INTRODUCTION

VICTORIAN SCIENCE AND IMAGERY

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What happens when we look at an artwork in terms of the ways its depicted subject, its medium, its method of production, or its formal elements correspond with the dominant scientific discourses of the period in which it was produced? This volume suggests that considering how objects from such conventionally separated categories as "empirical research" and "creative works of art" might share epistemological conditions offers fruitful interpretive possibilities. At a crucial moment in the development of the modern world, British and American visual culture helped to produce science, while science in turn newly informed art. Remarkably, in 1875 it was possible for an English scientist to maintain that "science and art . . . act and re-act upon each other with an almost exchangeable importance. Science is theoretical art; art practical science."[1] The art historians in this collection help us see the extent to which nineteenth-century "science" and "art" were not in fact separate fields but instead mutually constitutive.

A focus on the close kinship between the two fields in the nineteenth century is timely and topical, as it may help disrupt the subsequent reification of the idea of two antagonistic cultures, an image that became entrenched by the middle of the twentieth century.[2] Interpretive models emphasizing the ways that cultural knowledge emerges across a wide range of spheres might, in fact, offer us some salient wisdom in facing our current global crises; it will take both imagination and empirical data to solve the issues involved in climate change, for instance.

Foundational to our project is the acknowledgement that art and science are not tightly compartmentalized, separate spheres but rather loosely framed practices and knowledges that emerge from shared

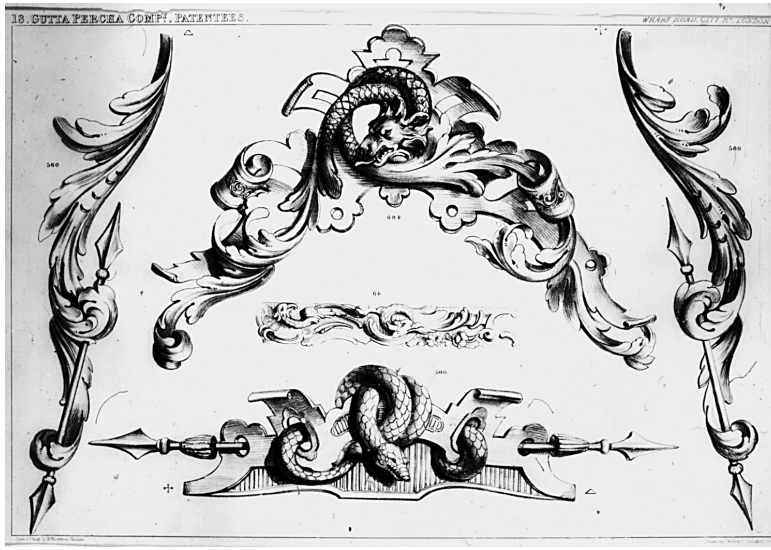

Fig. I.1. Hawkins's ornamental serpent designs reveal his close study of natural history. Benjamin Waterhouse Hawkins, *Decorative Motif in the Form of a Serpent.* Reprinted from *Gutta Percha Company's Pattern Book of Ornaments for the Use of the Trade* (London: Gutta Percha Works, 1850).

beliefs circulating in a society.[3] As Gowan Dawson and Sally Shuttleworth remind us, the same "metaphors, themes, images, and ideological orientations" inform poetry and science; in other words, like science, art and literature are both social products that manifest from and in turn produce the epistemological possibilities at play in any given moment in history.[4] Science does not remain objective, timeless, universal, and stateless while art gets to be imaginative, subjective, and culturally constituted; science is not the straight man to art's funky and unpredictable comedian. In the helpful characterization of Caroline A. Jones and Peter Galison, "neither practice has unique absolute purchase on 'reality,' and neither is as alienated from history as its rhetoric may imply."[5]

The story of one individual serves to illustrate the inseparability of artistic and scientific identities in the Victorian period. Around 1850, naturalist Charles Darwin wrote to Benjamin Waterhouse Hawkins, who had illustrated fish and reptiles for two volumes of *The Zoology of the Voyage of HMS Beagle* (1838–43): "Dear Sir, I have much pleasure in sending my testimony to your skill as an artist . . . , and in several departments in Natural History."[6] The unproblematic promotion of the same man as both scientist and artist suggests the compatibility of these roles in the Victorian period. A fellow of the Linnean and the Geological

Societies and a member of the Society of Arts, Hawkins also received recommendations from Royal Academicians John Rogers Herbert and the vice-president of the Zoological Society William Yarrell. Hawkins, a clubbable sort with a penchant for dramatically illustrated lectures and a gift for public relations, exemplified the possibilities open to Victorian men in possession of both empirical knowledge and artistic skills. He found work in both Britain and the United States due to the shared currency of artistic and scientific thought between the two countries, as well as to their comparable institutional structures. Combining his understanding of sculptural technique acquired from his academically trained teacher, William Behnes, with his natural history and geological knowledge gleaned largely from self-study, Hawkins's projects exemplify the type of hybrid forms seen elsewhere in this book.[7] Hawkins also deployed art to persuade, either in the service of commerce or to direct public opinion regarding scientific and social debates. In designs for the pattern book of the Gutta Percha Company, which fabricated objects from a recently isolated rubberlike material from Malaysian trees, for example, he drew snakes and other creatures featured in mass-produced moldings and decorative elements (see fig. I.1).

In this way Hawkins promoted through his art a new industrial material brought to England by a botanist and a doctor in 1843 and further refined by English scientists of the Joint Committee for Chemistry, Colonies and Trade.[8] Likewise, when commissioned by the planners of the 1854 Sydenham Crystal Palace Park geology display, who were familiar with his sculptural work from Royal Academy exhibitions, Hawkins realized life-size three-dimensional models of the famous paleontologist Richard Owen's visions, including the megalosaurus (fig. I.2). A boisterous dinner party staged by Hawkins for scientists (including Owen), journalists, and investors in the model of the iguanodon was an inspired promotion for what was essentially the world's first Jurassic Park (although Hawkins's dinosaurs remained inanimate, proliferating cartoons and anecdotes of mobile and nightmarish monsters threatening visitors, who sometimes stole their teeth as souvenirs, suggested otherwise).[9] Renowned for his accomplishments at Sydenham, Hawkins next designed a hadrosaur with Joseph Leidy of Philadelphia's Academy of Natural Sciences and then another dinosaur display for Central Park in New York (where it still lies buried, according to popular accounts).[10] These splendid models, undertaken in concert with men on different continents holding differing opinions about evolution and extinction, assured the visibility of both the debate and the debaters. While Leidy supported Darwin's theory of natural selection leading to evolution, Owen rooted his own mechanism for evolution in divine creation.[11]

