VICTORIAN SCIENCE IN CONTEXT

EDITED BY

BERNARD LIGHTMAN

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Bernard Lightman is professor of humanities at York University. He is the author of *The Origins of Agnosticism: Victorian Unbelief and the Limits to Knowledge* (1987) and coeditor of *Victorian Faith in Crisis: Essays on Continuity and Change in Nineteenth-Century Religious Belief* (1990).

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audience for whom it was intended but on its other audiences, including ourselves.

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9

"The Voices of Nature": Popularizing Victorian Science

BERNARD LIGHTMAN

In the past twenty years the Western public has developed a voracious appetite for information on the discoveries of modern science. The circulation of established magazines like *Science Digest, Scientific American,* and *The New Scientist* has increased significantly, while new publications, such as *Discover, Omni,* and *Physics Today,* have begun to line the magazine racks. Many book-length popularizations of science have appeared at the same time, written by scientists of stature, including Stephen Jay Gould, Lewis Thomas, Edward O. Wilson, Stephen Hawking, and Ilya Prigogine. The success of Carl Sagan's television series *Cosmos* has spawned a host of science documentaries, many featuring lavish, high-tech special effects, catering to the public fascination with the fantastic wonders of cutting-edge scientific discovery (Fahnestock 1993, 18). It is not possible to overestimate the importance of current popularizations of science, in all their varied forms, for our understanding of the relationship between contemporary science and culture. Can the same be said for the Victorian period, or is the popularization of science a phenomenon of significance only in the twentieth century? Who wrote the best-selling books on science for a popular audience—who were the Goulds and Sagans of the latter half of the nineteenth century?

Professional scientists such as Thomas Henry Huxley and John Tyndall account only for a small portion of the works of Victorian popularizers of science. As science became professionalized during the Victorian period and professional scientists began to pursue highly specialized research, the need arose for nonprofessionals, who could convey the broader significance of many new discoveries to a rapidly growing Victorian reading pub-

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lic. Some periodical editors even preferred to recruit journalists, rather than professional scientists, to write on scientific subjects. William Thomas Stead, editor of *Cassell's Magazine,* warned fellow editors never to employ an expert, scientific or otherwise, to write a popular article on his own area of research, for "he will always forget that he is not writing for experts but for the public and will assume that they need not be told things which, although familiar to him as ABC, are nevertheless totally unknown to the general reader" (Stead 1906, 297). Stead believed it was far better to use an ignorant journalist, who could tap the expert's brains to write the piece, and then send the proof to the expert to correct.

But there were knowledgeable amateurs and journalists in the latter part of the nineteenth century, many prolific and wildly successful, who produced books aimed at the mass market. Seldom mentioned by scholars until very recently, these popularizers of science may have been more important than the Huxleys and Tyndalls in shaping the understanding of science in the minds of a reading public composed of children, teenagers, women, and nonscientific males. Their success as popularizers was partially due to their ability to present the huge mass of scientific fact in the form of compelling stories, parables, and lessons, fraught with cosmic significance. Popularizers not only found the cosmic in the awe-inspiring infinite space of the heavens, they also detected it within the structure of the tiniest living organism. Though the common context provided by natural theology for the middle and upper classes was fragmented in part by the appearance of Charles Darwin's *Origin of Species* in 1859, many middle-class popularizers of science perpetuated a revised form of natural theology in their works. While professional scientists moved toward scientific naturalism during the Victorian period, middle-class popularizers of science and their audiences remained enthralled by the traditional moral, aesthetic, teleological, and divine qualities of the natural world. There were radical popularizers who produced a subversive science repudiating all of these qualities during the early Victorian period (Desmond 1987), but the focus of this chapter will be on a specific middle-class context.

If these popularizers of Victorian science were so important in their own day, why do we know so little about them? The relative neglect of popularizers by scholars is indicative of the success of the campaign waged by Victorian scientific naturalists to convince future generations that scientists were the authoritative guides to deciphering the meaning of natural things—that they alone gave voice to mute nature. Until recently, the concept of popularization has been dependent on a two-stage historiographical model (Hilgartner 1990, 519). Relying on the epistemological purity guaranteed by the scientific method, a scientific elite produces genuine, privileged knowledge. Popularizers then disseminate simplified accounts to a passive readership. Referred to by two historians as "the positivist diffusion model," this approach to popularization excludes both popularizers

and the reading public from the production of knowledge (Cooter and Pumfrey 1994, 251). Popularization can be relegated to a low status, to be left to "non-scientists, failed scientists or ex-scientists as part of the general public relations effort of the research enterprise" (Whitley 1985, 3). While any differences between genuine and popularized science are attributed to a process of distortion for which the popularizer is held responsible, the scientist is given the final authority to determine which simplifications are distortions (Hilgartner 1990, 520).

Since the 1980s, scholars have offered telling criticisms of the positivist diffusion model of popularization. Hilgartner, Whitely, and Cooter and Pumfrey point out that we should be suspicious of any model that, in granting to scientists the sole possession of genuine scientific knowledge, serves to support their epistemic authority. The idea that popularization is merely a simplification of pure knowledge is itself a simplification. Distinguishing appropriate simplification from distortion in popularizations of science is not straightforward. Similarly, the boundary between genuine knowledge and popularized knowledge is often difficult to find (Hilgartner 1990, 524–29). As Cooter and Pumfrey so acutely observe, we cannot adopt the positivist diffusion model as a heuristic guide to research because it uncritically assumes the existence of two independent, homogeneous cultures, elite and popular, and forces the latter into a purely passive role. Popular culture can actively produce its own indigenous science, or can transform the products of elite culture in the process of appropriating them, or can substantially affect the nature of elite science as the price of consuming the knowledge it is offered (Cooter and Pumfrey 1994, 249–51).

In addition to recent criticism of the traditional historiographical model for approaching the popularization of science in general, scholars have noted the paucity of studies of Victorian popularizers in particular. In his important article "Natural Theology, Victorian Periodicals, and the Fragmentation of a Common Context," first published in 1980 but written much earlier, Robert Young argues that the breakup of the common intellectual context informed by natural theology led to the development of specialization and increasing professionalization. Though Young confines his attention in this piece to elite intellectual circles, he asks, "Who was left to interpret science to the layman and to discuss the large issues raised by science" once scientists had withdrawn from the common intellectual culture? With the exception of professional scientists like Huxley, Wallace, and Tyndall, who were self-consciously involved in popularization, "the field was left to pretentious hacks and to more or less competent amateurs." Young issues a call for "detailed study of this new sort of interpreter" but does not himself undertake the project (Young 1985, 156).

