Introduction

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I

Recent work in the history of science has cast new light on many shadowy areas of past thought and practice. Historians have offered new interpretations of the earliest cuneiform texts in which Mesopotamian diviners used the stars to forecast the future and of the austere modern spaces in which molecular biologists analyze genes to decipher the language of life itself. Innovative books have called back to new life such understudied spaces for scientific work as the museum, the seminar, and the arsenal. New editions, translations, and commentaries have offered close readings of scientific works ranging from antiquity to recent times, and on subjects from anatomy and physiology to alchemy and astrology. Popular but undercultivated fields like the history of cartography—long the province of well-intentioned amateurs—have been settled, plowed, and tended by highly qualified specialists. Even the sales of books in history of science remain brisk, in defiance of the trends in scholarly publishing in general and history—especially European history—in particular.

These signs of growth, however, are accompanied by much more worrying signs of underlying disagreement—disagreement not only about the interpretation of individual works and careers, which will and should be with us always, but also about the basic subject matter and methods of the field. A divisive, partisan rhetoric has crept into critical discussions. Advocates of new methods have tried, in recent years, to blur the borders between the sciences now recognized and other fields of thought and action. They argue, reasonably enough, that knowledge about the natural world is always conditioned by the historical and cultural conditions within which it is framed. By precept and example they demand that historians pay attention not only to the classic texts in which the heroes of science published their results, but also to the particular contexts—social, political, and economic—in which they created them. Yet at times, they advance these claims in ways that seem to reduce the great men once primarily studied by historians of science to glib careerists whose efforts to master natural phenomena were motivated solely by a desire

for prominence or money. Defenders of tradition, by contrast, insist that rigorous interpretation of texts must precede and underpin the imaginative recreation of places of scientific work and the transactions that took place in them. Emphasizing the intellectual vitality and power of early, as well as recent, scientific work, they insist that only those who have substantial aptitude for and training in the modern sciences can study the history of science in a profound way.

More than once, the rhetoric of these debates has become divisive, even ferocious. Some of the more provocative new-style historians of science seem to argue that study of the traditional classics of science is little more than a distraction from their true task: showing that early scientists were engaged in an enterprise characteristically different, in vital ways, from what goes on in a modern university laboratory. Some of the more traditionalist scholars charge the innovators with lacking any interest in the substantial achievements of early scientists—of the methodological and substantive discoveries traditionally associated with the Scientific Revolution, for example. At times representatives of each side have accused the other of errors that vitiate their work, and even of deliberate falsification. The pages of the journals that encourage such polemics offer visions of scholarship looking less like *The School of Athens* than like a lurid nineteenth-century panorama of a battlefield, the ground littered with the bleeding bodies and fallen standards of two grappling armies. And the divisions that find expression in savage review essays are also embodied in divisions of other kinds, as conferences systematically exclude one set of voices or the other and journals dedicate themselves to the pursuit of those violent polemics that editors affect to dread but really love.

The present collection of essays is chiefly designed to present a wide range of new work on the study of nature in early modern Europe. But both it and the conference at which the papers were first read and discussed also had a larger purpose: to suggest a different point of view about the entire conflict. To put it very briefly: we believe that neither the revisionist nor the traditionalist approach sketched above does justice to the rich and complex scholarship of the last century on the study of nature in Renaissance Europe. Both approaches, we would argue, grew up simultaneously, in many branches of study. Neither of them is really so radical or traditional as their more extreme proponents seem to think. Properly applied, in fact, they do not refute but reinforce one another—as many of the essays that follow clearly show. The study of Renaissance approaches to nature, in other words, can be rewarding both as an introduction to a rich and fascinating set of texts, individuals, and historical developments and as an object lesson in the principle always insisted on by the great historian of historical thought Arnaldo

Momigliano: that the tradition of historical scholarship and writing has richer resources in it than current polemics reveal.

II

Almost half a century ago, Erwin Panofsky published his vigorous defense of the scientific originality of the Renaissance in "Artist, Scientist, Genius."[1] Few today would question the essential correctness of his view that natural philosophy and other nonmathematical scientific disciplines underwent crucial transformations in the fifteenth and sixteenth centuries. Indeed, salient developments of the Renaissance—including enhanced attention to description and depiction, both verbal and visual; the accumulation of fresh data (geographical, anthropological, zoological, botanical, anatomical); and the emergence of new social structures and environments in which the study of nature was pursued (botanic gardens, anatomy theaters, courts, museums, collecting, and artistic endeavors)—clearly transformed the study of the natural world.

But in the decades since Panofsky wrote, the historiography of Renaissance approaches to the world of nature has itself undergone dramatic transformation. Two generations of scholarship have left us considerably better informed about the sources, scope, and varieties of Renaissance thinking about nature than he could be at midcentury. Even more important, perspectives have radically shifted, boundaries have dissolved, new themes and new methodologies have emerged. Conceptual and chronological frontiers once apparently secure—"medieval science" and "the Scientific Revolution," for example—have changed out of recognition or, in the view of some scholars, disappeared altogether. The seminal studies of Michel Foucault and Frances Yates, even if not fully persuasive in every aspect, have made it impossible for historians ever again to ignore the role of various forms of magical thinking and practice in the Renaissance understanding of the natural world. The focus of inquiry has shifted away, to a considerable extent, from analysis of the content or transmission of individual major scientific texts of the period toward the identification of broader social, political, and cultural factors that shaped learning and practice. No one can any longer doubt that these new perspectives have immeasurably enriched understanding. Yet the need for textual studies has not diminished. On the contrary, in the case of many texts—some major and highly influential ones as well as a much broader range of "routine" writing about natural philosophy, medicine, and so on—in which Renaissance writers embodied their view of nature, even the most basic work remains to be done. New textual studies continue to

make fundamental contributions to the field. Increasingly, moreover, such studies are themselves now informed by newer historiographic insights, as students of the classical tradition try to reconstruct not only the fortunes of individual authors but also the larger social, institutional, and architectural worlds—the schools, universities, academies, libraries, and museums—in which they were copied, studied, and applied.