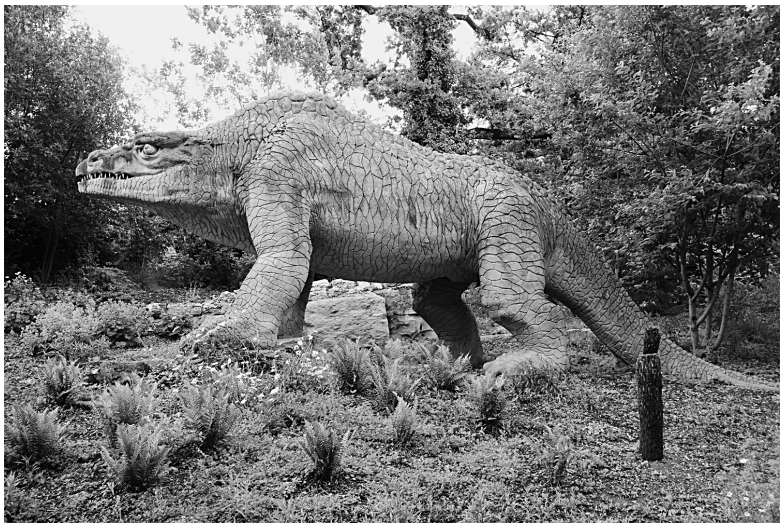

Fig. I.2. Working with paleontologist Richard Owen, Hawkins created the first "Jurassic Park" of life-size dinosaur reconstructions. Benjamin Waterhouse Hawkins, *Megalosaurus.* Concrete, iron, rock, pigment. Sydenham Crystal Palace, London, 1854. Credit: Chris Sampson, Wikimedia Commons.

As a scientist-artist, Hawkins could also design illustrations to express his opinions on the scientific debates of the period. A plate in his 1860 *Comparative Anatomy as Applied to the Purposes of the Artist* (fig. I.3), portraying a white man clasping the hand of a deferential African, simultaneously evoked the iconic "handshake moment" of history painting (suggesting a treaty or agreement) and refuted Darwinian claims about the evolution of man from apes, thereby entering the fray of the acrimonious public dispute between Owen and the biologist Thomas Henry Huxley, "Darwin's bulldog." In the text accompanying the plates, Hawkins emphasized that artists should use these "graphic illustrations . . . to contradict degrading theories in support of the fallacy of the Darwinian Paradox" and his diagram of the various primate species grouped together in harmony was intended to display their fixity rather than their evolution from beast to man.[12] With the central handshake, the Black and white figures appear to accept their positions as no. 2 and no. 1 in Hawkins' hierarchy. In another diagram (fig. I.4), Hawkins represented his interest in the divinely ordained (rather than evolving) hierarchy of man over animal—and of white over black races—by depicting, in skeletal form, a tableau of a standing and a kneeling figure that we can identify only through iconography: The chains and beseeching gesture of the skeleton on the right are part of a large catalogue of abolitionist imagery that worked to

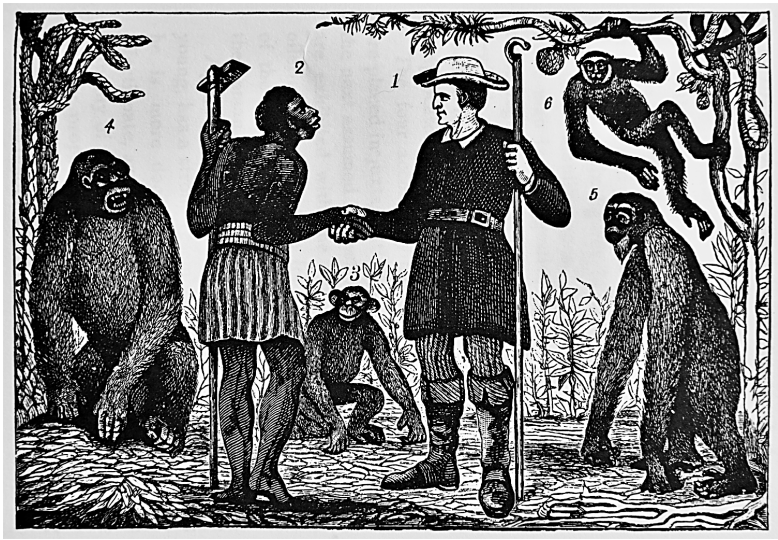

Fig. I.3. By placing the human figures in a numbered array of primates, Hawkins indicated his support for the belief in a divine, rather than evolutionary, natural history hierarchy with white man at its top. *Plate 2*, in Benjamin Waterhouse Hawkins, *Comparative Anatomy as Applied to the Purposes of the Artist*, ed. George Wallis (London: Winsor and Newton, 1860).

Fig. I.4. Based on a long history of Black figures kneeling before white men, including the Wedgwood Slave Medallion, Waterhouse's ostensibly empirical anatomical rendering is in reality heavily charged with racial meanings. Detail, *Plate 1*, in Benjamin Waterhouse Hawkins, *Comparative Anatomy as Applied to the Purposes of the Artist*, ed. George Wallis (London: Winsor and Newton, 1860).

assert and maintain the superiority of the white man, most influential of which was the medallion crafted by Josiah Wedgwood in 1787 in which the image was inscribed "Am I Not a Man and a Brother?"[13] The fact that racist comparative anatomy was taught to artists is yet another example of the inextricability of the arts and the sciences at this time.

Hawkins's plates, then, demonstrate the complex interweaving of the codes of art and of science in this period. They demonstrate that one man could skillfully deploy art as a weapon in scientific debate, on the one hand, while bringing keen empirical observation to the arts, on the other. Royal Academician Henry Stacy Marks's painting *Science Is Measurement* (plate 1) occasioned unusual scrutiny upon its exhibition at the Royal Academy in 1879, due to just this overt assertion of the relationships between art and science. Portraying a scholar-gentleman in an eighteenth-century periwig and knee-breeches, pencil in mouth and notebook and tape measure in hand, gravely evaluating a skeleton of a stork, the painting was important enough to be selected for Marks's "diploma picture."[14]

Despite the fact that the painting was set about one hundred years prior to its production, the critic for the *Leisure Hour* understood the piece as a paradigmatic and celebratory image of the modern era, proclaiming that it rose to a category of those rare artworks that became "typical representatives of the period of their production." The picture constituted "a doctrine of our more recent times" for making the case that "good could come of measurement applied to organisms, that life and mind and social phenomena could by any possibility be subject to laws, and that these laws could be discovered and made useful to man." Its primary contribution was in its acknowledgement that the biological kingdom had become newly subject to the type of empirical investigation previously reserved for the inanimate world, and that mysteries of organic forms could now be rendered transparent and rational. Everything, art included, now fell under the purview of the coherently calculable: "All art, which is in truth nothing but applied science, depends likewise on measurement."[15]

Marks, though, seems to add a question mark to his positivist title through the puzzled standoff between the stork skeleton and the ornithologist; although the scientist deploys the analytical gaze of the experimental observer, he appears to pause in confusion at what he sees. Moreover, his wig and knee-breeches make the scientist appear quaintly old-fashioned for those not immediately inclined to associate eighteenth-century dress with Enlightenment empiricism. What, in fact, *was* science, if not measurement?[16] For nineteenth-century thinkers and practitioners, and for Marks himself, it was, to a degree, art.