Young has been, of course, one of the early proponents of contextualist history of science, and we would expect to find a keen interest in science, popular culture, and the popularization of science among historians influ-

enced by his work. However, as Cooter and Pumfrey have noticed, the shift toward an interest in the social and cultural context of science ironically "tended further to close off the space for considering the dissemination and cultivation of science in popular culture." Young's call for a study of "this new sort of interpreter" went unheeded, largely because scholars believed that if all science was culturally situated, then it was not necessary to examine popularization in particular to uncover how science was shaped by its social and cultural context (Cooter and Pumfrey 1994, 241–42). To many contextualists, it seemed far more important to focus on Darwin, Huxley, Kelvin, and other major scientific figures, since internalist accounts of the history of science depended so heavily on the alleged purity of elite science.

It is only in the 1990s that scholars have begun to make a concerted effort to formulate a new historiographical model that treats popularizations of science as "sophisticated production of knowledge in its own right," to borrow a phrase from McRae's introduction to a collection of essays on twentieth-century popular scientific writing (McRae 1993, 10). In his study of science in mass-circulation family magazines in Britain in the late nineteenth and early twentieth centuries, Broks has drawn from the field of media studies to deal with themes such as the struggle over meaning and the production of consent (Broks 1993). Topham looks to the history of books for clues on how to recover the agency of readers in his fine essay on the communication circuit running from the authors of the *Bridgewater Treatises* through the publishers, printers, binders, distributors, and booksellers, to the audience (Topham 1994). Drawing upon the history of popular culture, Cooter and Pumfrey recommend that we pay more attention to "a greater plurality of the sites for the making and reproduction of scientific knowledge" (Cooter and Pumfrey 1994, 254). This means going beyond a narrow focus on the laboratory or the scientific society toward an investigation of science in such sites as the pub, as Anne Secord does in her superb article on artisan botanists (A. Secord 1994). Cooter and Pumfrey also urge us to move away from the idealist and textual products of authorized science and to be more open to "a greater plurality of signifiers of scientific activity," such as museums, world fairs, photography, and natural history (Cooter and Pumfrey 1994, 255).

There are three primary reasons why a study of Victorian popularizers of science is vitally important for our understanding of the social and cultural contexts of Victorian science. First, the topic of popularization offers scholars numerous opportunities to examine the rich interaction between Victorian science and culture. Perhaps the cultural dimension of science is nowhere more evident. During the latter half of the nineteenth century a series of overlapping cultural and social developments shaped the trajectory of science popularization. The growth of an educated middle class, and therefore a large reading audience, and the invention of new printing technologies made possible the birth of a mass market. But why did the reading audience choose to read about science? Commercial science journals, for example, flourished, increasing from five in 1815 to over eighty by 1895 (Brock 1980, 95). Is it merely coincidental that the births of mass media and professional science both took place during the second half of the nineteenth century (Broks 1993, 123)? Since science was now considered to provide important insight into the truth of things, the reading public wanted to know the implications of new scientific discoveries for the crucial issues of the day. What did science have to say about the controversies over the role of women in society? Could science provide a solution to economic and social upheaval, particularly in large urban centers prone to labor unrest? Did science throw any light on the question of the existence of God? The relationship between science, gender, society, and religion in Victorian culture are central issues in the works of the popularizers.

But to whom did the reading public go in order to learn about the ultimate meaning of modern science, the professionals or the popularizers? This brings us to the second important reason for investigating the Victorian popularizers of science: during that period they may very well have been more important than the professionals in shaping the public image of science. The success of scientific naturalists like Huxley and Tyndall in secularizing science dismantled the bridge between elite science and public discourse. Scientific naturalists worked to cleanse scientific thought of those elements that previously had connected public and scientific culture, including anthropomorphic, anthropocentric, teleological, and ethical views of nature. The resulting fragmentation of a common cultural context linking scientists, clerics, and laypersons in the 1870s and 1880s left the public in a precarious position. The professionals claimed to be the only experts with "a legitimate interest in, and with legitimate rights to pronounce upon, the domain of secularised nature" (Shapin 1990, 997–1000). The public was given the role of supporting the programs of work undertaken by the professionals from which they were to expect substantial utilitarian benefits. But did the public accept the role provided for it by the professionals? In the past, the public had been interested in what religious and moral lessons could be drawn from nature, not just the technical and economic utility of natural knowledge (Shapin 1900, 1005). The popularizers catered to this interest and continued to give the public a sense that they participated in the production of knowledge. The publishing success of popularizers indicates that there was resistance to the claims of professional scientists to provide the only legitimate voice of nature and to their attempt to secularize science.

The popularizers of Victorian science not only provided an alternate voice to be heard by the reading public, but also offered different ways of speaking about nature. Herein lies the third reason for pursuing an analysis of the popularization of science during the Victorian period: in examining

the attempts of popularizers to experiment with narrative form, the storytelling quality of all science is illuminated. Used by Galileo in his *Discourse Concerning the Two New Sciences* (1638) and by Robert Boyle in his *Sceptical Chymist* (1661), the dialogue was a conventional form for reporting scientific theories previous to the nineteenth century. Since the dialogue introduced a fiction to teach about facts, it explicitly embodied science in a narrative form. However, by the mid-nineteenth century the dialogue form rarely appeared in books dealing with scientific matters, even among popularizers, and the use of the dialogue by literary authors such as Charles Kingsley in *Madam How and Lady Why* (1869) and John Ruskin in his *Ethics of the Dust* (1865) to call to mind earlier views of nature represents the end of a tradition (Myers 1989). But the gradual disappearance of the dialogue did not bring to an end the narrative dimensions of modern science. Both popularizers and professionals have continued to tell stories about the ultimate meaning of things as revealed by science, though this characteristic of science has been more concealed in the scientific reports and papers of professional scientists (Locke 1992). The Victorian popularizers present us with a continuous spectrum of narrative form, from the most "fictional" parables to the least "fictional" imitations of the narrative of professional scientists, all of which tell the story of how science reveals the cosmic in the commonplace.

