think on a grander scale about new buildings for science. The best of these—the Grace Auditorium—works marvelously well, and its beauty shines through in the handsome images in this book. By contrast, the latest building—the Beckman Laboratory—is perhaps not as good as Elizabeth Watson's book makes it appear. Monumental in both style and size, it looms on the ridge like a large headache, and its mass overwhelms the more modest buildings that have served the laboratory so well.

From time to time, a few of us who remember the old Cold Spring Harbor get together and bleat about its newfound aspect as a DNA theme park complete with coffee mugs, T-shirts, and tourists. Casual visitors who buy this exquisitely produced book will find it informative, accomplished, and engaging. But it cannot move them as it moves us, who still dream of Cold Spring Harbor as it was. *Houses for Science* is, after all, a chronicle of our youth.

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Hopeful Meetings

The Cybernetics Group. STEVE JOSHUA HEIMS. MIT Press, Cambridge, MA, 1991. xiv, 334 pp. $25.

To a diverse group of mathematicians and behavioral scientists the time seemed ripe after World War II for a collaboration that would blend the mathematics of cybernetics and game theory with the new look in anthropology, biology, psychology, political science, sociology, and psychiatry. The 30-odd participants included Norbert Wiener and Julian Bigelow from the mathematics and computer side and, representing a concern with the development of the behavioral sciences, Gregory Bateson, Lawrence Frank, Lawrence Kubie, Rafael Lorente de Nó, Margaret Mead, and Arturo Rosenblueth. The challenge to the group was put forth most eloquently by Warren McCulloch, a neurophysiologist who played a central role and who on occasion would quote, "Tell me where is fancy bred, Or in the heart, or in the head?"

The form of the collaboration was a series of meetings called the Macy Conferences on Cybernetics that took place between 1946 and 1953. The story told in this account of the enterprise is a curious mixture of real politics, academic politics, egos, and great optimism in a period of political and scientific transition. In this context, a group of professionals who had little solid intellectual investment in common came together in a manner that permitted them to suspend at least some of their prejudices and engage in mutual monologues and possibly dialogues.

This reviewer, as a graduate student and postdoc, knew many of the *dramatis personae* covered in this book. Their enthusiasms, prejudices, and prognostications helped to make me understand the distinction between science and the sociology of science. This is a book about the sociology of science. It is written like a whodunit. The approach is historical. The context is set for U.S. physical and social science in the Cold War period. The liberal or conservative backgrounds of the major participants are sketched; the growth of McCarthyism and its influence on the academic community are noted. The narrative begins with a coming together of optimists as early as 1942, when Frank, Mead, and Bateson met with McCulloch and Rosenblueth to sketch out new ideas promoting the interaction of the so-called hard sciences with the social sciences. The concept of feedback as a means of modeling and studying human behavior caught the imagination of all. What analogies were in the minds of Wiener, Rosenblueth, and Bigelow may, however, have been far from those in the minds of Mead, Bateson, or the psychiatrist Kubie.

Possibly the most charismatic and dedicated seeker of the grail of understanding the mind and brain was McCulloch, whose dedication to the concrete understanding of mechanisms could and did drive most psychiatrists to distraction. The model of the mind put forth by McCulloch and Walter Pitts was congenial with the ideas of Wiener and John von Neumann and can be regarded as a precursor of the field of artificial intelligence.

In the social dynamics of the meetings it is of interest to note that the psychoanalyst Erik Erikson was essentially vetoed as a member by the more mathematical cybernetics wing, while the physicist and biologist Max Delbrück was invited to join but after attending the fifth meeting commented that it was "vacuous in the extreme" and declined to attend further.

The book provides thumbnail sketches of many eminent social scientists of the time, among them Leonard Savage, Paul Lazarsfeld, Kurt Lewin, and Gregory Bateson. As the plot unfolds one sees the battle between Kubie and McCulloch, in which the former expressed concern that Warren "needed help."

Where does the tale come out? Although one should not give away the plot, reviewers of complex mysteries with large casts are trapped into at least giving hints.

In academia it is still possible to use the conference series as a quasi-institution that self-destructs sooner or later. The Macy conferences enabled a large number of distinguished professionals to interact with, stimulate, infuriate, or fascinate each other. Other potential participants, such as Delbrück or von Neumann, attended infrequently or refused to join. Those with a deep mission such as McCulloch forged ahead, conferences or no.

The practice of holding pleasant half-baked conferences aimed at interdisciplinary collaboration is highly desirable. But the product cannot be measured easily in terms of joint papers or "breakthroughs." The interaction helps to change mind-sets, but in general the process is not immediate. When we view the sweep of the physical sciences, biology, the social sciences, mathematics, and computer science in the last 40 years, it is clear that the changes have been enormous. "Cybernetics" was an "in" word in the '50s; "chaos" is in now; strange attractors have trendy proponents and conservative detractors, but nevertheless knowledge has accumulated. The vision of being able to produce viable models of the mind and brain is still there; but the problems in understanding both human and artificial intelligence grow as we understand more.

The story told by this book is fascinating. The last line is, "The conversation continues." It also changes and expands.