The Nineteenth Century

As we learn from the foundational scholarship of Bernard Lightman, the nineteenth century offers some distinctive contributions to the student of the history of science. A number of significant discoveries in the sciences coincided with an expanding middle class and the rise of commodity production and consumer culture, while a receptive and engaged public eager for entertainment and education in a range of fields drove the proliferation of publications in both science and art. Before scientific knowledge became too arcane for a general audience, journals routinely assumed an educated readership thoroughly absorbed by the cutting-edge debates of the day.[17] The new medium of industrial printing expanded print culture, allowing for cheaper editions of theoretical texts and the spread of debated ideas.[18] Lightman's *Victorian Popularizers of Science* demonstrates that we must look beyond the work of canonical scientific figures of the period to identify and understand the widely varying beliefs of the new middle-class consumers of science, a subject that became both education and entertainment in a remarkably wide range of locations beyond the predictable lecture halls, periodicals, and libraries, including churches, artist's studios, shipyards, and zoos. In an era in which "the lines delineating science from spectacle had not been drawn," scientific display was as likely to be found under the oversight of showmen as in the care of learned dons. To comprehend the complex domains of Victorian science, it is also necessary, as Lightman notes, to explore the discourses and practices of marginalized groups, such as women, people of color, and the working classes, as well as those of alternative sciences such as phrenology or psychical research.[19]

From 1851, the year of the Great Exhibition at the Crystal Palace in London, World's Fairs became important sites for the display and dissemination of new information, and there were countless such locations in London alone, such as the Adelaide Gallery (1832), the Polytechnic Institution (1838), or the Royal Institution (1799).[20] Networks of scientific communication stretched across the Atlantic between individuals and institutions, even as American naturalists fought for acknowledgement as the experts on their own continent.[21] As natural history collections increasingly moved into dedicated spaces, Philadelphia's Academy of Natural Sciences (1812) and the American Natural History Society in New York (1869), followed by London's Natural History Museum in 1881.[22] By 1870 there were 125 scientific societies in Britain and Ireland, including the Royal Astronomical Society (1820), the Institute of Chemistry of Great Britain (1877), and the Geological Society of London (1807).[23] In the United States, the American Association for the Advancement of

Science was formed in 1848, followed by the National Academy of Sciences in 1863.[24]

Like the world of science, the art world became similarly institutionalized and ordered into hierarchies of educational, exhibition, and sales venues. The American Academy of Fine Arts (1802) and the National Academy of Design (1825) in New York and the Pennsylvania Academy of Fine Arts in Philadelphia (1805) were three of the most prominent organizations in the United States, while British art was dominated by the Royal Academy in London (1768).[25] Public art collections expanded in number, scope, and access, prominent among them being the National Gallery in London (1824), the Boston Museum of Fine Arts (1870), the Metropolitan Museum of Art in New York (1872), and the Pennsylvania Museum and School of Industrial Art (1876).[26]

While art and natural history began to be separated in the Enlightenment, they retained connections not fully severed until the twentieth century, if indeed this rupture was ever fully completed. Many scholars have traced the history of both scientific and art display in tandem with changing cultural norms and shifts in how knowledge was organized, particularly the move from *Kunstkammer* (cabinet of curiosities) to museum.[27] Such a scholarly turn of course follows in the wake of *The Order of Things* (*Les mots et les choses*), in which Michel Foucault proposed the concept of the "episteme," a slippery and shifting amalgam of discourses, constructions, institutions, orderings of knowledge, and ideologies that produce conditions of knowing in a given period. Thinking with Foucault illuminates how in fact the arts and the sciences not only can but should be seen as tightly interconnected and cross-fertilizing—as, to use the words of Jones and Galison, "regimes of knowledge, embedded in, but also constitutive of, the broader cultures they inhabit."[28]

Tony Bennett cites Krzysztof Pomian's argument that the fact that cabinets of curiosities gave way to natural history collections points to changing epistemes; focusing on the exceptional or curious object, one that inspired wonder, was well suited to the medieval and early modern worldview in which the notion of seeking for laws in nature was alien: the unique could therefore be exemplary.[29] During the Enlightenment, however, rational logical order, classification, connection and organization became governing principles, pushing art and natural history asunder while retaining less visible threads of attachment.[30] The rise of the scientific focus on the category or type—as opposed to the unique individual or specimen—accompanied the elevation of "objectivity" into an essential scientific moral quality.[31] At the same time, the mutual relationship between artistic and scientific practices continued in a range of practices, however; as Sally Gregory Kohlstedt has found, for instance,

natural history illustrations fed into arrangements of specimens, which in turn sometimes were copied by artists.[32]

As science developed, an emphasis on categories of rational classification led to the rise of new disciplines; the Victorian period saw the burgeoning of psychology, chemistry, physics, and many other fields. The term *scientist* was itself a nineteenth-century word, deployed first in 1834 by William Whewell, and it remained a fluid term until later in the century.[33] Dramatic advances drove confidence about the potential ordering and taming of the world through the sheer power and scope of reason, and the list of momentous and transformative discoveries occurring over a very short period of time is formidable. The universe became vaster but more crowded through advances allowing for astronomical observation and calculation, which in turn produced theories such as Whewell's nebular hypothesis imagining the creation of the planets and stars. Simultaneously, our environment grew ever more populated by the invisibly tiny: forty-nine new elements were discovered in the nineteenth century, and the development of the model of the atom as the smallest particle in the universe by John Dalton (1808) was modified at the end of the century by J. J. Thomson's discernment of a subatomic particle, the electron, in 1896.[34] From the mid-eighteenth century chemists proved the idea of the conservation of mass, the principle that nothing could be created or destroyed, followed by the formulation of the law of the conservation of energy.[35] Meanwhile, changing the face of medicine were John Snow's and Louis Pasteur's proof of the germ theory (1850s) for the transmission of disease, along with the deployment of chloroform during surgery (1847) and Joseph Lister's successes with antisepsis (1867).[36]

Even more paradigm-shattering were Charles Darwin's proposals regarding evolution and natural and sexual selection, which radically reoriented many fields, from theology to zoology to sociology, and participated in the gradual relocation of humankind away from its long-accepted position at the center of the universe. People increasingly belonged to the realm of the animal; biology had now "boldly entered the precincts of man's own and special order," as Andrew Wilson, a Scottish follower of Darwin, asserted in 1883.[37] In the wake of German scientists' contributions to the visualization of the workings of the cell and its components in the middle of the century, there blossomed a newly acute sense of the kindred relationship between all living things, based on the concept of protoplasm. Producing such visions as Huxley's fantasy of the transubstantiation of a man into a lobster, an imaginative investment in the exciting idea that there was one common substance shared by all organic creatures refashioned the order of the world.[38] Even plants could become cousins: as Wilson remarked, "the last decade

of science has certainly tended to raise the plant as a living, and moreover as a sympathetic and active being."[39]

In light of—and contributing to—the radical changes in structures of belief, traditional attitudes began to crumble. Nature was increasingly perceived as a comprehensible united system rather than an amorphous force inimical to human beings.[40] A view of scientific progress as a gradual mastery of the world also both allowed for and was part of the development of technologies of power deployed to subordinate and discipline all that fell under the category of "nature," relative to the human sphere of "culture." The normalization of values that instrumentalized the natural world in turn served and was served by the growing system of industrial capitalism, reminding us that any definition of nature is itself a product of culture with its own history.[41] Propelled by their growing economies, expanding empires indelibly marked the globe, generating encounters between peoples, species, plants, cultures, and knowledges, which in turn required cataloguing and recording. Indeed, the centralized concentration of raw materials brought together from the far reaches of the earth formed important laboratories. As Julia Voss has concluded, for example, it was Darwin's experience with the extraordinary accumulation of specimens in the British Museum that set him on the path to grasping the mechanisms behind the infinite variety of life.[42]

At the same time that imperial institutions and practices certainly contributed to knowledge, then, the dark side of empire and colonization produced systematic oppression and exploitation of people, animals, and lands, as Rachael DeLue tells us in her essay in this volume—as well as, of course, scientific racism. Art, too, must be situated in all of these contexts.