First appearing 1855, *The Parables of Nature* was an immense publishing success. In its eighteenth edition by 1882, the book was reissued many times by different publishers right up until 1950 and translated into German, French, Italian, Russian, Danish, Swedish, and Esperanto (*Dictionary of National Biography,* s.v. "Gatty, Margaret"). According to Rauch, *The Parables* was familiar to almost every middle-class child in the latter half of the nineteenth century (Rauch 1997). The author was Margaret Gatty (1809–73), the daughter of a clergyman, the Reverend Alexander John Scott, Lord Nelson's chaplain, and the wife of a Low Church clergyman, the Reverend Alfred Gatty, vicar of Ecclesfield, Yorkshire. Though the majority of her many works fall into the category of children's literature, she had more than a passing interest in science. Her passion for marine biology led to the publication of *British Seaweeds* (1863), a well-regarded introductory textbook. Gatty's scientific activity and her domestic life were virtually inseparable. She first collected seaweeds as an antidote to the boredom she experienced during a winter at Hastings recovering from the birth of her seventh child (Drain 1994, 6). On subsequent occasions, the entire family joined her at the seashore to help in the search for rare specimens, and her third daughter became a minor authority on seaweeds at the age of eight (Maxwell 1949, 97). For Gatty, the home was an important site for the production of scientific knowledge.

Gatty's *Parables from Nature* consists of a series of fictional short stories for children about the world of nature. She did not necessarily lose an

adult audience by choosing to write for children, since parents, teachers, or governesses would read her stories to their children. Gatty's natural world was not that of the scientific naturalist, stripped of moral and divine significance. Rather, it was the nature with which the public was so familiar, where moral dramas were enacted and from which moral lessons could be learned, whether the characters in the story were human or animals with human characteristics (Shapin 1990, 1005). In "Law of the Wood," for example, selfish spruce-firs, whose ethical "rule is to go our own way, and let everybody else do the same," don't realize that this rule would work only if everyone lived in a separate field. Their death as a result of growing too closely together is confirmation that "mutual accommodation is the law of the wood" (Gatty [1855] 1861, 86). Similarly, in the story "The Circle of Blessing," the generous vapors of the sea, who give of themselves to thirsty flowers, tumbling waterfalls, and the earth, illustrate through their "labours of love" how ethical goodness in the global circuit of the winds benefits the entire creation (Gatty 1861, 80).

For Gatty, the natural world was also charged with religious significance in the tradition of natural theology. In the story "Waiting," the only unhappy creatures on the prehuman earth are the crickets, who cannot understand their place in the scheme of things. A wise mole counsels patience. Wait and "everything will fit in and be perfect at last," the mole declares (Gatty 1861, 56). Sure enough, a future generation of crickets discovers that their purpose is to sing by the side of hearthstones in human houses. The teleological character of nature is also emphasized in "A Lesson of Hope," when a human impressed with the fury of a violent storm begins to think of disorder as the law of nature. A wise owl sets him straight by expounding on the lessons of natural theology. Disorder, death, and destruction are transitory, have no law or being in themselves, and exist only as disturbances within a purposeful scheme. "Life, order, harmony, and peace; means duly fitting ends; the object, universal joy. This is the law," the owl teaches (Gatty 1861, 64).

Though the teleological nature of things is often only dimly perceived by humans, Gatty believed that science offered the means for ascertaining the true meaning of God's works. Nature, she declared, held out to us "wonderful adumbrations of divine truths" in the many "similitudes and analogies between physical and spiritual things" (Gatty 1861, 192). Miraculous transformations in nature—the metamorphosis from caterpillar to butterfly or grub to dragonfly—gave rational individuals license to conceive of the existence of a higher spiritual reality. The resurrection of vegetable life out of decayed seed was analogous to the resurrection of the body; both St. Paul and Sir Thomas Browne had argued in such a fashion (Gatty 1861, 156). But to really understand the spiritual, and the analogy between the physical and the spiritual, it was absolutely essential to have a scientific grasp of the physical. Gatty therefore made her children's tales as scientifically accurate

Figure 9.1 "Inferior Animals," from *Red Snow and Other Parables from Nature* (Gatty 1864). The illustrations are by Gatty and her daughters.

as possible and even added in later editions of *The Parables* a lengthy section of notes that included detailed information on the scientific theories informing each of the stories. Even though Gatty's stories contained talking animals and plants, they were based on the observable and the empirical (Rauch 1997). The science is not merely incidental to the story. The analogy that underpins the point of the story can hold only if the scientific understanding of the physical is accurate. The happy song of the crickets, after discovering the purpose of their existence, becomes for Gatty a metaphor for the way analogies in nature can teach us about the human condition. Though we can recognize neither speech nor language in the crickets' song of hope fulfilled, "there is yet a voice to be heard among them by all who love to listen, with reverent delight, to the sweet harmonies and deep analogies of nature" (Gatty 1861, 60).

Gatty's perpetuation of the natural theology tradition brought her into opposition with professional scientists who espoused evolutionary naturalism (Katz 1993, 47–48). Her satirical story "Inferior Animals" (see figure 9.1) added to a later edition of *The Parables,* lodged a protest against the arrogance of evolutionists who claimed that Darwin's theory was ultimate truth (Rauch 1997). In this way she was able to participate in the controversy even though most women were excluded from the debate. Similarly, Gatty managed to cross the lines beginning to be drawn in the mid-nineteenth century between amateur and professional by cultivating the

acquaintance of experts like William Henry Harvey, who became chair of botany at Dublin in 1857, and George Johnstone, an authority on marine biology (Maxwell 1949, 93). Gatty became Harvey's unofficial assistant, and each benefited from their informal arrangement. In return for answering the questions of ignorant amateurs who wrote Harvey, helping him in the identification of seaweeds, and sharing with him anything unusual, Gatty received answers to her scientific queries, books and materials unavailable to her, and Harvey's help in correcting the proofs of her publications (Drain 1994, 7).

Like Gatty, the naturalist Eliza Brightwen (1830–1906) drew upon the natural theology tradition and conveyed scientific information to a popular audience by telling stories about the natural world. Brightwen was recognized in her time as one of the most popular naturalists; her *Wild Nature Won by Kindness,* first published in 1890, was in its fifth edition by 1893 (*Dictionary of National Biography Supplement 1901–1911,* s.v. "Brightwen, Mrs. Eliza"). Her other works included *More About Wild Nature* (1892), *Glimpses into Plant-Life* (1897), *Rambles with Nature Students* (1899), *Quiet Hours With Nature* (1904), and *Last Hours With Nature* (1908). Brightwen was raised by her uncle, Alexander Elder, one of the founders of the publishing house Smith, Elder and Company, after her mother's death in 1837. Plagued by a fear of abandonment, a feeling of loneliness, and an exaggerated sense of her own sinfulness, Brightwen could find comfort only in the study of nature (Brightwen 1909, 105–6). She married banker and businessman George Brightwen in 1855, and they settled in Stanmore on a beautiful, secluded estate, where Brightwen resided for the rest of her life surrounded by a menagerie of pet animals. In 1872 a physical illness led to complete debilitation, and only the death of her husband in 1883 roused her from her inactivity. Seven years later she began to write and publish her books.