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Neural Oscillations

Suprachiasmatic Nucleus. The Mind's Clock. DAVID C. KLEIN, ROBERT Y. MOORE, and STEVEN M. REPPERT, Eds. Oxford University Press, New York, 1991. xvi, 467 pp., illus. $85.

Like the answer to the question "How many circadian biologists does it take to screw in a light bulb?" (see below*), this book is best appreciated by those with some background in chronobiology. The focus is on the mammalian suprachiasmatic nuclei (SCN), two tiny groups of neurons located deep in the

*__Answer__: Two, as long as they are relatively coordinated (a reference to the term "relative coordination," used to describe the situation of an oscillator periodically influenced by, but not fully synchronized to, an entraining cycle).

brain. These neurons are essential for the generation of circadian rhythms, an animal's internal and behavioral cycles that have an approximately 24-hour period. The SCN are able to generate self-sustained oscillations, to synchronize with environmental cues, and to impose rhythmicity on a wide variety of other systems. Our understanding of the role of SCN neurons in circadian timing has blossomed in the past two decades, and this growth is well described in *Suprachiasmatic Nucleus: The Mind's Clock*.

The book is a collection of 24 chapters in eight sections, each of which begins with a short introductory piece. In general, these introductory segments are of little help, and I suspect that they will not be widely read. Furthermore, the historical background provided is scanty, and, oddly, no one chapter focuses on the function of the SCN in controlling circadian rhythms. Thus, this is not the book to open if you are looking for an introduction to the field. If, however, you would like a collection of scholarly, concise, and clearly written reviews of current neurobiological research on the SCN, then this is the book for you. Each chapter will bring you up to date on a particular aspect of SCN research, and reading the entire book will give you the background to appreciate several broader issues currently attracting interest.

One general issue highlighted in the book is how neural circuits differ in night-active and day-active mammals. Since SCN cells oscillate similarly in both groups, with peak activity in the daytime, these groups must differ in some aspect of their translation of the circadian-clock output signal. Watts, following his informative and well-illustrated review of SCN output projections, suggests possible anatomical sites where this nocturnal–diurnal difference might emerge. Meijer describes visual response characteristics of SCN neurons and nicely relates these to functional issues. For example, circadian clock cells of day-active mammals may be less responsive to light of low intensity, perhaps because of their history of exposure to brighter light than that experienced by nocturnal animals.

SCN neurons can generate circadian oscillations even when isolated from the rest of the brain. A rhythm in spontaneous neural firing of the in vitro SCN can be reliably measured and can be phase-shifted by cAMP, cGMP, and melatonin, as described by Gillette. A contrast between in vivo and in vitro studies of a rhythm in SCN glucose utilization is provided in the chapters by Schwartz and Newman. Newman suggests that oscillations measured from the SCN in a dish might differ from those in intact animals. Although this is a concern, the utility of studying the SCN in isolation is exemplified by his own preliminary results which indicate that the expression of a rhythm in glucose utilization remains apparent during infusions of tetrodotoxin, a blocker of sodium-dependent action potentials.

Another important concern is how a collection of 10,000 SCN neurons can generate a synchronized rhythm with such a long period. That question currently has no answer, but several clues indicate that surprises might be in store. Tetrodotoxin infusion studies, measuring either behavioral rhythms or, as discussed above, glucose-utilization rhythms, indicate that sodium-dependent action potentials may not be necessary. Developmental studies, reviewed in the chapter by Moore, indicate that very few synapses (less than one per neuron) are required. Communication between SCN glial cells, documented by van den Pol and colleagues in experiments using calcium indicator dyes, suggests that an exclusive focus on neurons might actually be misplaced. Could SCN glial cells, independent of SCN neurons, serve as a circadian pacemaker? Lehman *et al.* outline how transplant studies might be used to answer this question.

The SCN drives many rhythms, including a circadian rhythm in melatonin output of the pineal gland. Unlike many of the more commonly studied activity rhythms, pineal rhythms show a crisp rise and fall each day. By comparing light-induced phase-shifts of the beginning and the end of each day's hormonal surge, Illnerova supports theories of an underlying dual-oscillator structure for the mammalian circadian clock. Melatonin might also serve as a feedback signal, acting on SCN neurons to alter circadian rhythms, as reviewed by Cassone.

Several chapters combine to provide a clear description of how the duration of nightly melatonin secretion might be used to measure seasonally changing day length. Reviews by Karsch *et al.* and Zucker *et al.* describe how melatonin synchronizes internally generated annual reproductive cycles in long-lived animals, whereas in short-lived species melatonin actively drives the annual cycles. Zucker *et al.* provide an excellent review of studies indicating that in some species the SCN is not necessary for melatonin's mediation of photoperiodic effects. Weaver, working from studies of melatonin receptors, hypothesizes that melatonin may affect seasonal reproduction via action on the pars tuberalis, a poorly understood fragment of the pituitary.