Victorian Science and Art

The two fields under consideration in this volume are, then, profoundly interconnected. Most obviously, perhaps—certainly to Marks's depicted naturalist—artists and scientists both invested heavily in the faculty of sight.[43] The scientific gaze was an ostensibly objective form of looking increasingly shared by artists who, especially after the forcefully expressed artistic directives of the prominent cultural critic John Ruskin, began to practice close observation of the natural world. Ruskin advocated seeing rather than analyzing: "Do not think, by learning the nature or structure of a thing, that you can learn to draw it," he instructed, continuing, "To draw a man, a flower or a mountain" can be accomplished "only by looking at them; not by cutting them to pieces."[44] Countless scholars have observed the connection between vision, knowledge, and empiricism.[45]

Such a dependence on sight was paradoxically countered by an increasing doubt about the reliability of this sense. Vision, as we have learned, is both flawed and culturally constructed.[46] Feminist and postcolonial theorists have drawn attention to the ways in which the dominance of sight related to rational or scientific knowledge is "phallocentric, colonialist, and calculating," debased by exploitative and oppressive urges.[47] From the Renaissance, the development of one-point perspective, an artistic system for representing three dimensions in two that was perfected in the academic art of the nineteenth century, contributed to the notion that space was generated from the gaze of an omniscient beholder, rigidly defining the gaze as objective, mappable, and immobile. As has been well rehearsed in art history and visual culture, Hal Foster's foundational concept of "visuality"—later defined by historian of science Klaus Hentschel as a "variegated bundle of social factors involved in the process of seeing"—shows us that the optical entertainments and scientific instruments produced by a culture work as models for concepts of vision's function, producing socially contingent "scopic regimes" or "visual regimes."[48]

Art historians have long traced vision as historically conditioned.[49] More recently, Jonathan Crary, Christopher Otter, and others have generatively examined the historiography of the viewer, tracing how the Renaissance model of an objective eye passively reflecting the world had, by the nineteenth century, shifted to one in which vision was embodied and subjective, dependent on the responses of individual sensoria.[50] The discovery of binocular vision proved that sight was processed in the brain, and the phenomenon of after-images likewise demonstrated the extent to which it could be subject to misprision; by the mid-nineteenth century physicist Hermann von Helmholtz's experiments had definitively demonstrated the unreliability of the eye. Vision became less a universal, objective function and more an embodied, individualized experience; perception was, in Crary's words, transferred to "the thickness of the body."[51]

In chapters 4 and 7 in this volume, respectively, I and Barbara Larson take up these issues in the context of the study of hallucinations and optical physiology. The fact that our vision is not to be trusted, as Barbara Stafford notes, in turn informed anxious or dismissive responses to the image itself: "Visual evidence [came to be seen as] synonymous with legerdemain."[52] The denigration of the visual arguably continues in our time, a situation in which the contributors to this volume make an intervention through the vigorous assertion of the unique work performed by art and visual culture.

Ways of representing linked to ways of knowing, which in turn generated frameworks of power and control. Svetlana Alpers's *Art of*

Describing famously relates the Dutch seventeenth-century capitalist focus on possession of objects and land to acutely observed and obsessively rendered surfaces of their art.[53] Ann Shelby Blum follows Alpers to observe that the detailed, descriptive, mapping style of northern art was intertwined with—both produced and produced by—"the empirical agenda of scientific revolution."[54] And, as Daniela Bleichmar further suggests, the project of making visible was intimately bound up in making "imperial nature moveable, knowable, and ideally, governable."[55] Images allowed for notional possession.

With all due respect to Ruskin and Alpers, in the nineteenth century the dominant regime of knowing came increasingly to be based on the probing of invisible interiors rather than visible surfaces. New technologies such as X-rays retooled cognition to imagine what lay beneath, and in turn to conquer those depths.[56] For nineteenth-century scientists, such scientifically generated images became bound up in the pursuit of the holy grail of "objectivity," as Lorraine Daston and Peter Galison famously articulated: "The image, standard bearer of objectivity, is inextricably tied to a relentless search to replace individual volition and discretion in depiction by the invariable routines of mechanical reproduction."[57]

As Naomi Slipp recounts in chapter 5 of this volume, Foucault's analysis of the history of medicine found that patients were increasingly diagnosed by internal signs apparent only to the trained physician, rather than by external symptoms. Such a pattern corresponds with Foucault's larger argument that nineteenth-century science moved away from classification by visible markers to more arbitrary links based on abstractions. In her chapter on photographs of early operations on etherized patients demonstrating both the effects of the drug and the lack of pain, Slipp addresses the challenges of representing these invisible truths.

Indeed, the invisible—and the need to make visible—drove much science and art in this period, as we find also in my own essay on the ghostly and DeLue's chapter exploring the representation of the subterranean. "Imponderable matter," an etheric unmeasurable force or substance, became a leading subject for scientific scrutiny and experiment, sweeping up other practices such as mesmerism and spiritualism.[58] Some scholars have attributed the new concentration on the invisible as a response to the proliferation of things in the Victorian mass-produced, overstuffed world. Alice Jenkins, for example, points to a "profoundly dematerializing tendency in nineteenth-century physical science."[59] Observing this dissolving, dissipating materiality, Pre-Raphaelite associate John Tupper wrote a facetious poem titled "Progress of the Species," about the newly and disturbingly invisible. Citing "galvanism, and mesmerism,

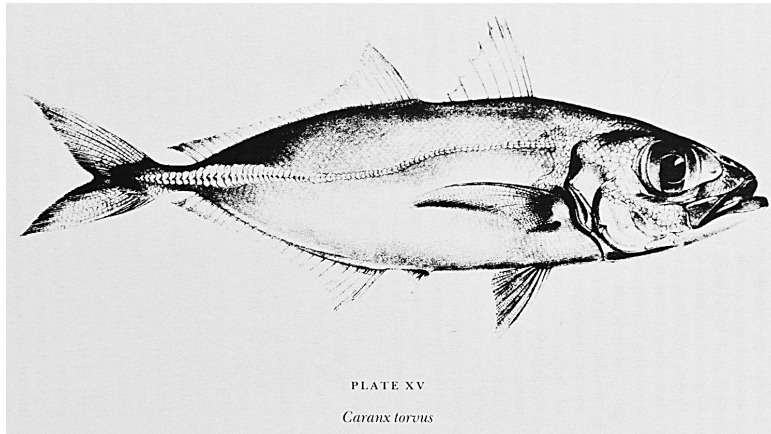

Fig. I.5. Hawkins produced the illustrations for Darwin's volume on fish by relying on a combination of careful observation of specimens and creative rendering. Benjamin Waterhouse Hawkins, *Goggle Eyed Scad*, engraving, plate 15 in Charles Darwin, ed., *Voyage of H.M.S. Beagle, Part 4 (Fish)* (London: Smith, Elder, 1840–1842).