Brightwen's purpose in *Wild Nature Won By Kindness* is to foster "the love of animated nature" in her audience, especially "in the minds of the young" (Brightwen 1890, 13). Reaching children is not a difficult task, according to Brightwen, for they "have a natural love of living creatures, and if they are told interesting facts about them they soon become ardent naturalists" (Brightwen 1890, 15). But Brightwen also simplifies her task by establishing a warm rapport with her readers through the use of a conversational mode of communication. She describes the chapters in her book as "quiet talks with my readers" in which she will "tell them in a simple way about the many pleasant friendships I have had with animals, birds, and insects" (Brightwen 1890, 12).

In contrast to Gatty's fictional parables based on scientific fact, Brightwen offered anecdotal stories, told from the first person point of view. These stories focused on her real experiences taming animals, conveying in the process scientific information on their habits, diet, and physiology. She

referred to these stories as "life histories of my pets"—or in the case of her pet robin Robert the Second, a "biography"—which began at the point when they were found as babies, recounted their memorable escapades, and then ended with their unfortunate deaths (Brightwen 1890, 16, 182). Each animal emerges as an individual, with its own personality. In "Richard the Second," Brightwen describes her relationship with her pet starling, Richard, who was part of her "home-life" for more than five years (Brightwen 1890, 42). With obvious relish, she recalls his mischievous pranks, his close brush with death when he went off to hobnob with wild birds, and his ability to speak some words. Even a snail, often thought of as slimy and ugly, "is a wonderfully curious creature" to Brightwen, with its own special characteristics (Brightwen 1890, 143). Seldom leaving the bounds of her estate, Brightwen came to view the abundant wildlife there as her dearest friends. Birdie, a nightingale, was her daily companion for fourteen years. "Never," Brightwen declares, "was there a closer friendship" (Brightwen 1890, 85). For his part, Birdie became so attached to Brightwen that he adopted her as a "kind of mate," constructing a nest for her and trying to put flies into her mouth (Brightwen 1890, 83).

Brightwen's anthropomorphizing of animals, her treatment of them as individuals rather than members of a species, and the fact that her work was done in her secluded country estate and not a laboratory (though this never damaged Darwin's reputation) flew in the face of the scientific naturalists' conception of proper science. But even worse, from their point of view, Brightwen was advocating an alternative, nonexperimental approach to gathering knowledge of nature in her instructions on how to tame wild animals. Brightwen advised that the "little wild heart" could be won only "by quiet and unvarying kindness," that "there are no secrets that I am aware of in taming anything, but love and gentleness" (Brightwen 1890, 12, 74). Brightwen is suggesting how to draw closer to living things—how to enter into a relationship with nature. While scientific naturalists could be seen to adopt the experimental model for knowing nature, with its emphasis on questioning nature so as to force it to reveal its secrets, Brightwen's experiential knowledge comes from a personal encounter with nature based on love. It is quite striking that Brightwen's books contain no references to authoritative scientific experts and borrow nothing from established scientific writers, even though she enjoyed the friendship during her life of several of the leading men of science, in particular, Philip Henry Gosse (whose second wife was her sister-in-law), Sir William Flower, and Sir James Paget. Her closer relationship to nature establishes her as an independent authority, and her books provide her readers with the method for obtaining the same status for themselves.

However, Brightwen's loving relationship to nature not only leads to scientific knowledge, it also leads to knowledge of God's existence and wisdom. Brightwen's strong evangelical leanings manifest themselves

throughout *Wild Nature Won By Kindness.* In the introduction, she hopes that her work will "tend to lead the young to see how this beautiful world is full of wonders of every kind, full of evidences of the Great Creator's wisdom and skill in adapting each created thing to its special purpose" (Brightwen 1890, 17). In the conclusion, titled "How to Observe Nature," she discusses the two great books given to us by God for our instruction. While the Scriptures are widely read, "how many fail to give any time or thought to reading the book of nature" (Brightwen 1890, 205). Brightwen shares with Gatty the firm belief that nature is designed by God to teach us moral lessons. "The whole realm of nature is meant, I believe," Brightwen announces, "to *speak to us,* to teach us lessons in parables—to lead our hearts upward to God who made us and fitted us also for our special place in creation" (Brightwen 1890, 204). Gatty's *Parables in Nature* are no more didactic than Brightwen's "lessons in parables" in *Wild Nature Won By Kindness:* both claim to attune their readers to the divine voice of nature.

Like Gatty and Brightwen, Arabella Buckley (1840–1929) popularized science in such a way as to draw attention to its storytelling nature. But whereas Gatty wrote fictional parables based on scientific fact and Brightwen related anecdotal stories about real experiences with nature, Buckley conveyed scientific information in the form of children's fairy tales. Daughter of the Reverend J. W. Buckley, vicar of St. Mary's, Paddington, she was in touch with the leading scientists of the day through her position as Sir Charles Lyell's secretary from 1864 until his death in 1875 (Kirk 1965, 592). Buckley's popular *Fairyland of Science* (1879) was published by no fewer than seven publishers in both England and the United States, the last edition appearing in 1905. Her other publications include *A Short History of Natural Science* (1876), *Botanical Tables for the Use of Junior Students* (1877), *Life and Her Children* (1880), *Winners in Life's Race; or, the Great Backboned Family* (1882), *Through Magic Glasses* (1890), *Moral Teachings of Science* (1891), and *Insect Life* (1901).

Buckley's avowed aim in *The Fairyland of Science* is to awaken "a love of nature and of the study of science" in "young people" who more than likely "look upon science as a bundle of dry facts" (Buckley 1879, v, 1). In order to undermine this uninspiring misconception of science, Buckley draws upon her audience's love of the magic and imagination of fairy tales. Science, Buckley promises, tells us about an enchanted natural world that, like fairyland, "is full of beautiful pictures, of real poetry, and of wonder-working fairies" (Buckley 1879, 2). To illustrate her point, Buckley draws attention to the storytelling nature of science in the opening chapter of the book. "Let us first see for a moment what kind of tales science has to tell," Buckley suggests, "and how far they are equal to the old fairy tales we all know so well" (Buckley 1879, 2). In "Sleeping Beauty" the spellbound inhabitants of the castle are frozen until the valiant prince kisses the princess and everything comes to life again. Is there less magic in the scientific tale of

frozen water, spellbound by "the enchantments of the frost-giant who holds it fast in his grip," until a sunbeam kisses the ice and sets the water free (Buckley 1879, 3)? Or compare the magical powers of the man in the fairy tale "Wonderful Travellers," whose sight is so keen he can hit the eye of a fly sitting on a tree two miles away, to the "wonderful instrument" the spectroscope, which enables you to tell one gas from another in the far-distant stars (Buckley 1879, 4). "We might find hundreds of such fairy tales in the domain of science," Buckley asserts (Buckley 1879, 5).

