Conclusions

This work has no hero. There is no great event, and no momentous consequences result from actions and reactions I describe. The problems of color—what it is, how it attaches to objects, why it behaves in certain ways—are as problematic at the end of the eighteenth century as they were at the beginning. How is this declension of ideas about its practices and its theories anything more than the presentation of coincidences? What have I shown you, and what does it show?

My interest has been to explore exchanges between ideas and techniques in eighteenth-century Europe and in this, the fact that so little seems to change in the long view is an advantage. We can look to what people do—through the actions they take and through descriptions and assessments of their activities—without the varnish of this or that effort being the one thing that moved all understanding closest to what we accept today. We must comprehend the structures underlying the exchanges of ideas without reliance on anachronistic assumptions of what it *should* be. This has meant a reconsideration of the foundations for interactions between techniques and ideas as they were seen from different perspectives. Those different perspectives were based in the workshop, laboratory and lecture hall, but they were also founded on information or inspiration from the library, the merchant's shop and the drawing room. The best authority is not always the person obvious to us—and it was not always a person.

My second interest was to develop a way to incorporate a clearer and deeper engagement with the practices employed in those exchanges between ideas and techniques. Eighteenth-century expressions of Enlightenment, of Baconian ideals, of the importance of improved commerce and the best ways to achieve it embraced demonstration—experiment *or* experience—as a valuable form of knowledge. Embedded in its acceptance was the assumption that this kind of understanding fostered improvement of goods, of trade, of taste, and of knowledge itself. My third concern was to place the practice-theory connections I outline within a broader context than the history of technology and the history of science. We cannot disregard the social and economic milieux of the eighteenth century. Examination of the exchanges between techniques and ideas must also accept that there is no single method to incorporate this information, and no single expectation for what it might yield.

These goals are well-served by the use of color as the underlying source of inspiration. In the eighteenth century, color was both familiar and remote. Successful creation of color in or on objects demanded specific procedures, skills, and materials, but color was also a philosophical subject, inspiring investigation beyond—but not always divorced from—the material world. The study of color as technology or as a science, as practice or theory, as a subject worthy of both the

Academy and the atelier, engaged its investigators on a personal level as well as a public one. This duality amplified its perceived significance: It is possible to find within the study of in color not simply interactions between practices and theories but also their connections to contemporary ideas about society, trade, and knowledge in general.

An important feature of my study is its inclusion of many production processes, several regions, and a variety of sources. I believe this breadth of sources enhances our recognition of eighteenth-century public and personal relationships, as it can better reflect the double goals of improved knowledge and good color. It highlights ways in which participants with different and varied expertise interacted to resolve accepted and common problems. The transmission of ideas about color, including ideas about its problematic nature, sparked new answers and new efforts. The alliances that resulted, whether deliberate or inadvertent, cooperative or competitive, advanced personal goals of enlightenment or economic improvement, advanced goals of public knowledge and enlightenment, and contributed to the commonwealth of a community that extended throughout Europe. Investigations flourished, despite modern assessments that color was a philosophical dead end in the eighteenth century.

Consider together the sections related to the color blue, for example, as a way to understand the advantages of this broadened structure. Whether the underlying subject was blue for painting pictures or chairs, for ceramics or glass, for enamels or artificial sapphires, for blue-dyed or printed fabrics, recognizable problems existed in the technical challenges of indigo and cobalt, and in the great expense of ultramarine. These problems intensified as blue-colors became increasingly fashionable; one result was the interest that fanned out in different directions. The search for native cobalt, especially outside of Saxony or the Erzgebirge, was tied to the development of zaffer and smalt industries—refined versions of cobalt used by painters and in vitreous colormaking—and to recognition of the quality of the cobalt-based colors. What had been unknown or poorly understood techniques in France and in Britain were sought out, learned and improved on in the Pyrenees and in Cornwall.

At the same time, Saxon blue was a name associated with some new colors for textiles, a designation for a novel process to create blue colors from indigo. Saxon blue color became a component of Saxon green. As Saxon green cloth became fashionable, ceramic manufacturers decorated their wares with a color called Saxon green, too. In this instance, even more than in the case of cobalt, new practical uses for color both resulted from and resulted in new kinds of goods—for example, printed cottons that included blue along with other colors. The eighteenth-century development of the Saxon blue, or copperas, vat was based on new combinations of ingredients, requiring only slight changes to skills. This almost certainly simplified the transfer of those techniques. Experiment, even

experiment based on hearsay or poor descriptions, could be carried out in colorhouses where the basic methods were already familiar.