and steam, / And gas, and anæsthetics!" as well as photography, Tupper suggested the ways in which Victorians were faced with disappearing things, exclaiming, "Dear man, you must have hated tangibles."[60]

Many of the images in this book, such as Southworth & Hawes's daguerreotypes (see figs. 5.1, 5.2, 5.4) or Joseph Maclise's anatomical drawings (see plate 5; figs. 6.1, 6.3, 6.5), demonstrate the overlaps and blurred boundaries between what was at the time understood as a subjective artistic practice and the objective, mechanical and documentary mode used by the sciences; between realism and classicism; and between scientific "objectivity" and nineteenth-century academicism. To produce the illustration of the delightfully dubbed "goggle-eyed scad" (fig. I.5) for Darwin, for instance, Hawkins first worked from preserved specimens to create an outline, which was approved by a zoologist; Hawkins then detailed the rendering on his own and copied the result to a lithography stone.[61] Imagination often complemented data and dry facts, as Martin J. S. Rudwick reminds us in *Scenes from Deep Time: Early Pictorial Representations of the Pre-historic World*. To recreate models of "antediluvian monsters" from—in some cases—extremely partial fossil evidence for the Crystal Palace Park at Sydenham, Hawkins drew on historically embedded artistic conventions used to illustrate deep time. In the "intersection of two traditions," dinosaurs were born.[62]

Some writers insisted that science itself was a source of imaginative inspiration, as did, for instance, influential early psychiatrist Henry

Maudsley, who declared, "No, science has not destroyed poetry, nor expelled the Divine from nature, but has furnished the materials, and given the presages, of a higher poetry and a mightier philosophy than the world has yet seen."[63] Likewise, John Tyndall maintained that scientists as diverse as Darwin, Isaac Newton, and Michael Faraday understood that "nourished by knowledge patiently won; bounded and conditioned by cooperant Reason, Imagination becomes the mightiest instrument of the physical discoverer."[64]

As scholars have demonstrated, however, others feared the world would become depleted of its mystery given too great an understanding of its mechanisms.[65] As a way of reenchanting subjects that seemed to have been rendered dull and bare through too much analysis, some nineteenth-century writers viewed science as sharing origins, models, and publics with the magical and supernatural. In fact, much recent writing has tracked the interconnection and inseparability of magic and science in this period, at a time when the pursuit of inexplicable phenomena could just as easily send investigators down paths that today might be dismissed as pseudoscience as on trails that ended in transformative empirical discoveries. As I discuss in chapter 4 in this volume, spiritualism and psychology were closely connected; physiologist and antispiritualist William Carpenter acknowledged that contemporary technological feats such as the Atlantic telegraphic cable strained the bounds of credulity in their seeming miraculousness.[66] Public educational spectacles often took on aspects of magicians' showmanship, as in the demonstration of the necessity of oxygen for respiration through the removal of air from a glass vessel in which a fluttering bird demonstrated a corresponding distress.[67]

Science and art also shared certain assumptions propelling their practices and pedagogy. Both participated in the nineteenth-century quest for universal principles uniting many complex, seemingly separate phenomena. Heat, light, electricity, magnetism, and gravity, for instance, were now understood as different manifestations of the same force. A drive toward wholeness marked many publications of the period, such as Alexander von Humboldt's influential *Kosmos* (1845), as scholars sought a single sublime law to explain the functions of the universe.[68] In the new world of Victorian matter, the same rules applied to the macro and the micro, making the minute or the detail itself a whole world, one that fulfilled, albeit in an empirical mode, the Romantic promise of William Blake "to see a world in a grain of sand / and a heaven in a wildflower."[69] "Though conversant with the minute forms of things," chemist Humphry Davy remarked concerning modern thinkers in 1830, "they have for their ultimate end the great and magnificent objects of nature.

They regard the formation of a crystal, the structure of a pebble, the nature of a clay or earth; and they apply to the causes of the diversity of our mountain chains, the appearance of the winds, thunder-storms, meteors, the earthquake, the volcano, and all those phenomena which offer the most striking images to the poet and the painter."[70] Confidence in the human ability to lay bare all spheres of existence through the intelligibility of laws applicable on the scale of both the pebble and the volcano was a hallmark of the Victorian ideology of progress. Human capacity to perceive expanded into the infinite space of the universe, on the one hand, and the impossibly tiny world of the atom and the subatomic particle, on the other.[71]

Nature, then, became a unity in which each part was vitally interrelated with all others. In chemistry, for instance, determining the relation of parts to the whole arose as a dominant experimental mechanism, allowing chemists to embrace perpetual change in the framework of constancy.[72] This was also true in other fields, such as medicine and anatomy; Galenic practice had treated the whole person, but increasingly the body became a system first of interrelated parts and then, eventually, of individual cells. As anatomist Joseph Maclise, discussed in Keren Hammerschlag's chapter in this volume, pronounced, "The womb of anatomical science is pregnant of the true interpretation of the law of *unity in variety*."[73]

The nineteenth-century tendency to establish unities and continuities, in a quest for single great laws to comprehend all the functions of the universe, corresponded to the aesthetic doctrines of the day, which advocated above all for unity and harmony. As in nature, all parts of an artwork should relate to the whole; Ruskin inimitably intoned: "A pure or holy state of anything . . . is that in which all parts are consistent. The highest or organic purities are composed of many elements in an entirely helpful state. The highest and first law of the universe, and the other name of life, is, therefore, 'help.' The other name of death is 'separation.' Government and cooperation are in all things, and eternally the laws of life; anarchy and competition eternally, and in all things, the laws of death."[74] That is, all parts should contribute to the whole. Such a grandiose set of claims helps us realize the seriousness and complex interrelationship of aesthetics and political and social structures in this period. For Ruskin, socialism generated vitality, while capitalist competition (or Darwin's and sociologist Herbert Spencer's survival of the fittest) was fatal for the social organism. Drawing manuals repeatedly characterized the aesthetic goals of variety in unity, coloration, lighting, and expression, signaling the operation of an epistemological framework extending across spheres of science and art. Yet, as one advised:

> This variety must not run riot, and be introduced merely for its own sake, but under certain circumstances and relationships, so as to allow—or, perhaps, rather to suggest—the idea of Unity. This idea of Unity, or oneness, which is the subordination of all the parts to the completeness of the whole is . . . essential in a work of pictorial art. We find it, like a cord, running through and tying together all nature; and it seems to have been a divine idea in the creation of all things, binding organic forms, from the highest to the lowest, into one complete cycle.[75]

