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of these machines—the camera obscura and the stereoscope—are still familiar today, although knowledge of their original purpose has been obscured because they have been generally associated with magicians and side-show theatrics. Readers may therefore be surprised to learn that many of our most beloved old masters, such as Jan Vermeer and Thomas Gainsborough, had no qualms about employing such tools to "fool the eye."

In my estimation, Kemp's last section, entitled "The Colour of Light," is his most interesting and original. Here (and in an excellent preceding chapter on "Seeing, Knowing and Creating") he investigates why and how art and traditional science began to go in separate directions after the 17th century. To summarize: From Aristotle until Newton optical theorists had struggled to explain the phenomenon of color in terms of arithmetic ratios that affect the eyes in somewhat the same manner that musical tones affect the ear. Renaissance painters, however, were unable to apply such concepts to practice, and many tended to give up on color altogether. In Florence particularly they concentrated their analytical attention on the disposition of lights and darks (*chiaroscuro*) in an otherwise colorless geometric pictorial space.

Until about 1700 both artists and scientists could take for granted that visual "reality" and linear-perspective pictorial "realism" were one and the same thing. After Newton published his seminal *Opticks* in 1704, in which was set down for the first time a geometric rationale for the way colors are refracted from white light, uneasiness about the painter's way of "seeing and creating" and the scientist's way of theorizing began to surface. Not that artists were abandoning science in favor of anti-intellectual "primitivism" (such as we witness today in "post-modern" art), but rather that they found Euclidean geometry did not go scientifically far enough. It failed, for instance, to rationalize what many agreed was another kind of universal human cognitive experience: enjoyment of that which is immeasurable and ineffable in visible nature.

Debate split the artistic community. One side gathered to the Newtonians, among whom were the stolid "neo-classical" academicians such as Sir Joshua Reynolds. They maintained that the practice of art was ultimately subject, just like Newton's cosmos, to mathematical law. Those on the other side (with a wide range of in-between opinions) included "Romanticists" such as William Blake and Johann Wolfgang von Goethe, who denied this premise most vehemently. The issue became further complicated when Immanuel Kant stepped into the fray with his notion of an innate aesthetic sense to explain why we appreciate "beauty" for its own sake. While the philosophical debate raged, many artists still worried about the nature of the universal essence of this "beauty," and about the practical questions of how they might effectively capture it given the physical and chemical properties of paint.

Even though Newton's optical discovery had only to do with demonstrating how white light is the product of additive primary colors, artists were soon to determine that pigments operate in just the opposite, subtractive, manner. Toward the end of the 19th century the French post-Impressionist Georges Seurat finally brought scientific color theory and painter's practice as closely together as they would ever again come . By means of his famous *pointilliste* technique, he was able to marshal oil-paint colors on canvas in such a way that the luminosity of natural daylight was recreated (even if the actual imagery was somewhat blurred).

In sum, Martin Kemp has convincingly demonstrated that even the most diverse styles of Western art from the Renaissance to modern times remained ever enthralled by scientific optics. Furthermore, Kemp keeps his readers' attention always focused on this matter and never strays into the vagaries of currently fashionable political interpretation. Finally, his publisher, Yale University Press, should be congratulated for producing this handsome volume (including a set of gorgeous color plates) for so modest a price.—*Samuel Y. Edgerton, Jr., Art History, Williams College, Williamstown, MA*

DANIEL WOJCIK M-2373

The Myrmecologist's Bible

The Ants. Bert Hölldobler and Edward O. Wilson. 732 pp. Harvard University Press, 1990. $65.

Ants are part of almost every terrestrial habitat from the tropics to the subarctic. Their ubiquity and abundance make them prime subjects for ecological research. In addition, their sophisticated behavior and complex social organizations make them "premier organisms for research in behavioral ecology and sociobiology."

The last comprehensive review of ant biology was produced by William Morton Wheeler in 1910. Since then many thousands of papers have been published about ants. Our knowledge of this important group has grown tremendously in almost every respect, especially in the areas of classification, social organization, caste determination and modes of communication. The challenge of summarizing and synthesizing this information into a single coherent volume is a daunting task that requires exceptional talent, experience and perseverance. Two of the world's finest myrmecologists have risen to the challenge and donned Wheeler's mantle.