Our goal in assembling the collection of essays in this volume is to present new work that exemplifies both the central themes and the important methodologies in the history of Renaissance natural philosophy and nonmathematical sciences as it is practiced today. The topics covered—Aristotelianism, Platonism, so-called new philosophies of nature, alchemy, medicine, and natural history—may seem disparate, but they reflect intellectual and disciplinary realities of the period. Four main themes, moreover, run through every section and unify the collection as a whole. The first is the exploration of specific examples of the appropriation, manipulation, and reworking of older traditions of knowledge—not only classical but also medieval—involved in so much of Renaissance innovation in theory and practice. This theme emerges, for example, with particular clarity in two essays that both deal directly with the continuing significance of Aristotelianism—and in so doing connect traditional ways of doing natural philosophy with the developing sixteenth-century taste for encyclopedic reference works of many different kinds. These two studies concern Aristotelian texts such as the *Problemata* and the *History of Animals,* long available in medieval Latin translation, which gained new types of diffusion, significance, and function in the fifteenth and sixteenth centuries. John Monfasani reveals the extensive modifications a humanist translator introduced as he rendered such works from Greek into Latin, and traces the publishing history that allowed his versions to become dominant in early editions. Ann Blair interprets the content and publication history of the *Problemata* and works based on it, in both Latin and vernacular versions, as a form of nascent "popular" science. Similarly, two essays on Renaissance Platonism by Michael Allen and James Hankins illuminate, respectively, aspects of Marsilio Ficino's original philosophical manipulations of Platonic concepts and the continued importance of the medieval Platonic tradition, characterized by study of the *Timaeus,* in early Renaissance Italy.

A second theme—illustrated by almost every essay—is the enormous impact of Renaissance humanism, and the new forms of philological scholarship and Greek learning associated with it, on the knowledge and practice of sciences of nature and mankind. During the fifteenth and sixteenth centuries, access to an enlarged range of ancient texts, ideas, or observations and

the use of new humanistic translations markedly affected every one of the natural philosophical traditions and scientific disciplines discussed in this volume, with the possible exception of alchemy. Nor was this effect limited to the realm of rhetoric. Enhanced and sometimes critical attention to Greek descriptive science played an essential part in some of the most striking sixteenth-century developments in scientific activity, notably the expansion—and heightened epistemological status—of observation and description in natural history and some aspects of medicine.

A third theme is the influence of disciplinary settings in shaping the way in which Renaissance individuals were able to study nature. The changing map of the disciplines, as new ones rose and old ones altered in status or content, brought about radical shifts in the alignment and interaction of the sciences. Thus, alchemy, natural history, and medicine all intersected repeatedly in this period. To the extent that alchemy was concerned, at least theoretically, with the healing of the human body (as Chiara Crisciani's essay in this volume demonstrates), its content overlapped with that of medicine. Moreover, both disciplines combined an authoritative textual basis with a tradition of practice involving material manipulations. Natural history, too, overlapped with medicine. Interest in plants (and some animals and minerals) had to a large extent grown out of, and was often still concerned with, their therapeutic uses. But the three occupied very different disciplinary spaces. Medicine enjoyed the prestige of a higher discipline established for centuries in the university curriculum. This endorsement was never acquired by alchemy, which always remained officially outside the university, though it was often—like medicine—welcomed at courts. Natural history, by contrast with both, provides a salient example of a science in the process of carving out a disciplinary position for itself, as two essays illustrate in complementary ways. Katharine Park draws attention to early interest in the subject among scholastic physicians who produced texts that bring together medical observation (of mineral springs) with fascination with "marvels of nature"; Paula Findlen traces the emergence of a scientific community.

Finally, a fourth theme that weaves through the collection as a whole is that of the material and practical means of the dissemination of knowledge. Translation and adaptation, manuscript diffusion, publishing strategies, the popularization of scientific information, papal patronage, the spread of humanist medicine from Italy to remote parts of Europe, the exchange of letters among like-minded botanists—all these modes of dissemination crop up repeatedly in the essays in this volume. None of the authors would claim that a particular system of dissemination fully explains the success of a given text or approach; all of them would insist that the available forms of transmission

and publication of knowledge, from the formal lecture to the easily copied marginal note, played a central role in shaping natural knowledge in early modern Europe.

III

At the end of the twentieth century, scholarship on the history of Renaissance natural philosophy and life sciences builds on a long history of previous endeavors. One important result has been to clarify the relation between the intellectual world of the Renaissance and that of the Middle Ages. The sharp contrast that Panofsky confidently drew between the Renaissance and all that had gone before was in part a reaction against the way that historians of medieval science had tended to dismiss the Renaissance entirely. The period between the 1920s and the 1960s was in some respects a golden age for the history of medieval science. It was certainly a time in which the subject entered the mainstream of historical inquiry in a way it had never done before. The new attention paid to medieval science came largely in response to—or reaction against—the influence of the ideas of Pierre Duhem (1861–1916). He had argued that the origins of developments in the physical and mathematical disciplines regarded as central to the Scientific Revolution lay in the late Middle Ages. George Sarton (1884–1956), one of the chief founders of the discipline of the history of science in the United States, also focused his attention on the Middle Ages. Meanwhile, the wide-ranging manuscript and bibliographical research of Lynn Thorndike (1882–1965) brought to light a vast corpus of largely unpublished and unstudied medieval writing on magical, astrological, and medical topics. In the middle years of the century, a younger generation of notable medievalist historians of science explored in detail the breadth and sophistication of fourteenth-century scholastic natural science and philosophy at Paris and Oxford. They concentrated on areas connected to the disciplines traditionally seen as central in standard accounts of the Scientific Revolution: physical science, cosmology, astronomy, and approaches to mathematization. The resulting impressive body of editions, translations, and studies revealed the medieval tradition of Archimedes and the range of the thought of Oresme, the Oxford Calculators, and many other scholastic authors as never before.[2]

To a hitherto entirely unprecedented extent, this body of work enriched understanding of medieval approaches to the world of nature. It also laid an indispensable foundation for the study of the history of erudite traditions over the following centuries. The immediate effect was, however, to direct the attention of historians of science toward thirteenth- and

fourteenth-century scholasticism and away from the world of humanism. In some instances, moreover, the influence of humanism was explicitly decried as hostile to scientific ideas and activities. Thorndike, for example, militantly repudiated the entire concept of a Burckhardtian Renaissance and dismissed the impact of humanism on science as negligible or even harmful.[3] Some influential scholars framed their work in strong theses that more or less explicitly defined the inquiry as a search for the origins of Western science, which they located in the Christian Middle Ages. Thus, in a widely read interpretive survey and in specialized studies Alistair Crombie claimed to have identified an experimental tradition in the thirteenth century. He held that this tradition combined with Greek philosophy, as transformed by thirteenth-century scholastic analysis of Aristotle's *Posterior Analytics,* and with characteristics peculiar to Christianity to produce a specifically Western scientific outlook. Crombie subsequently modified but never entirely abandoned these views.[4] In the light of these attitudes and interests, neither humanism nor fifteenth- and sixteenth-century cultural developments more generally seemed topics of central interest.