The stories of science have an affinity to fairy tales because in nature, as in fairyland, things happen "so suddenly, so mysteriously, without humans having anything to do with it" due to the magical actions of invisible fairies ceaselessly at work. "There are *forces* around us, and among us," Buckley writes, "which I shall ask you to allow me to call *fairies,* and these are ten thousand times more wonderful, more magical, and more beautiful in their work, than those of the old fairy tales" (Buckley 1879, 5-6). The first chapter of *The Fairyland of Science* deals briefly with the fairies heat, cohesion, gravitation, crystallization, and chemical attraction. The remainder of the book is devoted to explaining how the science fairies do their work in nature, particularly in sunbeams, gases, water, sound, plants, coal, and beehives. Buckley insists that any common object, "the fire in the grate, the lamp by the bedside, the water in the tumbler, . . . anything, everything, has its history and can reveal to us nature's invisible fairies" if "touched with the fairy wand of imagination" (Buckley 1879, 13). Entrance to the fairyland of science, then, is especially easy for children, who have the "glorious gift" of imagination that must be cultivated in adults (Buckley 1879, 7).

Despite Buckley's emphasis on the narrative quality of science, her book is less "fictional" than Gatty's *Parables* or even Brightwen's anecdotal *Wild Nature.* Buckley's sustained exploration of the analogies between fairies and natural forces functions more as a hook to capture the interest of her audience, and less as an element that disturbs the content of the story science tells. "With the exception of the first of the series," Buckley declares in her preface, "none of them have any pretensions to originality, their object being merely to explain well-known natural facts in simple and pleasant language." She acknowledges that she has availed herself freely of "the leading popular works on science" and that all of the material she presents has "long been the common property of scientific teachers" (Buckley 1879, v). Furthermore, Buckley refers several times with approval to the works of scientific naturalists like Tyndall and Huxley, praising the latter in particular for his ability to get beyond the dry facts of a scientific subject (Buckley 1879, 87, 128, 21, 23).

However, Buckley's scientific fairy tales present a challenge to the tales of scientific naturalists, not only in the moral lessons that we are to draw from them, but also in the teleological message they convey. In a number of her works, Buckley reinterprets the story of evolution in a way that emphasizes the moral dimensions of the process. The purpose of evolution was not, as Darwin had argued, merely the preservation of life, it encompassed the development of mutuality as well (Gates 1997). When Buckley deals with this theme in *The Fairyland of Science,* she connects it closely with the will of God. The mutual adaptation of bees and flowers "teaches the truth that those succeed best in life who, whether consciously or unconsciously, do their best for others." This leads her to conclude that from "our wanderings in the Fairy-land of Science" we "shall learn how to guide our lives" and we will see "that the forces of nature, whether they are apparently mechanical, as in gravitation or heat; or intelligent, as in living beings, are one and all the voice of the Great Creator, and speak to us of His Nature and His Will" (Buckley 1879, 237). Though Buckley is post-Darwinian in her emphasis on natural law—the invisible fairies are, after all, secondary natural causes—the world is no less a pre-Darwinian arena of divine design. Buckley's fascination with the "wonderful contrivances" in the relationship between bees and flowers, her perception that everything has a purpose (even those ancient plants that later became coal in order to make England great), and her belief that a child who gazes at nature with open eyes "must rise in some sense or other through nature to nature's God," all mark her out as a part of the natural theology tradition (Buckley 1879, 233, 192, 25). The wonder of fairyland is the same wonder perceived by the natural theologian.

Though more conventional in his selection of a narrative form, Richard Anthony Proctor (1837-88) had no reservations about indulging in daring speculations on the existence of extraterrestrial life in his many popular astronomical works. Thousands of members of the public were introduced to astronomy by Proctor's writings (Crowe 1986, 377). The youngest son of a wealthy solicitor, Proctor entered St. John's College, Cambridge, in 1856, where he studied theology and mathematics. To pay off a huge debt, incurred when an investment failed, Proctor turned to a career in journalism. Though his literary career was never a resounding financial success, he was able to develop a writing style that eventually won him recognition from both professionals and the public. In 1866 he was elected to the Royal Astronomical Society, later filling the office of honorary secretary, while his first major success, *Other Worlds Than Ours* (1870), was followed by triumphant lecture tours of America and Australasia. His other major works, all of which were published in three or more editions, include *Lessons in Elementary Astronomy* (1871), *Light Science for Leisure Hours* (1871), *The Sun* (1871), *The Orbs Around Us* (1872), *The Moon* (1873), and *Transits of Venus* (1874).

Proctor catered to the reading public rather than the expert astronomer. A number of his books were easy-to-follow guides for budding young astronomers, such as *A New Star Atlas for the Library, School and the Observatory* (1870), which by 1895 had sold nineteen editions. Proctor stressed

hands-on astronomy, for he who takes his astronomy at second hand from books "may lightly disregard the grand lesson which the heavens are always teaching, and find only the grotesque and the incongruous, where in reality there is the perfect handiwork of the Creator." But the astronomer, Proctor declared, "imbued with the sense of beauty and perfection which each fresh hour of world-study instills more deeply into his soul, reads a nobler lesson in the skies" (Proctor 1870, 158). Proctor therefore saw himself as leading his readers to God through the lessons of astronomy.