The example of blue is further extended by considering Prussian blue. The history of its development highlights the way that new colors were based on a different kind of new source for coloring materials. Prussian blue was not the result of geological investigations, or of new opportunities for trade, or a differently-configured dye vat: It was a new coloring material, created in a laboratory. Within thirty years of its development, Prussian blue had overtaken many of the painterly uses for which both inexpensive indigo and very expensive ultramarine had once been recommended, and it was adapted to textile production not long after.

In these examples, no one type of production is the consistent lead in the development of blue colors elsewhere. Theories, as demonstrated by George Berg's experiments with soot, could aid progress in its early stages. The amorphous nature of the interaction between techniques and ideas in the eighteenth century is also evident in the example of three-color or trichromatic theory. The fundamental concept, that a limited number of colors could be used to make all others, had existed in colormaking practices before Isaac Newton, Robert Boyle, Robert Hooke, and other seventeenth-century scientists adopted it as an experimental example. The notion of primitive or primary colors that accompanied descriptions of trichromacy was derived from practice but it connected those practices to older traditions. In the eighteenth century, without losing its original value to practical applications, philosophical experiments with red-yellow-blue trichromacy absorbed practices as its model. In this revised form, the principle that only a few colors might be necessary to create all others was marked by idealism about the value of theories for practices. The trichromatic ideal was explained by Jacob Christoph Le Blon, used by Charles-François Dufay, adjusted by Jacques-Fabien Gautier and Louis-Bertrand Castel, made visible by Tobias Mayer, Moses Harris, Johann Heinrich Lambert and others. The concept, its connections to theory more or less intact, was included in presentations of practical advice about color production and color use for many different specialties. Determination of the proper or appropriate coloring materials for a three-color theory —the "real" real colors—could establish order for other, related scientific inquiries. Identification of those colors would simplify the creation of good color for all objects. In the course of investigations, practitioners and theorists alike suggested their own variations on the use and value of theories of basic colors. A few achieved a broader acceptance; most did not.

The example provided by the uses of trichromacy is thus also an excellent model—within this larger object, color—of eighteenth-century interaction between practice and theory. Trichromatic propositions never functioned as expected, but the discrepancies only fueled further studies. The inability to reconcile the color

mixtures of light with color mixtures on the palette, or in the dye vat, did not end the investigations, and they did not prevent theorists or practitioners from continuing to state (and, we must assume, believe) that a limited number of colors, when properly combined, would yield all others.

The broadened structure also highlights the different ways theory and practice combined in the eighteenth century. Each was a resource for the other. The two did not function in the master-amanuensis roles often (if falsely) used to depict later connections between science and technology. The eighteenth-century relationship between practices and ideas was symbiotic. Neither dominated; instead there were constant shifts in significance. The heroes we might expect to find in a more linear projection of this relationship—theorists and practitioners such as Jean Hellot, Josiah Wedgwood, the Gravenhorst brothers, George Berg, François Gonin, even perhaps Mayer Oppenheim and George Palmer—gave substance to study and improvement, but they were not focal points around which all ideas or projects revolved. Antoine Lavoisier, whose appearance here is brief, but who in the history of chemistry is often granted a position similar to Newton's in physics, was more a source of information, and perhaps inspiration, than a provider of dominant, or even correct, concepts.

Interactions between theory and practice in the eighteenth century can be characterized as flexible, adaptable, and capable of accommodating several different descriptions or definitions at one time. In some respects, the relationship looks backward, incorporating an idealized model of the ancient world, or beliefs about what that might have been, for inspiration. This was a part of the alliance of theory and practice. The union clearly took from and gave to the surrounding world, and relied on connections between workshop and laboratory, workshop and reader, studio and inventor, and other social, intellectual, and economic combinations to achieve its goals.