Few would now maintain the strong form of the thesis of continuity between scholastic science and a clearly delimited Scientific Revolution. As the author of a recent survey of *The Beginnings of Western Science* puts it, "the more extreme claims made on behalf of medieval science and its anticipation of early modern developments are not merely exaggerated, but false."[5] Attention instead has shifted away from tracing linear development in selected sciences toward an endeavor to map the whole range of medieval and Renaissance natural knowledge. Indeed, rather than a unified history of "science," we now have a picture of many different and sometimes overlapping sciences, skills, and disciplines, developing at different rates and in different ways. At the same time, awareness has grown of the extent to which common intellectual assumptions and methods characterized the disciplines studied in the world of the medieval universities.[6] Over the last thirty years, in addition, the history of all periods of premodern science has been profoundly affected by a general shift toward attention to life sciences, to social and intellectual contexts of scientific knowledge, to connections between sciences and systems of belief, and to the cultural relations of ideas and practices about nature. The influences ultimately responsible for this shift are too varied to be summarized here, though the work of Foucault should probably be included among them. Newer work also tends to have a different geographic and institutional (or rather extrainstitutional) scope; attention is paid somewhat less to Oxford and Paris than formerly, and more to southern Europe and the world outside the universities. All these trends, by now incorporated

in works too numerous to mention in an introductory essay, may be exemplified by a journal devoted to "nature, sciences, and medieval societies" launched in 1993. An editorial preface asserts the intention to bridge "sciences of nature and social history" and "the history of scientific thought and cultural anthropology."[7] Themes of successive annual issues have included the body, sciences at a royal court (that of Frederick II), alchemy, and the theater of nature. From this perspective, the development of physical and mathematical sciences appears as only one of many strands—though obviously a major and central one—in the tapestry of natural knowledge woven between the thirteenth and the seventeenth centuries.

These bodies of scholarship—at once textual and social, internalist and revisionist—ensure that we are now in a much better position than Panofsky was to appreciate the continued vitality of medieval, as well as classical, forms of erudition, not only throughout the fifteenth and sixteenth centuries, but even into the early seventeenth century. Notable studies have revealed the strength and diversity of Renaissance Aristotelianism. At the most fundamental level, new bibliographical reference tools have charted the full extent of the vast output of Aristotle editions and commentaries in the first two centuries of printing.[8] In addition, some leading scholars of medieval Aristotelianism have carried their research forward into the following period. Thus, studies by Edward Grant, whose earlier work concerned medieval physics and cosmology, trace the enduring appeal into the seventeenth century of traditional topics and methodology in debates about space, place, and the structure of the universe.[9] The diversity and vitality of Renaissance Aristotelianism are stressed in the work of Charles Schmitt and Edward Mahoney. Indeed, as Schmitt remarked, it seems preferable to speak of Renaissance Aristotelianisms in the plural, since approaches to the Philosopher between the fifteenth and the early seventeenth century were striking in their variety. Alongside the scholastic treatments of cosmology traced by Grant, humanists concentrated their attention on editing, retranslating, and commenting upon the Greek text, on integrating the full range of ancient Greek commentary into their own work, and on weeding out spuria. A lively Averroist tradition persisted even as biologists and anatomists developed a new interest in Aristotle's works on animals and in the botanical writings of his pupil Theophrastus. Both the radical naturalism of Pomponazzi and the interpretations of the Jesuit Coimbra commentators found shelter under the capacious Aristotelian umbrella. Moreover, these different versions of Aristotelianism often did not exist in isolation from each other but rather mingled and cross-fertilized. For example, Nicoletto Vernia (d. 1499), who was

formed entirely in the Latin scholastic tradition, and his pupil Agostino Nifo (ca. 1470–1538), who learned Greek in middle age, both began their careers as Averroists. When they subsequently abandoned Averroës for religious as well as philosophical reasons, they developed a preference for Aristotle's Greek commentators, one of whom, Themistius, they knew in the humanist translation of Ermolao Barbaro. Subsequently, some Platonic themes also appeared in Nifo's work. Indeed, much Renaissance Aristotelianism had an eclectic cast, drawing freely on other traditions. Thus, as Brian Copenhaver and Giancarlo Zanier have pointed out, even the thought of Pomponazzi, the most radical of Aristotelians, reveals influences from Ficinian Platonism and ideas about natural magic.[10]

Like Aristotelian philosophy, Hippocratic-Galenic medicine was an intellectual tradition of long standing in the Latin West. The large body of Latin medical literature that took shape between the late eleventh and the early fourteenth century conveyed ideas and therapeutic practices derived from Hippocratic-Galenic medicine, but they were transmuted by translation and reworked by the interpretations of Arabic and Latin writers for a new social and cultural context. Medicine was endowed with a more or less standardized curriculum of authoritative texts, taught in association with scholastic Aristotelianism. When universities arose, it was accepted as one of the three higher disciplines. Scholastic physicians of the thirteenth to early fifteenth centuries subjected Hippocratic, Galenic, and Arabic works to a continuing barrage of exegesis, elaboration, and problem solving in works of traditional form, *quaestiones* and commentaries, but the medicine of the late Middle Ages also had a strongly practical side. Medicine offered the example and potential of a discipline that rested on ancient textual authority. Yet in some respects—for example, in central aspects of physiology—it offered a challenge to Aristotle. It was securely entrenched in the universities but was also practice-based, requiring attention to particulars of patients, diseases, plants, animals, and so on. The structure, methodology, and much of the scientific content of this medical system continued to underlie sixteenth-century medical teaching and learning. The Latin medical literature of the eleventh to early fifteenth centuries was widely disseminated in numerous editions during the first seventy-five years of printing. Some texts—for example, the medieval Latin translations of the principal works of the major Arabic medical authors Avicenna and Rasis, and the *Conciliator* (of medical and philosophical opinions) of the celebrated physician, philosopher, and astrologer Pietro d'Abano (d. 1315)—had a much longer printing history.[11] In sixteenth-century universities, justly celebrated new practices, new sites for teaching and learning,

and newly edited and translated texts that greatly amplified knowledge of ancient medicine were more often additions to than substitutions for existing curricular arrangements.