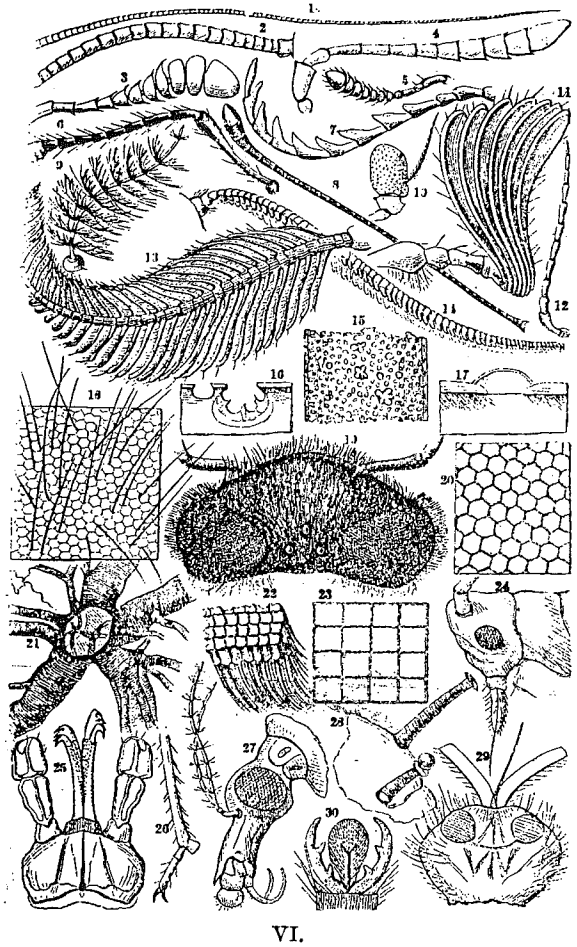
Proctor's most popular book, *Other Worlds Than Ours,* which by 1909 was in its fourth edition, cast his science into a teleological framework. When considering the glowing mass of Jupiter, which can sustain no life, readers are invited to find a "raison d'être," for Proctor cannot accept the idea that God would create something for no purpose at all. The "wealth of design" in Saturn is so striking in Proctor's eyes that we cannot question but "that the great planet *is* designed for purposes of the noblest sort," though we may be unable to fathom those divine purposes. And Proctor enthuses as if he were a Bridgewater Treatise author over the recent discoveries of science, which "are well calculated to excite our admiration for the wonderful works of God in His universe" (Proctor 1970, 154, 159–60, 21). Proctor even structured *Other Worlds Than Ours* along the lines of a cosmic, post-Darwinian natural theology. The beginning chapters, "What Our Earth Teaches Us" and "What We Learn from the Sun," set the didactic tone for the entire book. Here nature's lessons concerning God's intentions and will are revealed by the telescope, spectroscope, and the other tools of the astronomer's trade. These first two chapters are a part of the nine-chapter section on the solar system, which leads into a series of three chapters on the stars and nebulae, extending the discussion of how God instructs us through nature to the rest of the universe. The concluding chapter, titled "Supervision and Control," is designed to teach the public how to read the lessons to be found by examining astronomy and the province of God. Proctor's story is a familiar one—it is the same cosmic story of purpose and design told by natural theologians, though it is validated by the findings of the most up-to-date astronomical science (Lightman 1996).

The Reverend John George Wood (1827–89) found that the cosmic story of natural theology was as appropriate for speaking to a popular audience of the minuscule wonders of the microscopic world as it was for conveying the majesty of the heavens. His *Common Objects of the Microscope,* published in 1861, was so popular that it eventually required a third edition. Wood was a prolific writer whose publications included *Bees* (1853), *Common Objects of the Sea Shore* (1857), *The Boy's Own Book of Natural History* (1860), *Animal Traits and Characteristics* (1860), *The Natural History of Man* (1868–70), *Common Moths of England* (1870), *Insects at Home* (1872), *Insects Abroad* (1874), *Half Hours with a Naturalist* (1875), *Half Hours in Field and Forest* (1875), *Common British Beetles* (1875), *Common British Insects* (1882), *Illustrated Natural History for Young People* (1887), and *The Romance of Animal Life* (1887).

Celebrated as a great popularizer of his day for his long list of publications and his lecturing, Wood was an Oxford man, receiving his B.A. in 1848 and an M.A. in 1851 (Gates 1993, 304). He was appointed to a series of ecclesiastical and academic posts, including curate of the parish of St. Thomas the Martyr, Oxford, in 1852, chaplain to St. Bartholomew's Hospital in 1856, and reader at Christ Church, Newgate Street, but ill health in 1858 forced him to resign from all three. The success of his voluntary work with a parish choir led to his appointment as precentor of the Canterbury Diocesan Choral Union, whose annual festivals he conducted from 1869 to 1875. Wood later took up lecturing as a second profession, delivering a series of lectures from 1879 to 1888 throughout England and America. His lectures, particularly the Lowell Lectures at Boston in 1883–84, were renowned for their inclusion of color chalk illustrations (*Dictionary of National Biography,* s.v. "Wood, John George").

Many of Wood's books were designed as introductory works to a particular field of scientific study. Wood's *Common Objects of the Microscope,* like Gatty's *British Seaweeds,* is meant to be a catalogue of the basic facts for the "young and inexperienced observer" (Wood 1861, 37). In the preface Wood explains that his book has been produced to satisfy "a general demand" for "an elementary handbook upon the Microscope and its practical appliance to the study of nature" (Wood 1861, iii). Wood leads his readers through a series of microscopic observations of vegetable cells in plant hairs, starch grains, pollen, seeds, and algae, and of animal structures such as fish scales, insect antennae, feathers, and human skin, nails, bone, teeth, and muscle. After introducing readers to the different types of microscopes available, Wood instructs them to compare objects they view under the microscope to the illustrations provided and to check the accuracy of their observations (see figure 9.2). He then informs the audience of the conclusions to be drawn from such an exercise.

Though *Common Objects of the Microscope* appears to amount to little more than a list of different images viewed under the microscope, Wood nevertheless has a tale to tell his audience. It is the story of the divine wonders of the microscopic world that exist all around us but, until recently, remained unknown. Drawings, Wood declares, cannot do justice to the "lovely structures revealed by the microscope." Form and color can be indicated, "but no pen, pencil, or brush, however skillfully wielded, can reproduce the soft, glowing radiance, the delicate pearly translucency, or the flashing effulgence of living and ever-changing light with which God wills to imbue even the smallest of his creatures, whose very existence has been hidden for countless ages from the inquisitive research of man, and whose wondrous beauty astonishes and delights the eye, and fills the heart with awe and adoration" (Wood 1861, iv). In Wood's eyes, the microscope is a



VI.

Figure 9.2 Plate 6 from *Common Objects of the Microscope* (Wood 1866?). The illustrations are by Tuffen West.

tool that allows access to a new world of wonders testifying to the existence and wisdom of God, a new revelation of his immense power.

Such an accessible tool was too important as an aid to faith to be left in the hands of the professional scientists for use in their private laboratories. Furthermore, the microscope was not one of those expensive scientific instruments that only the wealthy could afford to buy. Wood intended to restrict his observations "to that class of instrument which can be readily obtained and easily handled, and to those supplementary pieces of microscopic apparatus which can be supplied by the makers at a cost of a few shillings, or extemporized by the expenditure of a few pence and a little

ingenuity on the part of the observer" (Wood 1861, 1). In the second chapter, on different types of microscopes, Wood goes into great detail on the least expensive, but most adequate, microscopes and gives tips on how to construct important apparatus on the cheap. It was not "the wealthiest, but the acutest and most patient observer who makes the most discoveries," Wood affirmed, "for a workman is not made, nor even known by his tools, and a good observer will discover with a common pocket-magnifier many a secret of nature which has escaped the notice of a whole array of *dilettanti* microscopists in spite of all their expensive and accurate instruments" (Wood 1861, 7).