Details of SCN anatomy are attentively described, with chapters on intrinsic anatomy, visual-input pathways, and efferent projections. SCN cells contain a variety of neurotransmitters, peptides likely to modulate neurotransmission, and neurochemicals for which functions are currently unknown. For example, van den Pol describes the localization of both nerve growth factor (NGF) receptor and VGF, a protein regulated by NGF, in the SCN. The functions of these are still obscure. Card and Moore describe visual input pathways and integrate recent work using viruses to accomplish transneuronal tract tracing.

What is the role of this multitude of neurochemicals in modulating the circadian clock? Many of the neurochemicals localized to the SCN can induce phase-shifts in circadian rhythms, but few induce phase shifts in a pattern similar to those induced by visual input. Albers *et al.* provide a thorough review of studies on the major neurochemicals of interest, Majzoub *et al.* review studies of circadian rhythms in vasopressin mRNA, and Morin reviews work on phase-shifting effects of benzodiazepines.

A comparison of the chapters by Reppert, Rivkees, and Weaver leads to the suggestion that signals used to synchronize the circadian clock early in development depend on the degree of maturation at birth. Rodents have functioning circadian clocks in the fetal stage, and these clocks are entrained via signals from the mother. Opossums, on the other hand, are born at an earlier stage of development, and in fact most SCN neurogenesis occurs postnatally. Unlike the fetal rodent, the circadian clock of the young opossum is not entrained by signals from the mother but is instead directly entrained by light.

SCN tissue from a fetus can be transplanted into the brain of an animal whose own SCN was ablated. Such transplants restore circadian rhythmicity. Restored rhythms express a period similar to that of the donor's clock, as reviewed by Ralph. Though early "SCN island" studies indicated that neural pathways connecting the SCN to other brain structures were essential for the SCN to act as a pacemaker, more recent work has led many researchers to doubt this conclusion. Anatomical studies of SCN transplants, described in a critical review by Lehman *et al.*, promise to address the controversy over whether circadian clock output is neural or humoral.

A great deal of excitement in this field centers on advances in understanding alterations in gene transcription induced by light. SCN cells in animals exposed to light show increases in mRNAs for several immediate early genes. This response is only observed following light pulses given at phases when light will phase-shift rhythms. Though this line of research was not formally discussed at the meeting that initiated this book, the editors wisely slipped in a final chapter (by Aronin and Schwartz) describing the regulation of c-*fos* expression in the SCN. This review is clear and informative, but, ironically, probably the most dated of all the chapters, as research on molecular events associated with phase-shifting has proceeded at an incredible pace during the past few years.

One serious omission is a thorough discussion of multi-oscillator models of the mammalian circadian system. Though Kittrell provides a valuable review of the controversy over SCN control of temperature rhythms, research results do not yet allow firm conclusions. On the other hand, work by Stephan and others has demonstrated the existence of a circadian oscillator, entrainable by restricted food access, which is definitely not located in the SCN. Adding a review of this important work would have strengthened the book.

In many cases, a reader of this book can almost hear various authors addressing each other, approaching the same question using different techniques or interpreting the same data in slightly different ways. The uniform quality of the literature reviews ensures that the book will not be quickly dated. Though this book is currently referred to within the field as "the SCN book," it certainly has the potential for being "*The* SCN Book."

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High-Energy Preoccupation

The Structure of the Proton. Deep Inelastic Scattering. R. B. ROBERTS. Cambridge University Press, New York, 1991. x, 182 pp., illus. $49.50. Cambridge Monographs on Mathematical Physics.

The structure of the proton has been one of the main preoccupations of high-energy physicists—experimenters and theoreticians alike—for the last three decades. A major breakthrough in the late 1960s, which occurred during scattering experiments at the Stanford Linear Accelerator Center, showed large probabilities for scattering electrons on hydrogen targets. These unexpected results indicated that the electric charge in the proton was carried by smaller entities variously called quarks or partons. The initial experiments spawned a great deal of subsequent experimental and theoretical activity, which is still ongoing. The original experimenters had to visit Stockholm two years ago.

Deep inelastic scattering is, however, only one of the windows we have for looking inside the proton. There is also a great deal of spectroscopic evidence, and the integration of the information from each of these fields of research is still rather clumsy at present and open to controversy. In *The Structure of the Proton*, Roberts deals only with data and interpretations from deep inelastic scattering experiments. The book gives a concise, complete, and up-to-date summary of the field, from precise definitions of lepton-nucleon cross-sections in terms of structure functions, to their interpretation in terms of the quark-parton model, to perturbative quantum chromodynamics and nuclear effects. All this is done in about 180 pages. The emphasis is on concise presentation, and one can find all the main equations and references to the literature very easily. For example, the topic of polarized structure functions, a subject of intense debate during the last four years, is disposed of in about four pages.

The book will therefore be of greater use to people who have an interest in the subject already (and wish to find a particular equation or reference) than to greenhorns. Roberts refers the reader to Frank Close's *An Introduction to Quarks and Partons* (Academic Press, 1979) and Richard Feynman's *Photon-Hadron Interactions* (Addison-Wesley, 1989) for a more historical introduction and broader discussion of the subject. I expect to see the present book on the shelves of friends who are involved in data analysis and the design of new experiments, but not among the broader ranges of graduate students.

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