The modern study of medieval medicine still rests in part on foundations established by medical historians of the late nineteenth and early twentieth century, most notably Karl Sudhoff (1853–1938). These scholars were primarily engaged in tracing the history of the scientific content of their own professional discipline. But over the last thirty years the history of medicine in all periods (not just premodern medicine) has become a subject of interest to social and cultural historians. At the same time, the turn in the history of medieval science toward life sciences and the social aspects of knowledge has also ensured a more prominent place for medicine.[12] Fundamental contributions of recent years have included editions and studies of major texts and their transmission as well as much archival work on social aspects of medicine.[13] The connections between medical ideas and natural philosophy have also begun to be explored. Medicine has taken its place as a key element in medieval intellectual culture as well as social practice.[14] Emergent historical themes—for example, the body, sexuality, and gender—have also stimulated new work.[15] In particular, recent studies have revealed the early involvement of medical practitioners in various peripheral activities relating to the care or investigation of the body, such as the early history of autopsy and endeavors to prolong life.[16] These activities seem highly relevant to the Renaissance expansion of the scope of medicine to intersect with or give birth to other branches of knowledge.

Medicine and alchemy intersect in various ways, for alchemy as it developed in the late medieval West was a science of life as well as of matter. But as noted above, an early established, enduring, and significant difference between the two disciplines lay in their levels of institutionalization. That alchemy was practiced outside the university and had potentially illicit aspects perhaps constrained its development in certain ways, but it may also have fostered conceptual freedom.[17] Revived interest in the history of alchemy is yet another manifestation of the broader approach to the history of medieval science characteristic of recent years. Indeed, in the view of one of the principal modern historians of the subject, "the historiography of alchemy is still in a pioneering state."[18] Studies published in the last decade substantially revise the traditional account of the development of the discipline between the reception of Arabic alchemical texts in the twelfth century and the seventeenth century. It is now apparent that the sixteenth-century reception and transformation of alchemical tradition by Paracelsus and his followers and other sixteenth- and seventeenth-century alchemists was one stage in a long his-

tory, the end of a series of earlier intellectual and textual transformations. The major text known as the *Summa perfectionis,* now securely identified as a product of the thirteenth-century Latin West, gave a central place to mercury and sulfur and developed the concept of *minima naturalia.* Its author, who wrote under the name of Geber, may have been a Franciscan friar.[19] Analysis of some of the alchemical writings attributed to Raymond Lull has contributed much new information about the fourteenth- and fifteenth-century development of an alchemy suffused with both mysticism and vitalism. In the concept of an "elixir" that would heal and preserve human bodies as well as play a part in transmutatory alchemy, ideas regarding medicine, alchemy, and the prolongation of life came together and mingled.[20] Indeed, the more alchemical processes were described in a sexualized or physiological language, the more medicine and alchemy drew on a common body of terms and ideas.[21]

In sum, much of the institutional structure and organization of knowledge within which new information, new ideas, and new disciplines burst forth in the fifteenth and sixteenth centuries had been established in the thirteenth century. The set of disciplines taught in the universities was put in place during the first century of their existence. Moreover, standard texts and curricula (for example, the division of medical teaching into separate courses in *theoria* and *practica*) also took shape in the thirteenth or early fourteenth centuries. The same may be said of teaching methods: the practice of teaching by commentary on authoritative texts and the arguing of *quaestiones* were enduring aspects of early university instruction that continued to shape the intellectual environment of the fifteenth and sixteenth centuries.[22] In due course, scholastic commentary would be replaced by humanistic commentary, and new observations would be brought to bear on old *quaestio* topics.

The establishment of natural philosophy and medicine as university disciplines ensured the continuity and respectability of systematic teaching about the natural world. In the Italian schools, the close relation between these disciplines was expressed institutionally, in the formation of student universities of "arts and medicine" and doctoral colleges of philosophy and medicine (that is, in both cases, liberal arts, natural philosophy, and medicine), as well as biographically, in the careers of numerous masters who at different times of their lives taught logic, philosophy, and medicine.[23] At the same time, other branches of natural knowledge flourished outside or on the periphery of institutionalized university teaching. And many signs show that academic and nonacademic branches of knowledge freely intersected and influenced one another. Thus, by the thirteenth century, surgery, like medicine, was equipped with substantial and authoritative specialized literature in Latin. Learned surgeons, who wrote in Latin, imitated writers on medicine

in claiming for aspects of their discipline the status of *scientia* (in the Aristotelian sense of a subject in which syllogistic reasoning from generally accepted premises could lead to universal truths). Surgery was indeed occasionally taught in a university setting in Italy. More important, central concepts—about therapy as well as the nature of science—were shared between the university world and this quintessentially manual discipline. By the fourteenth and fifteenth centuries, as many scholars have shown, much scientific and technical literature with origins in the learned tradition was circulating outside the academy in vernacular form.[24] Furthermore, it was not participation in manual activities that distinguished surgeons, alchemists, and magical practitioners from the inhabitants of the university world. Whether based in or outside the universities, medical practitioners and astrologers, too, were inextricably involved with manual, practical, and technical skills.

The natural knowledge of the later Middle Ages, then, was already diverse and open to many varieties of learning and experience. Indeed, the principal trend that has been noted in the medicine of the fifteenth century is growing interest in individual cases, diseases, remedies, and events of daily life.[25] It has further been argued that a line of descent can be traced from fascination with marvels and wonders to the attention to particulars that characterizes Renaissance descriptive sciences and ultimately to the emergence of the concept of objective factual information.[26] But the line is not equally straight and full in all fields. Danielle Jacquart has drawn attention both to the increasing interest in experience of fourteenth- and fifteenth-century medical authors and to their awareness of its often problematic nature.[27] By contrast, if one may judge by such striking thirteenth-century precedents as Frederick II's *De arte venandi cum avibus* and portions of the works on animals of Albertus Magnus, writers on zoology seem to have had more confidence. Nevertheless, as Katharine Park points out in this volume, the ability of the authors of fourteenth- and fifteenth-century works on natural thermal springs to make additions to knowledge based on their own observation represents a significant step toward a new and broader natural history.

