sciousness (as promised), the book does provide an engaging review of this long-standing and tendentious controversy. The considerable reward of reading it is a wealth of provocative vignettes, psychophysical conundrums, and literary examples that are a lot of fun—and probably relevant to thinking about consciousness. In the end, however, Dennett admits—with admirable candor—that he has really only replaced one set of metaphors (those of the Cartesian Theater) with another (multiple drafts, virtual machines, pandemoniums). In this day and age, many readers will conclude that metaphors are not enough.

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Tracking Phytochrome

Pigment of the Imagination. A History of Phytochrome Research. LINDA C. SAGE. Academic Press, San Diego, CA 1992. xx, 562 pp., illus. $99.50.

During the decades in which photosynthesis researchers were focusing on light as a source of energy, phytochrome researchers were demonstrating the importance of light quality, quantity, and duration as environmental signals that modulate many developmental processes in plants. Phytochrome represents an important class of light-sensing pigments and is unique among photosensory pigments in that it is photoreversible. Absorption of red light converts it to a form that absorbs far-red light and absorption of far-red light converts it back to the form that absorbs red light. This photoconversion is a key component in phytochrome's ability to trigger a variety of growth responses that allow plants to adjust to changes in their surroundings throughout all stages of their life cycle, from seed germination to flower development. Some responses, such as induction of the expression of several photosynthetic genes by red light, can be rapidly induced by a single, short pulse of light. In other cases the responses occur more slowly and require repeated exposures to particular light conditions, in many cases requiring the measurement of daylength. For example, some plants flower only after they are exposed to the increasingly longer days of summer, whereas others require additional exposure to the shorter days of late summer before they will flower.

Pigment of the Imagination provides a fascinating account of the vast amount of phytochrome research that has been conducted during the past eight decades. It is the product of extensive work by Linda Sage, who analyzed scientific literature and personal records and conducted numerous interviews. The book is divided into two parts, each with 17 chapters. Part 1 chronicles the major events that took place from the initial discovery that plants were able to respond to photoperiodic stimuli to the extraction of the light-sensing pigment from seedlings. Part 2 deals with research conducted over the last 20 years and includes a thorough and current account of the important advances that have been made on many fronts, including refinements in the techniques of molecular biology.

Part 1 is a well-balanced blend of research data and personal information that provides the reader with the facts as well as an appreciation for the ingenuity and insights of many of the key investigators. For example, in describing the early work on the action spectrum for flower initiation, Sage not only presents the principles behind action spectroscopy and the results obtained but also provides fascinating details about the way Sterling Hendricks and his colleagues begged and borrowed components for the Beltsville spectrograph when they were short of research funds. Although instrumentation was critical for much of the research that resulted in the eventual discovery of phytochrome, Sage is careful to stress that it was the insightful analysis of the data that led to many of the crucial advances. The early days of phytochrome research provide wonderful examples of the benefits of collaborative research among scientists trained in a variety of disciplines.

An interesting, but very brief, discussion is included in part 1 of how a minor investment of about $10,000 in basic research led to billions of dollars of benefits to farmers, horticulturalists, and plant breeders. For example, agronomists now test the photoperiodic requirements of new crop varieties so they can be introduced only where the growing season provides the necessary daylength. Horticulturists routinely change daylengths in greenhouses to control flowering in a vast array of ornamental plants in such a way that, for many plants, blooms can be obtained in all seasons. Plant breeders manipulate daylength in greenhouses to increase the number of generations per year, to obtain seed of varieties that fail to reproduce outdoors, and to synchronize flowering of varieties that normally flower at different times for generating hybrids. These important offshoots of the basic research on phytochrome are often overlooked in textbooks, and so a little more space devoted to this topic would have been welcome.

With preparations of the phytochrome protein in hand, an increase in the number of researchers in the field, and numerous technological advances, the time was ripe to try to solve the ultimate mystery: How is the primary absorption of light by phytochrome converted into a growth response? Although the jury is still out on this issue, part 2 provides a wealth of information obtained from various fronts. Several chapters chronicle the frustrations and triumphs that led to the detailed characterization of the biochemical nature of the protein-pigment complex, the cloning of the first phytochrome gene, and the discovery that there are multiple species of phytochrome. Other chapters focus on various aspects of phytochrome physiology in a diversity of systems, including the importance of the phytochrome system in the natural environment and the interactions between circadian rhythms and phytochrome action. In the 1960s it became apparent that phytochrome determines some responses through the regulation of gene expression, and several chapters cover many of the advances that have been made in characterizing the interactions between regulatory sequences in several phytochrome-regulated genes and the trans-acting factors that interact with them. Considering that much has happened since the book was written, part 2 does a superb job of bringing together contemporary information on the latest advances with molecular genetics, biochemistry, and biophysics to dissect the complex physiology of phytochrome action.

In addition to being a valuable resource for both the novice and the seasoned photobiology researcher, *Pigment of the Imagination* should be enjoyed by everyone interested in plant physiology or the history of science, whether teacher or researcher. In many ways this book is like a good mystery story. In this case the mystery began with the profound discovery that flowering in some plants is triggered by their ability to detect daylength or the duration of the photoperiod. This led to the mobilization of research "detectives" from around the world to chase down and identify the "culprit," phytochrome. The chase often led to dead ends and involved some wild speculations, but Sage shows us that it was during some of these wayward quests that important clues were uncovered and new research directions were carved out. I look forward to the sequel, in which we will find out how researchers finally arrive at a comprehensive understanding of the mode of action of the pigment that has captured the imagination of so many.

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