In fact, once the amateur was armed with a decent microscope, there was no telling what important discoveries would result. As long as the amateur had an "observant mind" and the discipline to study "the commonest weed or the most familiar insect, he would, in the course of some years' patient labour, produce a work that would be most valuable to science and enrol the name of the investigator among the most honoured sons of knowledge" (Wood 1861, 5). As encouragement to his readers, Wood recounted the story of an old lady who, through her study of her own tiny backyard in the suburbs of London, contributed many "valuable original observations" to his notebook (Wood 1861, 4). There was no need to have access to a laboratory or to travel to the ends of the earth for exotic specimens to study. "So richly does nature teem with beauty and living marvels," Wood insisted, " . . . there is not one who may not find an endless series of Common Objects for his microscope within the limits of the tiniest city chamber" (Wood 1861, 3). Since the cosmic could be found within all common objects, anyone could use the microscope to conduct useful research in any place. Wood's entire series of books on commonplace objects in nature, whether they be moths, beetles, insects, or marine life, represents an open invitation to amateurs to become producers, not just consumers, of knowledge.

Similarly, Agnes Mary Clerke (1842–1907), a late Victorian popularizer of astronomy, summoned amateurs to contribute to the collection of astronomical data. Astronomy is "the science of amateurs," Clerke announces, and "there is no one 'with a true eye and a faithful hand' but can do good work in watching the heavens" (Clerke 1885, 7). Like Wood, Clerke was convinced that, with her help, the reader's encounter with nature would lead "towards a fuller understanding of the manifold works which have in all ages irresistibly spoken to man of the glory of God" (Clerke 1885, vi). The daughter of a bank manager with a keen interest in science, Clerke was educated entirely at home as a child. At the age of thirty-five, she embarked on a writing career and produced a series of important works, including *A Popular History of Astronomy During the Nineteenth Century* (1885), *The System of the Stars* (1890), *The Herschels and Modern Astronomy*

(1895), *Problems in Astrophysics* (1903), and *Modern Cosmogonies* (1905), that gained her partial admission into the male-dominated astronomical world.

In her *Popular History of Astronomy,* which reached a fourth edition in 1902 in addition to being translated into German, Clerke explained to the reading public how the new astronomical information generated by the spectroscope and camera had revealed a divinely designed universe full of complexity. A devout Catholic, Clerke perceived the hand of God in the most spectacular astronomical phenomena. Whether it be the evolution of the planets, whose growth is guided "from the beginning by Omnipotent Wisdom"; or the "sequence of Divinely decreed changes" by which nebulae are transformed into star clusters; or even gigantic galactic rifts of starless space, wherein "Supreme Power is at work in dispersing or refashioning" star clouds, Clerke saw the hand of God (Clerke 1885, 348; 1905, 297; 1903, 541). Though the picture of the cosmos emerging from the "new astronomy" of the late nineteenth century emphasized complexity and inexhaustible variety, Clerke nevertheless asserts that no matter where the telescope is pointed, it reveals the same pattern of design in the limitless regions of space that was so evident on the earth (Clerke 1885, 24). Even at the end of the nineteenth century, the natural theology tradition within popular scientific works was perpetuated by Clerke.

Clerke had no interest in experimenting with narrative form. Her scholarly works, written from the impersonal, objective point of view, imitate the form adopted by professional scientists. Clerke's high standing within the astronomical community, relative to other popularizers, also can be attributed to her attempt to interpret the larger meaning of recent astronomical discoveries to the professional astronomers themselves. Though contributing no original research, Clerke took the discoveries of isolated specialists and synthesized them. In her later works, Clerke often ended her review of the most recent research in a particular area with suggestions on the future work to be done by astronomers to answer the remaining questions. For some astronomers, like Richard A. Gregory, Norman Lockyer's protégé and assistant editor of *Nature,* Clerke represented a major problem. When Clerke began to work on projects that were less accessible to a popular audience and more technical in nature, Gregory wrote a series of vicious attacks on her scientific credentials in *Nature* pointing to her gender as grounds for refusing to take her work seriously. In presuming to instruct the experts as to the direction of their research, Clerke had, in Gregory's mind, crossed the line separating female popularizers of science from male professionals (Lightman 1997).

Two important observations have emerged from our study of Victorian popularizers of science. First, the question of who should participate in the making of science was still unresolved during the Victorian period. As Anne Secord has demonstrated, "the contest over science in the early nineteenth century was a contest about who could participate and on what terms" (A. Secord 1994, 299). By the mid-nineteenth century, popular science was becoming increasingly marginalized, and clergymen, women, artisans, and "nonprofessionals" in general were excluded by professionals. But science continued to be contested territory in the latter half of the nineteenth century. Wood's invitation to his readers to engage in the production of scientific knowledge is a theme lying latent in the works of popularizers, though participation in science likely meant something different to each of them. Do-it-yourself guides like Gatty's *British Seaweeds,* Proctor's *New Star Atlas* and Wood's entire series on common objects and animals encouraged the reader to actively observe nature and become familiar with basic scientific facts. But only Wood strongly encouraged his readers to seek out new knowledge. Popular science periodicals, in particular, mechanics' magazines and natural history periodicals, also encouraged amateur scientific activity (Sheets-Pyenson 1985, 553–54). The immensely successful *English Mechanic,* for example, a cheap mass-circulation science journal founded in 1865, was run cooperatively with its largely working-class readers, who used the pages of the publication to exchange views and information on a wide range of topics (Brock 1980, 111–13). The number of women engaged in popularizing science in the latter half of the nineteenth century is also indicative of the continuing efforts of marginalized groups to be a part of the scientific world. Buckley and Clerke accepted the traditional responsibility of women to educate and teach morality to the uneducated and the young, but both also represent a new confidence among women popularizers of science in their ability to speak with authority and to make contacts with leading scientists (Gates 1993, 298). But by the end of the century women began to lose their status as popularizers, not only because male popularizers perceived them as competitors, but also because of the introduction of natural history education into the schools, which reduced the need for science books in the home (Gates 1993, 305).