The early history of anatomical dissection—yet another area of medieval scientific endeavor that has become the subject of new attention and some revisionism—may serve as a final example, one that encapsulates much of the complicated recent history that lies behind Renaissance approaches to the world of nature. The most celebrated early practitioner of human dissection, Mondino de' Liuzzi (d. 1326), professor of practical medicine in the University of Bologna, flourished in an academic environment and produced scholastic commentaries.[28] For the most part, to be sure, dissections were undertaken infrequently and used to illustrate medical teaching based on com-

pendia that very inadequately represented Galen's anatomical knowledge. The results bore little resemblance to the conduct, depiction, and narrative of anatomy made possible in the sixteenth century by the reception of Galen's full anatomical works, by changing artistic values, by printing, and by the investigative research of Vesalius and others. These developments are now once again a focus of attention for historians of medicine who are able to build on a substantial groundwork of technical analysis provided by historians of an earlier generation. As one might expect, the new work on Renaissance anatomy emphasizes cultural, social, and intellectual connections.[29] Academic anatomical dissections of the human cadaver were indeed only one of several practices originating in the fourteenth century or earlier that involved opening the body. Other purposes included funerary embalming, forensic investigation, and private autopsy. Yet it remains noteworthy that human dissection was institutionalized in the high scholastic period as an accepted part of the most advanced type of medical education, reviving a practice that had lapsed for a thousand years. The confidently invasive attitude toward the human body that this innovation seems to imply is well exemplified by the proem to Mondino de' Liuzzi's anatomical textbook, which prefaces instructions for dissecting the corpse of a criminal with a ringing statement about the nobility of mankind.[30]

IV

Just as Panofsky set too sharp a break between medieval and Renaissance ways of organizing and pursuing the study of nature, he also assumed too readily that Renaissance ways of studying the classics departed radically from those that had flourished in the cathedral schools and universities of medieval Europe. At the outset of his essay, he restated a principle that he had developed in the 1930s, working in collaboration with Fritz Saxl at the Warburg Institute—the interdisciplinary research institution for the study of the classical tradition founded by the art historian Aby Warburg in Hamburg, which moved to London in the 1930s with its incomparable stock of books and much of its incomparable group of affiliated scholars intact. Using classical mythology as their case in point, Panofsky and Saxl argued that medieval culture had been characterized by "the principle of disjunction." Medieval scholars knew a vast amount about the names and characters of the ancient gods, whose adventures they interpreted at length—usually as allegorical accounts of ethical principles or early human achievements. Medieval artists knew a vast amount about the forms with which Greek and Roman artists had represented the gods in sculpture and painting. But the persistent sep-

aration between the world of the intellectuals and that of the artists—and the radical lack of any sense of anachronism characteristic of all medieval thinkers—made it impossible for anyone to combine classical form with classical content in an internally consistent way.

In the Renaissance, by contrast, scholars came to see the ancient past from "a fixed historical distance"—just as artists came to see the physical world from a fixed distance. The "historical perspective" attained by men like Petrarch and Valla enabled them to see the differences between their world and the ancient one; to fuse the ancient forms once more with the beings they had represented; and, by doing so, to revive ancient culture as a whole. For Saxl and Panofsky, the fusion of the star maps transmitted over the centuries in the Islamic world with the classical images of the constellations transmitted in Latin manuscripts of the Aratea—a synthesis that took place in the schools and courts of Renaissance Italy—represented the first characteristically modern conquest of the historical world. In his essay on the Renaissance, Panofsky offered only one example: the juxtaposition of Palladio's Villa Maser with the Pantheon. But he also argued that the historical scholarship of the Renaissance humanists proved basic to the Scientific Revolution. Only the techniques of philology enabled intellectuals, for the first time since antiquity, to understand in detail the classic works of ancient science, to dismantle the frame of medieval commentaries that hung about and distorted many of them, and to identify both their strengths and their weaknesses.[31]

The tradition of research into the classical tradition that Panofsky and Saxl helped to found has flourished in the decades since. One of the greatest of the many great Renaissance scholars who came to maturity in the 1930s, Eugenio Garin, has devoted much of his career to developing similar theses about the historical revolution caused by Renaissance humanism. But the tradition has also grown in directions that these scholarly pioneers could not have predicted. Another great German-Jewish scholar of the same generation, Paul Oskar Kristeller, spent much of his remarkable career arguing that the revival of ancient learning and philosophy in the Renaissance took many forms, only a few of them governed by the philological historicism that Panofsky saw as typical of the period. Relying on a vast amount of new evidence, Kristeller argued that students of the philosophical classics often drew as heavily on the traditions of medieval as of humanistic learning. More paradoxically still, students of Plato—the preeminent scholarly rediscovery of the Italian Renaissance—often read his dialogues in a highly anachronistic way, through the interpretative screen provided by the treatises and commentaries of late antique Neoplatonists like Plotinus—whom Ficino not only studied intensively but also translated into Latin.[32] Similar arguments

were advanced by other scholars of the same generation, like Raymond Klibansky, who organized a great collective project to edit the documents that attest to the continuing life of Plato in the Middle Ages.[33]

Thanks above all to Kristeller and his students, from Charles Schmitt to James Hankins, it has now become clear that there was far more continuity than Panofsky believed between medieval and Renaissance efforts to understand the classics of ancient thought about the natural world. Texts long available in medieval schools and libraries—like the translation of the *Timaeus* by Calcidius—continued to be studied by humanists from Petrarch onward, as Hankins shows in his essay in this volume. The cosmology of the *Timaeus,* he demonstrates, offered a radical challenge to the Aristotelian views of eternity, time, and nature that flourished in the medieval universities: indeed, the *Timaeus* inspired Johannes Kepler to undertake his first sketch of a radical new cosmology, the *Mysterium cosmographicum* of 1596. But this challenge represented, in some respects, less a classical revival than the revenge of the Platonist school of Chartres of the twelfth century against the new Aristotelianism of the universities.