Color is always the outcome of a process. Production and production experiences were allied to materials and techniques, as well as to the ultimate placement of the color, as part of an object. Knowing process and production was as essential to eighteenth-century systems of knowledge as was knowing other experimental derivations and proofs. Understanding the constraints of production and understanding the conceptualization of processes are equally essential to our mastery of this world. Obtaining this knowledge was the only way to effect improvement. Thus, it is essential that we have more than a superficial understanding of eighteenth-century processes, in order understand eighteenth-century approaches to the production of color, and to locate the models adopted for further improvement in those practices and elsewhere.

Thorough examinations of practices were undertaken by theorists such as Jean Hellot, by practitioners such as John Wilson, and by others who assumed that the

transmission of knowledge was an inherent good. Investigations incorporated the manipulation of materials, efforts to comprehend their nature, and the skills and techniques needed to reproduce a desirable result. We cannot deny the continued problems that philosophical understanding created for practical approaches. It was not simply questions of Newtonian versus anti-Newtonian theories. A resort to those polemics, even the eighteenth-century versions, obscures the nature of the assimilation efforts.

Identification of details in any eighteenth-century set of practices is significant to understanding contemporary notions of its nature and to understanding the ways those notions changed. Without these details, we do not comprehend the manner of their improvement. Familiarity with a practice might inspire transfer of the basic method to other materials, creating a new process. Purple of Cassius was always made by disbursing gold in a tin chloride solution. References to the procedure are found consistently in eighteenth-century publications and lectures; it was a well-known and visually striking process and phenomenon. In the case of Cornelis Drebbel, who invented a bright red dye color by mixing cochineal with a tin mordant, we cannot prove that the inspiration for the invention was directly related to this production method for gold purples, but, even if the connection is only circumstantial, it is a circumstance we cannot completely ignore. Although they may include analogies to the theoretical examples, practical experiences played a more direct role in changes to production processes. This is particularly apparent for colormaking processes, and in color-dependent manufactures.

Experience was crucial to the structure of these eighteenth-century theories: It provided the opportunity to demonstrate the validity of one's beliefs. The method to establish this legitimacy included experiment, but that was not the sole means. Observation was also an acceptable form of experience, if a passive one, under certain theoretical models. A person interested in practices might observe insects feeding on a plant and be moved to experiment with those insects as a coloring material. Someone with practical experience, on observing a color used in a novel way on an object, might recognize that another workshop had solved a technical problem or created an object worthy of imitation.

It is also important to understand where activities took place. Eighteenth-century sciences were by no means confined to the laboratory. Eighteenth-century colormaking practices were not limited to the workshop. Each engaged the other within their respective houses. Both were investigated by people with access to neither. We can see this in the range of occupations and social divisions represented in the petitions for awards or rewards for new color. We would expect participation in these competitions from theorists or practitioners with identifiable connections to the color-dependent industries: colormakers, colormen, factory-owning merchants, painters, enamellers, dyers, drysalters. The work of apothecaries or physicians does not seem far removed. But why would a person

of leisure become interested in the improvement of either color practices or color theories? How do we explain the soldiers, or the ladies' maids who offered their colormaking secrets? Why was the multifaceted nature of color important to more than a narrow band of philosophical practitioners and practical philosophers? The reasons are lodged not only in science and technology but in the broader demands of eighteenth-century social life: economy, consumption, and participation in or recognition of culture of the time.

The notion of progress and its value in these venues was both implicit and explicit in eighteenth-century culture. The preoccupation extended beyond acquisition of material goods to include the consumption of culture; it was part of an ongoing debate about the requirements of an enlightened, polite society. The notion of consumption incorporated the accumulation and appropriate use of ideas as a valid means to establish or confirm the merit of an individual, a city, or a nation. The pursuit of scientific learning—reading the book of nature—was one way to demonstrate this broad social goal of consumption. A city or town could show that it held a place in enlightened society by supporting a literary or philosophical club, one or several lecture series, or by encouraging an enlightened attitude among its citizens. An individual could display acceptance of enlightened and polite culture by participation in it. The desire to exhibit a virtuous nature might lead one to more-personal study, investigation, and experiment. And, if scientific progress were an ultimate expression of the value of knowledge, then practical improvement that used science had the further advantage of public progress at several levels.