The unresolved question of who participates in the making of science was raised by popularizers in tandem with a second concern about what kinds of stories should be told about nature. For professional scientists, the answer was clear. The story should describe the operation of nature according to secondary law, particularly the law of evolution, avoiding all reference to supernatural causes. Professionals, like Huxley, Tyndall, and Herbert Spencer all tried their hand at writing popular works. Perhaps the most famous attempt at codifying and popularizing scientific knowledge in a systematic fashion to a wide reading public, *The International Scientific Series,* appeared in the United States and five European countries in over 120 titles between 1871 and 1910. Written for the most part by professional scientists, directed in its early years by an advisory committee composed of Huxley, Tyndall, and Spencer, and devoted, particularly in the eighties, to exploring the wider implications of evolutionary theory, the series stands

as a monument to the efforts of professionals to control the public's understanding of modern science (MacLeod 1980). Popularizers like Gatty, Brightwen, Buckley, Proctor, Wood, and Clerke rarely sought to engage professionals in controversy, but they were not passive conveyors of the story of scientific naturalism. Their emphasis on the teleological, aesthetic, moral, and divine quality of nature connects them to the earlier natural theology tradition. Their alteration of the story told by scientific naturalists was not the result of ignorance or simplification—it was an intentional refashioning of recent scientific discovery into a form full of meaning for their audience. Competing interpretations of the cosmic significance of science were offered by popularizers committed to natural theology and popularizers and professionals grounded in scientific naturalism.

Perhaps it is more accurate to characterize the competition as existing between two groups of professionals, professional scientists and professional writers. Cross has analyzed the formation of writers into an occupational group during the nineteenth century (Cross 1985). As the mass reading public grew in numbers, it was possible for more and more "common writers" to make a living in the publishing industry. Certainly Gatty, Proctor, and Clerke devoted much of their time to their craft and depended heavily on their writing as an important source of their total income. They and the countless writers who supplied newspapers and journals with endless copy on scientific topics saw themselves as professional writers and therefore could draw strength from their link to the profession as a whole. The professionalization of science took place during the same period. The clash between two groups of recently established professionals may therefore be an important factor in the relationship between scientists and popularizers of science.

Scholars have barely scratched the surface in their attempts to understand the popularization of Victorian science. We still know very little about the major popularizers. Books, of course, were only one medium for the popularization of science. We need to know far more about how science was popularized during the Victorian period in magazines, journals, textbooks, children's literature, encyclopedias, and newspapers, and we need to go beyond the written word to popular lectures, museums, fairs, and exhibitions. But even so, concentrating on the thoughts and methods of the popularizers does not bring us into direct contact with the audience for whom these popularizations of science were intended. How did they read the message directed at them, and how was the message read and appropriated in different ways in different local settings by different social groups, whether they be aristocratic, middle class, or working class? This would lead us to examine the relationship between the popularization of science and elite and popular science.

In the sixth lecture of her *Fairyland of Science,* Buckley instructed her readers on "The Voices of Nature and How We Hear Them." Nature speaks

to us, Buckley asserts, through sound waves, in a voice that "is sharp or tender, loud or gentle, awful or loving" (Buckley 1879, 159). Listen to these voices, Buckley advises the reader, "and ponder how it is that we hear them" (Buckley 1879, 166). Though Buckley has been dealing here with the physics of sound and the physiology of the human ear, her book, and the books of the other popularizers, are intended to be "voices of nature." The popularizers claimed, as did the professionals, to speak for a mute nature, or at least to interpret the true meaning of what seems to be a cacophony of noise for the reader whose ears are not properly attuned to the voices of nature. But behind these voices, Buckley and the others heard the "voice of the Great Creator" (Buckley 1879, 258). The voices of nature spoke to them of God's purpose, of his moral and natural laws, and of the place of humanity in the grand scheme of things. Their books were therefore designed to be reflections of the second revelation of God's will in nature, of the wonder to be found in the limitless heavens as well as the tiniest microbe, as Brightwen put it, "lessons in parables," or as Gatty says, "lessons of analogy." The cosmic stories of these popularizers testify to the continuing importance of religion to the reading public in the latter half of the nineteenth century and the belief that science was still an aid to faith, no matter what the Huxleys, Tyndalls, or Darwins said to the contrary.

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The best theoretical and historiographical studies on the concept of popularization of science in general are Whitley (1985), Hilgartner (1990), and Cooter and Pumfrey (1994). No published account of the popularization of science in nineteenth-century England exists. However, two dissertations focus on specific periods, Kitteringham (1981) from 1800 to 1830, and Hinton (1979) from 1830 to 1870. For information on Huxley, a professional scientist who was also an important popularizer, see Jensen (1991), Paradis (1978), and Block (1986). MacLeod (1980) explores the role of *The International Scientific Series* in popularizing the scientific naturalism of professional scientists. Myers (1985) looks at the career of a particular scientific metaphor within popular writing and culture in his essay on nineteenth-century popularizations of thermodynamics, which includes sections on such professional scientists as Tyndall, Kelvin, James Clerk Maxwell, and Balfour Stewart.

Moving on to the "nonprofessional" popularizers, Robert Chambers and his vastly popular *Vestiges of the Natural History of Creation* (1844) are examined in Hodge (1972), Millhauser (1959), J. Secord (1989, 1994), and Yeo (1984). In her book on Mary Somerville, Patterson (1983) focuses on another significant popularizer from the first half of the century. Useful secondary sources on the popularizers discussed in this chapter include Drain (1994), Katz (1993), Maxwell (1949), and Rauch (1997) on Gatty, Lightman

(1997) and Brück (1991, 1993, 1994) on Clerke, Lightman (1996) on Proctor, and Gates (1997) on Buckley. There are a few short studies that deal with several popularizers by looking at a particular aspect of the popularization of Victorian science. Gates (1993) examines the way female popularizers retold the story of science, touching on Margaret Bryan, Jane Marcet, Buckley, Alice Bodington, Wood, and Brightwen. Myers's (1989) essay on scientific dialogues for children and women investigates Maria Edgeworth, Kingsley, and Ruskin.

As Myers (1994) points out, science existed in many forums and forms during the nineteenth century, not just in books. However, scholars are only beginning to explore these various forums. The popularization of science in periodicals has received attention from Sheets-Pyenson (1985) and Broks (1988, 1990, 1993), while Brock (1980) has drawn attention to the development of commercial science journals. Yeo's essay on encyclopedias (1991) does not address the popularization theme directly. The theme of science and its publics, which is closely connected to the issue of popularization, has also generated some interest. Shapin (1990) delivers a useful overview of the relationship between science and the public in the West from the seventeenth century to the present. Turner's (1993) chapter on public science in Britain from 1880 to 1919 dwells on the body of rhetoric, argument, and polemic produced by professional scientists to persuade the public or influential sectors thereof that science was worthy of support. Finally, Topham (1994) is one of the few who attempts to move from the authors of popular scientific works to their readers.

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