True, recent work on the classical tradition has also emphasized, as Panofsky did, the growth of new philological techniques—and has connected these with the rise of the new technology of printing and the transformation of education that took place in the new secular schools that urban elites created at the urging of Italian and northern humanists. Hankins shows not only that the Latin *Timaeus* of the Middle Ages continued to be read but also that it came to be flanked by the Greek *Timaeus,* which Ficino, Pico, and many others read in the original, with close attention to the details of wording and argument. But more recent research has also qualified Panofsky's thesis in crucial ways. Kristeller, Garin, D. P. Walker, Frances Yates, and others have shown, for example, that the scholars of the Renaissance did not rely on the canon of pure ancient authorities that the historical scholars of eighteenth- and nineteenth-century Germany identified as authentic and reliable. The Greek dialogues ascribed to the ancient Egyptian sage Hermes Trismegistus—works really written in the first through third centuries C.E., though evidently based in part on earlier Egyptian materials—were translated by Ficino, equipped with commentaries by him and other influential scholars, and widely interpreted as the sources of Plato's dialogues.[34] The Jewish tradition of Cabalistic Bible interpretation—transmitted in texts that claimed even older origins than the Hermetic corpus—fascinated Pico, who saw Cabalistic techniques as far more ancient and profound than the philological techniques of interpretation that he learned from the humanists of his time. Brian Copenhaver's article in this volume examines this process in detail,

showing how medieval traditions of reading meaning into the forms of Hebrew letters played a crucial role in Pico's development of one of his most ambitious intellectual projects.[35]

A second vital point also emerged most clearly from the work of Kristeller, Klibansky, and Walker. Renaissance students of the ancient world took not only the objects they studied but many of the methods they applied to them from what they saw as a coherent, unbroken classical tradition. The late antique Neo-Platonists, like Proclus, and the fathers of the church offered what they took as profound interpretations of Plato's dialogues and doctrines: and these later readings, which nineteenth- and early-twentieth-century scholars tended to dismiss as schematic or fanciful, often proved as vital as Plato's own work, or more so, in shaping the cosmologies of Renaissance thinkers. Both Michael Allen and Luc Deitz document this point in detail, showing how the most committed Platonists of fifteenth- and sixteenth-century Italy took vital elements of their systems from Numenius and Proclus.

These technical and internal strands of historical analysis do not represent the only legacy of the Warburg Institute. Warburg himself was as fascinated by postclassical adaptations and misuses of ancient texts and symbols as by philological efforts to understand them as they really were. He was passionately interested, for example, in the way the Florentine merchants of the later Middle Ages and the Renaissance imagined the goddess Fortuna—who became, in their eyes, a wind goddess who could fill or refuse to fill the sails of their richly loaded trading ships. Under his direction and Saxl's, the Warburg Institute devoted as much attention to the cheap German pamphlets and popular images that brought knowledge of the ancient star gods to a wide public as to the grand Italian frescoes in which their ancient forms were restored with archaeological faithfulness.[36] Renaissance and later responses to the classical tradition have proved to be as varied, and in part as wild, when studied through the Warburg Institute's multiple lenses, as those of their medieval predecessors—a point emphasized at the Warburg Institute, in recent years, by Charles Schmitt and Jill Kraye, who have richly documented the continuing use of and respect given to texts now generally dismissed by classical scholars as pseudo-Aristotelian. In dealing with the Aristotelian *Problemata* both John Monfasani and Ann Blair take one such text and its fate as their subject.

Finally, the scholars associated with the Warburg also made clear a point Panofsky omitted from his essay—that the choice of classical texts to study, and of approaches to take to them, is far from neutral. Renaissance scholars' decisions about which texts to analyze and which analytical methods to ap-

ply to them often reflected less a calm, rational study of the whole classical corpus than a particular political situation—such as the collapse of the Florentine republic, which, as Felix Gilbert, Delio Cantimori, and others showed, inspired Machiavelli and his associates in the circle of the Rucellai family to steep themselves in the study of Roman politics, using the histories of Polybius and Livy. The creation of a canon of texts could often have profound methodological and intellectual consequences, as, for example, when humanists chose Tacitus rather than Livy as their model for political analysis of past societies.[37] Paula Findlen's essay and Thomas Kaufmann's comment show that even texts as apparently innocent as the works on natural history of Dioscorides and Pliny could serve powerful political purposes—within both the narrower context of disciplinary politics and the wider one of courtly patronage.

The world of scientific knowledge and ideas described by the essays in this volume is nonetheless very different from that of the twelfth to early fifteenth centuries. It was transformed by changes in the political, social, and religious sphere, as well as the philosophical and scientific; by the invention of printing and the discovery of the New World; and, just as radically, by the challenges to the intellectual authority of texts posed by artists like Leonardo da Vinci. This volume offers only a partial introduction to the many kinds of research currently being done in Renaissance approaches to the natural world, and it examines only some of the many ways in which natural science and philosophy were transformed.[38] But it does illustrate, in a powerful sense, the fruitfulness of the disciplinary strategy that Panofsky thought characteristic of the Renaissance itself. For it shows that decompartmentalization—the breaking down of divisions between the Middle Ages and the Renaissance, textual analysis and social history, high and low culture, the university and the court—remains an effective way to attack the culture of the period, to reveal the continuing value of older traditions of analysis, and to shift the attention of historians from contemporary skirmishes to the lines where the real intellectual battles of the fifteenth and sixteenth centuries were fought.

NOTES

1. Erwin Panofsky, "Artist, Scientist, Genius: Notes on the 'Renaissance-Dämmerung'," in *The Renaissance: Six Essays* (New York: Harper, 1953), pp. 121–182.

2. The bibliography of the history of natural philosophy and branches of scientific knowledge in the High Middle Ages and Renaissance (ca. 1100–ca. 1600) that has grown up since the mid-twentieth century is far too extensive to be listed here. In this and the following notes, we confine examples to a highly selective list of authors and, in most cases,

to one work for each author: see Marshall Clagett, *The Science of Mechanics in the Middle Ages* (Madison: University of Wisconsin Press, 1959); Anneliese Maier, *An der Grenze von Scholastik und Naturwissenschaft,* 2nd ed. (Rome; Edizioni di Storia e letteratura, 1952); John Murdoch, "'Mathesis in philosophiam scholasticam introducta': The Rise and Development of the Application of Mathematics in Fourteenth-Century Philosophy and Theology," in *Arts libéraux et philosophie au moyen âge* (Montreal: Institut d'études mediévales; Paris: Vrin, 1969), pp. 215–252, Edith Dudley Sylla, "Medieval Concepts of the Latitude of Forms: The Oxford Calculators," *Archives d'histoire doctrinaire et littéraire du moyen âge* 30 (1973): 223–283; and Curtis Wilson, *William Heytesbury and the Rise of Mathematical Physics* (Madison: University of Wisconsin Press, 1956). An important feature of the work on medieval science between the 1950s and early 1970s was the publication of scholarly text editions: for example, Marshall Clagett, ed., *Archimedes in the Middle Ages,* 5 vols. in 10 (vol. 1, Madison; University of Wisconsin Press, 1964; vols. 2–5, Philadelphia: American Philosophical Society, 1976–1984); Edward Grant, ed. and trans., *Nicole Oresme and the Kinematics of Circular Motion* (Madison: University of Wisconsin Press, 1971); David C. Lindberg, ed. and trans., *John Pecham and the Science of Optics* (Madison: University of Wisconsin Press, 1970).

