, providing a new mechanism for disease pathogenesis. They discuss this hypothesis in relation to myotonic dystrophy and suggest that a similar model may account for the pathogenesis of other neuromuscular diseases. The chapter by Cannon (Pathomechanisms in channelopathies of skeletal muscle and brain; pp. 387–416) reviews the pathogenic mechanisms of channelopathies, a diverse array of human disorders caused by mutations in ion channels genes. They focus on skeletal muscle disorders caused by mutations of voltage-gated ion channels and fast ligand-gated ion channels resulting in abnormal excitability of the membrane. The article by Perlmutter and Mink (Deep brain stimulation; pp. 229–258) reviews progress made towards understanding the basis of therapeutic effects of deep brain stimulation (DBS) seen in patients with Parkinson's disease.

In conclusion, while I feel that this edition deserves library space in biological research institutes; as a book, the value to individual researchers is questionable. Having said that, I would still recommend this edition as a valuable source to the neuroscience researcher, where given the breadth of knowledge presented, this book is likely to present interesting avenues to further his/her research. For the student of neuroscience, the exhaustive list of references can serve as a useful starting point. I hope by organizing the reviews thematically, I have made their job of deciding somewhat easier.

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