As suggested even in art instruction, then, the Victorian era was a period of a complete reconsideration of the categories of matter and form, body and mind, and body and spirit. In the wake of German philosopher Immanuel Kant, British philosophers, physiologists, and psychologists shared a common preoccupation with solving the age-old debate over whether there was a world apart from the mind's perceptions. Materialists insisted that things existed regardless of the presence of human beings to perceive them, while idealists argued that there was no reality outside of human perception. Huxley neatly formulated one solution relevant to both artists and scientists: "In itself it is of little moment whether we express the phenomena of matter in terms of spirit, or the phenomena of spirit in terms of matter; matter may be regarded as a form of thought; thought may be regarded as a property of matter."[76] Art critic Philip Gilbert Hamerton could therefore similarly argue that "artistic aesthesis is rooted in physical sensation."[77] The materiality of artworks themselves was therefore newly relevant, Hamerton observed: "In the Graphic Arts you cannot get rid of matter. Every drawing is *in* a substance and on a substance. Every substance used in drawing has its own special and peculiar relations both to nature and to the human mind."[78]

The place of the material body in the nineteenth century, however, was famously vexed. Dawson's work on the "Fleshly School" of poetry, a moniker coined in 1871 by a critic hostile to the sensual verse of Dante Gabriel Rossetti, Algernon Charles Swinburne, and others, demonstrates the extent to which the experience of the senses might be read through an ethical lens that could equate materialism with atheism.[79] Larson astutely points out connections between Rossetti's first "fleshly painting" of 1859 and Darwin's *On the Origin of Species*, noting that the so-called New Painting, or aestheticism, with its disinterest in moral truth twinned with an engagement in material pleasures, took on the same position in its field as materialist, apparently godless evolutionists marked out in theirs. Elsewhere in her work on the Victorian understanding of the body's relationship with its environment, Larson draws on German philosopher Robert Vischer's idea of empathy relating

to vibrations of the nerves caused by our sensory engagement with objects.[80] For decades now, readings of the novel, from D. A. Miller's *The Novel and the Police* (1988) to Nicholas Dames's *Physiology of the Novel* (2007), have likewise been based on understanding the way in which the sensations produced by certain types of prose engage the physiology of the reader.[81]

This type of interpretive gambit, based on interlaced discourses of humanities and science, seems uniquely suited to illuminating this period of radical change. Literary critic Katherine Boehm notes how industrialization, paired with discoveries in physiology, encouraged a collapse of subject/object relationships, in which "subjects and objects constitute one another in a relationship characterized by 'reversibility' and 'intertwining'"; she cites Maurice Merleau-Ponty's contention that the body "is double-belongingness to the order of the 'object' and to the order of the 'subject.'"[82] The subject was reconfigured, becoming so interconnected with its environment that boundaries of selfhood could break down. Similarly, just at this time, the turn toward "Brunoism" in medicine, a practice named for the Scottish physician John Brown, insisted that "the body was the site of active interchange of forces with the external world."[83] Comprehending the body's shifting definitions and boundaries in the nineteenth century is instrumental in shaping theories regarding the intersection of representation and knowledge.

Methods for Histories of Art and Science

Until recently the interpretation of Victorian culture in light of the science of the period has largely emerged from the minds of literary critics and historians of science; this volume, in contrast and in complement, makes a case for its distinctive foregrounding of the practices, tools and contributions of art history. Models abound for the challenging project of interdisciplinary treatment of humanities fields and science, and this book is therefore in a privileged position in the wake of exceptional and wide-ranging academic work.

A major focus for this blended field has been the way that art was transformed by scientific shifts. Martin Kemp's early work in this area, *The Science of Art* (1990), concentrated on finding evidence that artists were drawing on scientific practices or knowledges. Kemp, like others, used the methodological approach of intellectual history largely adopted by historians of science by tracing personal networks, libraries, accounts of processes or intentions, and communities of practice and reception.[84] Scholars of this bent often attempt to establish the monodirectional impact of one discipline or set of ideas on another; for example, Phillip Prodger argues that Darwin "forever changed the way pictures

are seen and made," extending a "decisive influence on the history of art."[85] Darwinian theory in particular has indeed proved a fertile area to consider regarding its consequences on visual culture, and in the last decade, several exhibitions and their catalogues have demonstrated a range of ways artists deliberately drew on concepts such as the survival of the fittest in ways that allowed them to disrupt conventional knowledges.[86]

Many direct responses by artists to innovations in thought and materials are indeed visible in the historical record. After the discovery and isolation of magnesium came the development of efficient and effective flash photography, for instance.[87] Quick to take up new pigments produced by innovations and experiments in chemistry, Joseph Mallord William Turner and the Pre-Raphaelites altered the face of British art.[88] Some nineteenth-century artists believed that aesthetics were generated by natural laws; optical experiments and color theory produced the concept of complementary colors and also yielded new meanings for pigments, which could now convey emotional or symbolic qualities.[89] A scientific basis emerged for imaginative interpretations of the world and of art, such as the anthropomorphizing ideas of the poet, novelist, and natural historian Johann Wolfgang von Goethe, who argued that blue was cold and male, yellow warm and female.[90]

More recently, cultural historians have moved away from the practice of uncovering precise proof regarding the influence of science on art to draw instead on models such as intersection or association. In his study of the Pre-Raphaelites, for instance, John Holmes is not concerned with retrieving historical records of the exact knowledge possessed by these artists; instead, as he notes, "we don't know what they knew but we can be sure of the significance and visibility of science within the wider culture of the 1840s and 50s."[91] He finds both direct and indirect evidence for the Pre-Raphaelites' incorporation of empirical discoveries, and, in turn, argues that "Pre-Raphaelitism came to be the visual language of science" via the architecture of the University Museum at Oxford and the Natural History Museum in London.[92] In another relevant volume, *Nature's Truth: Photography, Painting, and Science in Victorian Britain*, Anne Helmreich asserts that at the core of her project is the belief that "artworks can be persuasively *associated with* changes in nineteenth-century paradigms."[93] This more capacious model allows for art historians to contemplate objects rather than biographies, meaning rather than means of production. Matthew C. Hunter's *Wicked Intelligence: Visual Art and the Science of Experiment in Restoration London* offers an especially sophisticated model for parsing the interrelationships of emergent "experimentalist" and artistic communities in early modern

Britain, reading the ways in which the "didactic dimensions" of texts like Robert Hooke's *Micrographia* "are embedded in form and content alike." Hunter examines "how scientific images turn out to be scientific objects and vice versa." Rather than mere "illustrations or models," diagrams, drawings, and other images are "the residue of actual thought processes" that "reveal what it was to think through scientific questions because it was itself part of the thought."[94] From an art historian's perspective, likewise, we can see how certain paintings are only possible in the wake of altered scientific paradigms. Martin Meisel and Michel Serres, for instance, have both considered Turner's amorphous energetic vortexes of paint in relation to how the "science of heat based on the study of energy and entropy led to new channels of thought and feeling."[95]