3. To quote one of his milder remarks on the subject; "Strange, is it not, that these medieval and scholastic centuries which were ever seeking after something up-to-date, should have been stigmatized as benighted and behind the times by subsequent historians, while the humanist reaction that followed, with its turning back to Rome and Greece, should have been hailed as the beginning of the modern mind and times!" Lynn Thorndike, *A History of Magic and Experimental Science* (New York: Columbia University Press, 1923–1958) 3:262–263.

4. A. C. Crombie, *Augustine to Galileo: The History of Science, A.D. 400–1650* (London: Falcon Press, 1952), second edition published as *Medieval and Early Modern Science,* 2 vols. (Garden City, N.Y.: Doubleday, 1959); and idem, *Robert Grosseteste and the Origins of Experimental Science, 1100–1700* (Oxford: Clarendon Press, 1953). For a detailed retrospective evaluation, see Bruce Eastwood, "On the Continuity of Western Science from the Middle Ages: A. C. Crombie's *Augustine to Galileo,*" *Isis* 83 (1992): 84–99.

5. David C. Lindberg, *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, 600 B.C. to A.D. 1450* (Chicago: University of Chicago Press, 1992), p. 360.

6. For an important statement of common assumptions and methods as regards natural philosophy and theology, see John Murdoch, "From Social into Intellectual Factors: An Aspect of the Unitary Character of Medieval Learning," in *The Cultural Context of Medieval Learning,* ed. Murdoch and Edith Dudley Sylla (Dordrecht: Reidel, 1975), pp. 271–348.

7. Agostino Paravicini Bagliani, "Perchè *Micrologus?*" unpaginated preface to *Micrologus: Natura, scienze e società medievali* 1 (1993).

8. F. Edward Cranz and Charles B. Schmitt, *A Bibliography of Aristotle Editions, 1501–1600,* 2nd ed. (Baden-Baden: Koerner, 1984); Charles H. Lohr, *Latin Aristotle Commentaries,* vol. 2, *Renaissance Authors* (Florence: Olschki, 1988).

9. Edward Grant, *Much Ado about Nothing: Theories of Space and Vacuum from the Middle Ages to the Scientific Revolution* (Cambridge: Cambridge University Press, 1981); idem, *Planets, Stars, and Orbs: The Medieval Cosmos, 1200–1687* (Cambridge: Cambridge University Press, 1994).

10. See Charles B. Schmitt, *Aristotle and the Renaissance* (Cambridge, Mass.: published for Oberlin College by Harvard University Press, 1983), with remark alluded to at p. 10; Edward P. Mahoney, "Philosophy and Science, I: Nicoletto Vernia and Agostino Nifo," in *Scienza e filosofia all' Università di Padova nel Ouattrocento,* ed. Antonino Poppi (Trieste: Lint, 1983), pp. 135–202; Andrew Cunningham, "Fabricius and the 'Aristotle Project' in Anatomical Teaching and Research at Padua," in *The Medical Renaissance of the Sixteenth Century,* ed. Andrew Wear, Roger K. French, and Ian M. Lonie (Cambridge: Cambridge University Press, pp. 195–222; Brian Copenhaver, "Did Science Have a Renaissance?" *Isis* 83 (1992): 387–407; Giancarlo Zanier, *Ricerche sulla diffusione e fortuna del "De incantationibus" di Pomponazzi* (Florence: La Nuova Italia Editrice, 1975).

11. See Nancy G. Siraisi, *Avicenna in Renaissance Italy: The "Canon" and Medical Teaching in Italian Universities after 1500* (Princeton: Princeton University Press, 1987).

12. For a thoughtful and persuasive evaluation of the relation between the two disciplines, see John Harley Warner, "The History of Science and the Sciences of Medicine," *Osiris* 10 (1995): 164–193.

13. Charles Burnett and Danielle Jacquart, eds., *Constantine the African and Ali ibn al-Abbas al-Magusi* (Leiden: Brill, 1994); L. Garcia-Ballester, J. A. Paniagua, and Michael R. McVaugh, general editors, *Arnaldi de Villanova Opera medica omnia,* 7 vols. in 9 to date (Granada: Seminarium Historiae Medicae Granatensis, 1975–); Michael R. McVaugh, ed., *Guigonis de Caulhiaco (Guy de Chauliac) Inventarium sive Chirurgia Magna,* 2 vols. (Leiden: Brill, 1996–1997). Mention should also be made of the various studies by Alain Touwaide on the Byzantine Dioscorides manuscripts and tradition and of the ongoing research by Monica Green into the manuscript tradition of texts associated with the name of Trotula. A notable example of the integration of archival research into social aspects of medicine with its intellectual history is provided by Michael R. McVaugh, *Medicine before the Plague: Practitioners and Their Patients in the Crown of Aragon, 1285–1345* (Cambridge: Cambridge University Press, 1993).

14. Jole Agrimi and Chiara Crisciani, *Edocere medicos: Medicina scolastica nei secoli XIII–XV* (Naples: Guernini, 1988); Mark Jordan, "Exegesis and Argument in Salernitan Teaching on the Soul," in *Renaissance Medical Learning: Evolution of a Tradition,* ed. Michael R. McVaugh and Nancy G. Siraisi, *Osiris,* 2nd ser., 6 (Philadelphia: History of Science Society, 1990), pp. 42–61.

15. Danielle Jacquart and Claude Thomasset, *Sexualité et savoir médicale au Moyen Age* (Paris: Presses universitaires de France, 1985); Joan Cadden, *The Meanings of Sex Difference in the Middle Ages* (Cambridge: Cambridge University Press, 1993).