The Ants by Bert Hölldobler and Edward O.Wilson is a myrmecological masterwork—a marvelous combination of eminent scholarship and fine publishing. The book is thoroughly rooted in the most sophisticated ecological and evolutionary traditions of our day; nevertheless, the writing is clear and occasionally spiced with vivid or humorous descriptions. Overall, the book will be comprehensible to almost anyone with an interest in natural history.

The book is magnificently designed and illustrated (compliments to the publishers). It includes more than 700 figures as well as 24 color plates. My favorites are J. D. Dawson's minutely detailed color illustrations of ant biology. Even stodgy scientists can love a good picture book. When I got my copy, I couldn't resist the temptation to show it off to all my colleagues!

Even more important, the book is scientifically stimulating. (My copy is now marked with numerous notations of ideas for future research.) Specialists will find *The Ants* thoroughly referenced. Altogether, the book includes almost 3,000 citations; the authors have used more than 80 pages of tables to systematically present the pertinent literature. This strategy allows a reasonably thorough coverage of the literature without burdening the text with undue detail.

The most notable feature of the book is its chapter on ant classification, because it provides the first readily available taxonomic keys to the ant genera of the world. Previously, this information was scattered among numerous sources which were available only to the most determined of ant taxonomists. The new keys, most of which were written by Barry Bolton, Stefan Cover and Robert W. Taylor, will open the doors of ant taxonomy for the first time to the general scientific community. They will also be invaluable to scientists in many developing nations who, until now, have not had access even to regional keys. Furthermore, I am pleased to report that the authors have made every effort to make the keys "user friendly." To that end they have included a special glossary of taxonomic terms, supplemented by a series of anatomical figures. Most important, they have provided illustrations for vir-

Chains of African weaver ants bend a leaf during nest building. From *The Ants*.

tually every one of the 292 living ant genera, and an excellent table of all living and fossil ant genera, together with their synonyms, and citations to pertinent monographs.

The other chapters that deserve special mention are those that deal with ant communication, foraging strategies and community organization. The first of these is probably the most thorough treatment of ant communication to date. The basic theme is that "pheromones play the central role in the organization of ant societies." Hölldobler and Wilson characterize "the typical ant worker as a walking battery of exocrine glands." They describe in detail how chemical, glandular and behavioral aspects of ant biology have been "ritualized" to serve the needs of colony communication. I found the comparisons among different phylogenetic groups to be particularly informative. This chapter also has numerous excellent illustrations of exocrine glands, and of communication behaviors.

The latter two chapters represent the authors' answer to critics who question the importance of competition in the structuring of ant communities. "Competition," according to Hölldobler and Wilson, "is the hallmark of ant ecology." They discuss evidence for competition and the probable mechanisms involved. Territorial strategies are discussed in detail. These discussions are followed up with examples of how competition has structured ant communities through niche differentiation, density specialization, size differences and character displacement. While much remains to be learned about the structure of ant communities, there should be little doubt that competition is frequently important.

Readers will also find a wealth of information about colony life cycles, altruism, the origin of the worker caste, kin selection, colony odor, kin recognition and queen numbers. There are also excellent reviews of caste structure and the allocation of labor in ant colonies based on Wilson's previous groundbreaking syntheses. In addition, there are discussions of the symbiotic relationships between ants and other ants, between ants and other arthropods, and between ants and mutualistic plants; also covered are the natural history of army ants, fungus-growing ants, harvesting ants, weaver ants and a number of specialized predator ants. All of these ants have unusual habits or particularly sophisticated social organizations. The book concludes with a brief account of methods used to collect, culture and observe ants.

As with any major reference work, this book has weaknesses and omissions that are mainly attributable to size limitations and reader biases. Each expert will undoubtedly have his or her own list of mostly minor quibbles. For instance, I noted that the book offers very little information on applied aspects of myrmecology. My greatest concern, however, is not with the book's content but rather with the thought of waiting another 80 years for its sequel.

The Ants is destined to become the myrmecologist's Bible. Serious students of ant biology will definitely want a copy. This book will also be of considerable value to ecologists, behaviorists and entomologists who work with associated organisms. A copy of *The Ants* should be on the shelves of every university and college library in the United States.—*Sanford D. Porter, Insects Affecting Man and Animals Research Laboratory, USDA–Agricultural Research Service, Gainesville, FL*