One reason for the relative paucity of any serious analysis of scientific imagery is that science itself has only recently embraced the image, having suffered both from a fundamental distrust of the reliability of the visual and, paradoxically, from an overinvestment in its transparency.[96] Citing Steve Woolgar's *Science: The Very Idea*, visual sociologist Luc Pauwels notes that the act of representation itself is linked to the idea that "there are, or were, discrete objects 'out there' that exist independently of our perception . . . [they are then] reflected *truthfully* through various forms of representational devices."[97] The belief that the eyeball simply recorded what it saw, Blum relates, allowed for the "confidence in the possibility of unmediated representation."[98] But, as Pauwels continues, this is never possible: "There is no state in which things are perceived in an unbiased form."[99] Scientific imagery is therefore never about reproducing reality.[100] Similarly, Bruno Latour observes that for many, illustrations in a scientific text "are the world itself," so that "to call them image, inscription, representation, to have them exposed in an exhibition" is to reveal them as fabricated.[101] Visual culturists like Pauwels remind us that the "issue of *representation* touches upon the very essence of all scientific activity": "What is known and passed on as science is the result of a series of representational practices."[102]

While historians of science originally shared their field of study's initial disdain for images, neglecting to attend to them with much sensitivity, this is no longer the case.[103] Alex Pang helpfully summarized the state of this field in 1997, citing Bernard Smith's *Imagining the Pacific: European Vision and the South Pacific* (1959) as an exemplary account of how the scientific renderings of the artists who accompanied explorer James Cook dramatized connections between the climate and the ecology.[104] As noted, the foundational work of Daston and Galison established the importance of image-producing recording devices in the march toward ostensibly "objective" experiments.[105] Pang's project, however, is

ultimately concerned with contributing to and explaining the history of science, producing a "more detailed and complete picture of how scientific practices and ideas work," rather than interpreting art.[106]

It is crucial, then, to bring art historians' methods to the field of the history of science, considering the medium and the formal elements of scientific imagery. Ann Shteir and Bernard Lightman engage in some of the most comprehensive thinking about the intersections between history of science and history of art in their introduction to *Figuring It Out: Science, Gender and Visual Culture.* They ask, "How can a study of visual features help us to understand better the subtle and complex ways that the modern Western culture of science developed?" while pointing out the pitfalls of too blithe an approach of this kind, noting that "using images to make explicit the often hidden cultural connotations in the work of science is inevitably problematic."[107] Lightman and Shteir observe that the meaning of any given picture is unstable and must be understood in light of the history of its chain of quotations and references, urging the necessity of contextualizing an image in its means and moment of production.[108] Lightman, for instance, notes how the visual and material properties of colorfully illustrated popular science books, particularly those by women, contributed to their particular form of natural history.[109] The goal of scrutinizing the "ornamental, rhetorical, and authoritative use of visual images" is shared by the authors of this volume.[110]

Other writers, including several assembled here, are engaged in considering more general metaphorical or epistemological links between the fields. It is therefore as useful to question the ways in which literary metaphors or artistic forms might have formed scientific thought as it is to discern how scientific concepts produced new literary tropes.[111] Concepts like "transmission," for instance, applied both to social ideas and to natural forces, and the electrical technologies involved in new forms of transmission gave rise to literary metaphors of influence and creativity.[112] Catalyzed by Gillian Beer's pioneering *Darwin's Plots* (1983), science writing has been dissected as literature, often due to its authors' saturation in aesthetic theory—in the case of Darwin, his absorption of the categories of the sublime, the picturesque, and the beautiful was generative for the models he produced, while the variety and changeableness characteristic of the picturesque can be related to his interest in species differentiation.[113]

Voss suggests that Darwin's own drawings—as well as the images that appeared in his publications—made meaning in specific ways related to their visual forms. Observing that scientists in search of methods by which to portray processes that occurred too slowly for measurement

developed new kinds of representations, such as the geological cross section or the series suggestive of embryonic development, Voss finds that geologists' "translation of form and time into a symbolic system of rows, lines, angles, or points opened up space for Darwin to conceptualize his theory of evolution."[114] Blum underscores the fact that scientific illustrations are not only about their depicted subjects but also about the mechanisms by which those subjects were represented on the page.[115]

Art history, with its affinity for form and style, as well as for history, is clearly ideally positioned to contribute to this conversation. While formalism in literary studies has returned to the fold with productive results, it has never left the art historian's tool box.[116] Just as literary historians have produced illuminating new work by evaluating the ways in which Victorian texts drew on the language and forms of science, this collection calls on art historians to probe their subjects in this light. The creative, thoughtful essays here assembled remind us that science and art shared forms, which we see manifest as waves, layers, lines, or geometries; and of course, that both fields invest in the idea of the evolution of form as well as generate surprisingly kindred responses: pain, pleasure, empathy, sympathy, to name just a few. These writers are alert to the work that artistic media themselves do, as for instance in Slipp's analysis of the uncertainties "regarding the purposes and technological limitations of photography" or Larson's interest in the facture of Rossetti's paintings. Moreover, they also take into account the material and experiential contributions of the technologies and empirical disciplines they invoke. This collection, in short, rewrites and regenerates the histories of both science and art.

Art history is clearly a productive partner in this investigation of nineteenth-century science, although its proffered assistance has been often oddly overlooked even in works purporting to be about visual culture. Jonathan Smith rightly admonishes "sociologists and historians" for treating images as if they illustrate an a priori event, text, or object, and, on the other hand, "literary and cultural historians" for ignoring the original contexts of scientific illustrations.[117] Yet, strikingly, he leaves out art historians altogether. Too often images are seen as passive mirrors of preexisting ideas by historians of science.[118]

As Diana Donald reminds us, however, images are in reality "constitutive of meaning, giving form to concepts, perceptions, reflections and emotions that could not be expressed in words."[119] As Barri Gold puts it, "Art, literature and science work *together* to form and reform how we understand the world."[120] Art is active, "working" through its mediations of the world, not merely passively reflecting a truth or reality "out there."

Chapter Synopsis

Crucial to the writers in this collection, then, is clarity regarding interpretive processes, hermeneutic armatures, and methodological goals. These are not essays in the history of science but rather in the history of art; their focus is to illuminate conditions and configurations of knowledge shared by science and art in the nineteenth century. Treating British and American visual culture as they relate in terms of common cultures of science and imagery, the volume contributes to an excitingly expanding way of seeing. The authors assembled here "investigate the dialogical relationship between artists and scientists,"[121] ways in which artists may have been "attuned," to use Alison Syme's word, to the science of the period. Syme examines "tropes that cut across the different contexts and representational regimes with which the illustration engages" with a focus on "the figure of metamorphosis in particular—transformation or translation from one state to another, material, linguistic, or otherwise." George Levine characterizes this practice as an interest in discerning distinctive cultural narratives, a seeking of "how the culture tells stories, that is, imagines its life, subtly informs the way science asks questions, arrives at the theories that reshape the culture that informed them."[122]

In some instances, artworks are interpreted via popular scientific theories (such as Darwinian evolution and sexual selection); other authors investigate how images functioned when read in light of broader contexts of science. Linking the different chapters is a shared attentiveness to the ways in which the visual produced new notions about the place of the human in the natural world during a period of burgeoning theories and discoveries that challenged longstanding boundaries between animal, plant, and human. Artists and scientists studied here both struggled to come to terms with the issues of imperial modernity, in a world in which dawning recognition of entropy and climate change suggested a potential dissolution of the man-centered world order—and even of civilization altogether, as Syme observes.