16. Luke Demaitre, "The Care and Extension of Old Age in Medieval Medicine," in *Aging and the Aged in Medieval Europe,* ed. Michael M. Sheehan (Toronto: Pontifical Institute of Mediaeval Studies, 1990), pp. 3–22, Katharine Park, "The Criminal and the Saintly Body: Autopsy and Dissection in Renaissance Italy," *Renaissance Quarterly* 47 (1994):

1–33; Agostino Paravicini Bagliani, *Medicina e scienza della natura alla corte dei papi del Duecento* (Spoleto: Centro italiano di studi sull'Alto Medioevo, 1991).

17. Chiara Crisciani, "Aspetti della trasmissione del sapere nell'alchimia latina: Un'immagine di formazione, uno stile di commento," *Micrologus* 3; *Le crisi di alchimia* (1995): 149–210.

18. William R. Newman, *Gehennical Fire: The Lives of George Starkey, an American Alchemist in the Scientific Revolution* (Cambridge, Mass.: Harvard University Press, 1994), p. 92.

19. Geber, *The "Summa perfectionis" of Pseudo-Geber,* ed. and trans. William R. Newman (Leiden: Brill, 1991).

20. Michela Pereira, *The Alchemical Corpus Attributed to Raymond Lull* (London: Warburg Institute, University of London, 1989).

21. Barbara Obrist, "Alchemie und Medizin im XIII. Jahrhundert," *Archives internationales d'histoire des sciences* 43 (1993): 209–246; Chiara Crisciani, "Medici e alchimia nel secolo XIV: date e problemi di una ricerca," in *Atti del congresso internazionale su medicina medievale e scuola medica salernitana* (Salerno: Centro Studi Medicina "Civitas Hippocratica," 1994), pp. 102–118.

22. Brian Lawn, *The Rise and Decline of the Scholastic "Quaestio Disputata"; With Special Emphasis on Its Use in the Teaching of Medicine and Science* (Leiden: Brill, 1993).

23. Nancy Siraisi, *Taddeo Alderotti and His Pupils: Two Generations of Italian Medical Learning* (Princeton: Princeton University Press, 1981), offers some examples.

24. See, for example, Monica Green, "Obstetrical and Gynecological Texts in Middle English," *Studies in the Age of Chaucer* 14 (1992): 53–88. Extensive work has been done on German vernacular medicine by Gundolf Keil and many others.

25. See, for example, Danielle Jacquart, "Theory, Everyday Practice, and Three Fifteenth-Century Physicians," in McVaugh and Siraisi, *Renaissance Medical Learning,* pp. 140–160.

26. See Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150–1750* (New York: Zone Books, 1998).

27. Danielle Jacquart, *La médecine médiévale dans le cadre parisien* (Paris: Fayard, 1998), pp. 415–432.

28. On Mondino, see now Romana Martorelli Vico's introduction to her edition of Mondini de Leuciis, *Expositio super capitulum De generatione embrionis Canonis Avicennae cum quibusdam quaestionibus,* Fonti per la Storia d'Italia (Rome: Istituto Storico Italiano per il Medio Evo, 1993), and the introductory material in Mondino de' Liuzzi, *Anothomia,* ed. Piero P. Giorgi and Gian Franco Pasini (Bologna: Istituto per la storia dell' Università di Bologna, 1992).

29. Two noteworthy studies are Andrea Carlino, *La fabbrica del corpo: Libri e dissezione nel Rinascimento* (Turin: Einaudi, 1994), translated as *Books of the Body* (Chicago: University of

Chicago Press, 1999); and Giovanna Ferrari, *L'esperienza del passato: Alessandro Benedetti filologo e medico umanista* (Florence: Olschki, 1996). A special issue of the *Journal of the History of Medicine and Allied Sciences* has also recently been devoted to early anatomy; see vol. 50, no. 1 (January 1995).

30. Mondino, *Anothomia,* pp. 100–104.

31. See Erwin Panofsky and Fritz Saxl, "Classical Mythology in Mediaeval Art," *Metropolitan Museum Studies* 4 (1933): 228–280.

32. See the classic studies by Paul Oskar Kristeller collected as *Renaissance Thought and Its Sources,* ed. Michael Mooney (New York: Columbia University Press, 1979).

33. Raymond Klibansky, *The Continuity of the Platonic Tradition during the Middle Ages* (London: Warburg Institute, 1939).

34. See the classic survey of Frances A. Yates, *Giordano Bruno and the Hermetic Tradition* (Chicago: University of Chicago Press, 1964). The large and lively controversial literature on Yates (and Hermes Trismegistus) is best approached through the very well-informed introduction in *Hermetica; The Greek "Corpus Hermeticum" and the Latin "Asclepius," in a New English Translation,* ed. trans. Brian P. Copenhaver (Cambridge: Cambridge University Press, 1992). A powerful dissenting view is that of Paola Zambelli, *L'ambigua natura della magia* (Milan: Il Saggiatore, 1991).

35. See the great work of Chaim Wirszubski, *Pico della Mirandola's Encounter with Jewish Mysticism* (Cambridge, Mass.: Harvard University Press, 1989). New work on the diffusion of the Cabala in Christian circles is owed above all to Moshe Idel; see, e.g., his foreword to Johann Reuchlin, *The Art of the Kabbalah: De arte cabalistica,* trans. Martin and Sarah Goodman (Lincoln: University of Nebraska Press, 1993).

36. Aby Warburg, *Ausgewählte Schriften und Würdigungen,* ed. Dieter Wuttke, 2nd ed. (Baden-Baden: Koerner, 1980); Fritz Saxl, *Lectures,* 2 vols. (London: Warburg Institute, University of London, 1957).

37. See, e.g., *Tacitus and the Tacitean Tradition,* ed. T. J. Luce and A. J. Woodman (Princeton: Princeton University Press, 1993).

38. For other views of Renaissance approaches to the natural world, see two other recent collections: *Renaissance and Revolution; Humanists, Scholars, Craftsmen, and Natural Philosophers in Early Modern Europe,* ed. J. V. Field and Frank A. J. L. James (Cambridge: Cambridge University Press, 1993), and *Reading the Book of Nature: The Other Side of the Scientific Revolution,* ed. Allen G. Debus and Michael T. Walton (Kirksville, Mo.: Sixteenth Century Journal, 1998).

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Natural Philosophies