Color, in its many forms, proved to be an especially fruitful place from which to increase public understanding, to explore notions of improvement and of politeness through the combination of science and industry. Information about color was readily available and its philosophical questions engaged some of the best minds of the age. Explanations of color offered by natural philosophers to the public and to their peers relied on practical examples to illuminate concepts. Pigments, glazes, and dyestuffs explained the physical notions of colors in the lecture hall and in serious and playful books about the sciences. Throughout the eighteenth century, color and colormaking remained suitable examples of a subject that involved both scientific precepts and commonplace objects. This created an atmosphere of potential. In the public eye, theory could be connected to practices by a search for new colors with obvious benefits. The requirements of a good color, and the failure of so many colors to meet those criteria, were well known. And, although creating color in an object was never as simple as directing a prism toward a beam of light, it offered many opportunities to learn about, understand, and improve or simplify existing materials and methods. Overall, this formed a powerful impetus for scientific amateurs, and for improvers of all things, to explore these connections. The explication was Baconian at its core: Knowledge

is power, but knowledge also had a direct connection to improvement. As ideas improved so would economies, and so in turn would society both locally, nationwide, and beyond.

Order, improvement, and invention in color were thus tied to intellectual mobility, but there was a social element as well. In this sense, enlightenment and politeness served personal goals; this cannot be forgotten in a discussion of improvement to color whether that improvement was scientific or technological. Participation in polite society and, through this, fitness to enter the circles of social or intellectual elites was a motive behind a whole array of publications and, no doubt, lectures, lessons, even objects. Part of this drive was due to the kind of improvement brought about by consumption, in the guise of more clients, a clientele that extended to or beyond Paris and London, or affiliations with other disciples of contemporary polite culture. If access to this elite portion of society meant that theories must be incorporated into practice, then presentations geared to an appropriate level of engagement could be found among existing publications.

But I have had another set of objectives for this book as well. They involve a description of how the concepts of color—what color is, how it is created on objects—changed in the eighteenth century. These objectives were to test the characterization and the framework I develop for the narrower set of objectives, and vice versa. Even without a great rupture, ideas about color and about the creation of color in objects was transformed in several ways. And, as might be expected, general descriptions of these alterations are not always divisible into neat groups that can show this change or that.

It is clear that, in the eighteenth century, the study of color was not a static entity in any respect. It changed in response to the techniques, materials, and information that became available. Color as an idea, but equally, color as a collection of techniques to produce colored objects, was altered as a result of changing ideas about art, about commerce, about the sciences. The best examples of this are found in explorations of manufactured colors. Even without widespread acceptance of new theories in chemistry—assumptions about elements, or measurement, or phlogiston-based theories of coloration—the focus on colormaking as a chemical operation grew during the eighteenth century. Prussian blue was an early eighteenth-century accident that proved worthy of exploitation as a scientific *and* a practical discovery. Zinc white and Scheele's green were colors developed through investigations of mineralogical chemistry. Scientists and manufacturers strove to understand how the color was created, an interest that was directed to the exploitation of substances that might be derived from similar methods, and directed toward general philosophical understanding.

What, then, was the sum of the relationship between theory and practice in the

eighteenth century? The interactions were as formless and as interdependent as color itself. Theory did not drive practice; practice did not secure theory, but there was constant interplay between them. There were universal experiences but no unifying ones—not among theorists, not among practitioners, and not among any of the smaller communities that formed and reformed as subsets of any larger group. Yet even without unified experience, there were unified goals. Progress could result only if practice, practical experiment, and theoretical concepts were combined. How should this be done? This goal was approached throughout the eighteenth century, in the persistent search for better color. Aspirations were fueled by hopes for personal and public economic benefit and by the opportunity to participate in public culture and public life. All those concerned with color, in all its forms, during the eighteenth-century believed that color and colormaking would improve, and already had improved, as a result of their investigations. Eighteenth-century investigators recognized that color was not yet perfect. Their work was about enlightenment and it was about instruction; it was to improve trade, and it was to better understand goods received. Perhaps it was only a question of more time and of continued endeavor. Perhaps information would be clear only if one was engaged in practice; perhaps it was not necessary to have more than a rudimentary knowledge of the work of an artisan. It was simple and it was complicated.