In chapter 1, "Measuring Native America: Early American Archaeology and the Politics of Time," Rachael DeLue explores the geological underground as a subject for artists and other image makers in the nineteenth century in the United States by exploring how these practitioners confronted the paradox of picturing what exists beneath the earth's visible surface. DeLue illuminates the intellectual and historical stakes of envisioning the subterranean, here understood broadly as a location or space as well as an object, concept, phenomenon, or metaphor, and elucidates a sustained attempt in the nineteenth century to compel images to

take measure of what lies beneath. The intertwined fields of archaeology, paleontology, and geology, she contends, produced new temporal configurations that worked to write Native Americans out of history.

Continuing to mine the geological vein in chapter 2, "'All That Is Solid Melts Into Air': Burne-Jones, Glaciation, and the Matter of History," Syme argues that commercial and glacial allusions in art offer a glimpse of the very material forces that have shaped our natural and cultural histories in a way that resonantly suggests our evaporating futures. In this chapter, Syme contextualizes one of Edward Coley Burne-Jones's illustrations for the Kelmscott Chaucer in terms of nineteenth-century writing on and imaging of glaciers by Ruskin and others, and its depiction of a glassy mountain of inscribed ice in terms of Victorian consumer culture, glassworlds, and celebrity. Blurring the line between nature and culture, the illustration suggests the erosions and reshapings to which human history—as exemplified, made, and marked by its famous men—is subject. Syme contends that the evocative conflation of the geological and historical records in the illustration encapsulates Burne-Jones's concerns about the erosion of history, substance, and meaning in modernity: it pictures the transience of all human words and deeds, the material substrate and visual history of which seemed to be fading at an accelerating rate in the artist's commodified Victorian modernity.

Moving to the surface of the earth, Carey Gibbons considers the process of forecasting the weather during the Victorian period, in chapter 3, "Grasping the Elusive: Victorian Weather Forecasting and Arthur Hughes's Illustrations for George MacDonald's *At the Back of the North Wind*," revealing a similarity between the thought processes and representational techniques developed within the field of meteorology and those employed by Hughes in his illustrations for MacDonald's 1871 novel. The wave expresses a tension between the desire to grasp multiple conditions concurrently and the realization that mental mastery and control are continually challenged by unpredictable, inexplicable forces.

In chapter 4, "A Haunting Picture, in Light of Victorian Science: John Everett Millais's *Speak! Speak!*" a chapter bridging the volume's interests in the physical and biological sciences, I analyze a painting in light of how the Victorian understanding of candle flame related to debates about materialism, human perception, and the nature of reality. Millais's *Speak! Speak!* (1895) takes up these themes in ways that were also shared by contemporary debates in the intertwined fields of chemistry and psychology. I argue that this painting deploys its forms, particularly its light effects, to represent a complex meditation on life, death—including the artist's own—and art. *Speak! Speak!* is, then, a painting alight with fire's metamorphic potentiality.

Shifting to medicoscientific representations of the human body, in chapter 5, "Photographing Ether, Documenting Pain: Representing the Chemical Invisible in the Daguerreotypes of Southworth & Hawes," Naomi Slipp discusses how the production of surgical daguerreotypes linked medicine with technological and chemical progressiveness, relating the presumed documentary effects of the photographic medium to medical objectivity early in the professionalization of both fields. These daguerreotypes have typically been viewed as transparent records of early surgery, but Slipp's study repositions them within the history of medical professionalization, period theories on corporeal pain, and a comparison of the perceived "magical" effects of ether and daguerreotypy. Slipp further reveals the professional agendas of doctors and photographers who consciously used the visual arts to advertise medical advancements that were, ironically, difficult to communicate visually. Slipp underscores the relationship between photography and power, following scholars such as Daniel Fox and Christopher Lawrence, whose 1988 *Photographing Medicine* proposed that "photos have a history and pictures like this have been among the means by which medical power has been legitimated and extended."[123]

Moving from the image of the actual, if anaesthetized, body to the ideal body of anatomical treatises, Keren Rosa Hammerschlag explores the complex and contested relationship between anatomy and race in the developing discourses of evolution in mid-nineteenth-century Britain and America in chapter 6, "Drawing Racial Comparisons in Nineteenth-Century Surgical Anatomies." The visually arresting mid-nineteenth-century surgical anatomy by Joseph Maclise (surgeon and brother of the successful Royal Academy artist Daniel Maclise) included an illustration of a black man who is rendered white in the American edition of the same atlas. Hammerschlag inquires what this "whitewashing" means for the histories of medicine, art, and the representation of race.

Taking up the discussion of evolution and art in chapter 7, "The Post-Darwinian Eye, Physiological Aesthetics, and the Early Years of Aestheticism, 1860–1876," Barbara Larson examines ways in which the development of psychophysiology and evolutionism in Great Britain of the 1860s and early 1870s helped produce the theory connected with the art movement aestheticism. Both Darwin and psychophysiologists emphasized the significance of a coordinated sensorium that responded to the environment in a holistic manner. Larson ties together two usually unrelated phenomena, the rise of physiological theory and the transition in art practice away from a focus on detail toward an interest in obscurity, the atmospheric, or materiality.

Finally, functioning as a case study of some of Larson's themes, Caitlin Silberman's chapter, "Darwinian Aesthetics and Aestheticism in James McNeill Whistler's Peacock Room," investigates the web of connections between the decorative program of James McNeill Whistler's celebrated Peacock Room (1876–1877) and discourses of evolution and aestheticism. In filling the room with anthropomorphic peacocks, Whistler employed two ostensibly distinct but overlapping ways of thinking through the origins and instrumental value of humans' sense of beauty: the Darwinian approach and the aesthetic mode. In its claim that beauty needed no moral purpose, the threat of Whistler's aestheticism differed little from Darwin's materialism.

Together our authors illuminate the world in which Hawkins was able, in his purposefully titled *The Science of Drawing Simplified* (1843), to argue for the importance of artistic training for the scientist: "To the naturalist . . . the study of form and facility in drawing are indispensable: the anatomist, botanist, ornithologist, entomologist, and geologist observe generic distinctions so minute as to escape the vulgar eye; and to delineate these accurately, requires not only correctness and dexterity but scientific knowledge."[124] Hawkins also reasoned, conversely, that the empirical observation skills taught by drawing produced moral benefits: "By quickening the child's perception of the external characteristics of objects, it creates a lively interest in them. . . . It promotes habits of consideration both for living creatures and inanimate objects, and of care in handling them; both which are influential in preventing the practice of cruelty and the tendency to destroy; a knowledge of the structures of animals induces humane feeling, and promotes reflection; for the child will not injure what it has so much pleasure in observing."[125] We might well take a lesson from Hawkins in his equation of looking closely with discovering in ourselves care and empathy for the observed object. In light of centuries of environmental havoc wrought by the innovations of human civilization, we are in need of just such nurturing ways of seeing our place in the world in relation to other forms of life. It is to be hoped that art, science, and the sort of visual historical consciousness found within this volume will help us do just this.