Medieval Robots
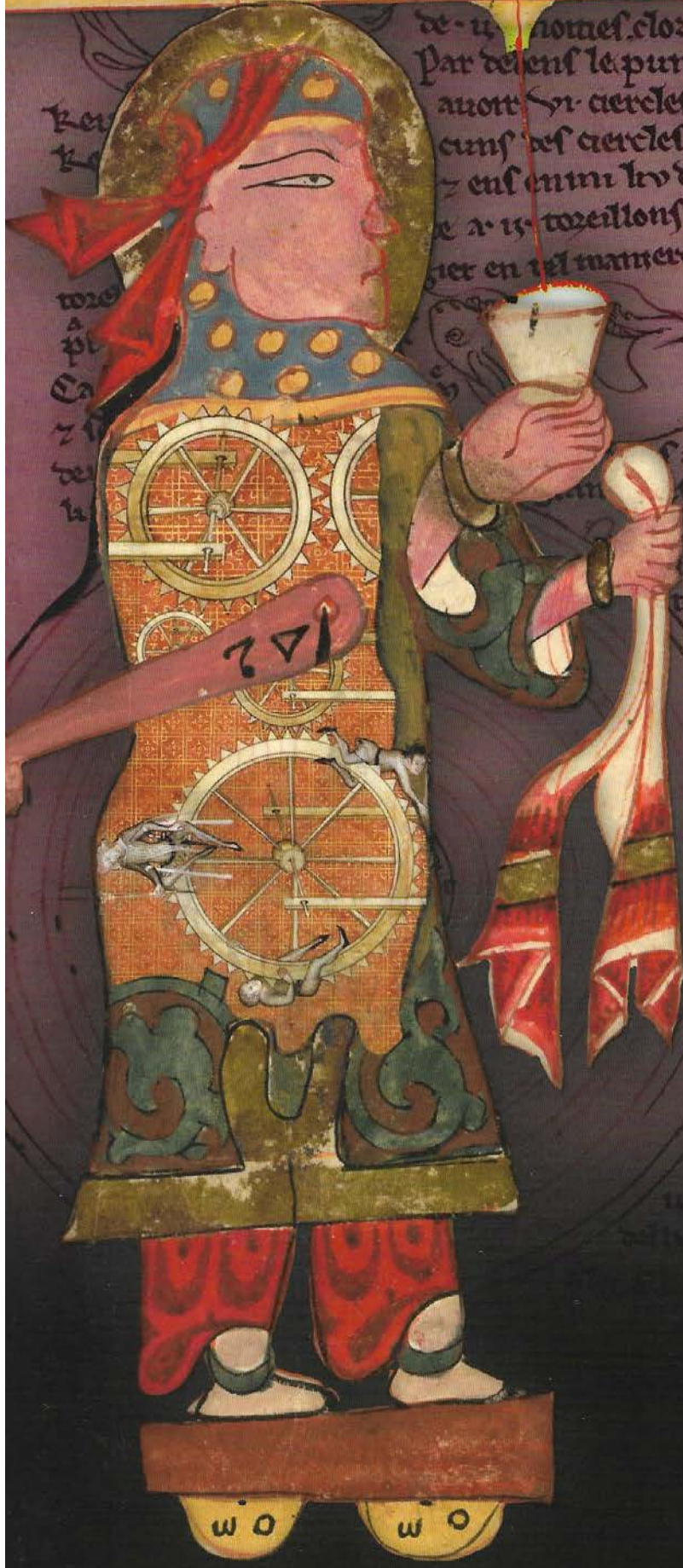
Mechanism, Magic, Nature, and Art

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The Persistence of Robots:
An Archaeology of Automata

Golden birds and beasts, musical fountains, and robotic servants astound and terrify guests. Brass horsemen, gilded buglers, and papier-mâché drummers mark the passage of time. Statues of departed lovers sigh, kiss, and pledge their love. Golden archers and copper knights warn against danger and safeguard borders. Mechanical monkeys, camouflaged in badger pelts, ape human behavior in the midst of a lush estate. Corpses, perfectly preserved by human art, challenge the limits of life. Brazen heads reveal the future, and a revolving palace mimics the revolution of the spheres. Medieval robots, both actual and fictional, take many forms.

And they were far more than delightful curiosities. Automata stood at the intersection of natural knowledge (including magic) and technology, and they embodied many themes central to medieval learned culture. Indeed, automata were troubling links between art and nature. They illuminated and interrogated paired ideas about life and death, nature and manufacture, foreign and familiar. They performed a multitude of social and cultural functions: entertainment, instruction, prophecy, proxy, discipline, and surveillance. Automata enlivened courtly pageantry and liturgical ritual throughout the Middle Ages. They appear in *historia* and *romanz*, in travelogues and encyclopedias, in chronicles and *chansons*. By excavating the complex history of medieval automata, we can begin to understand the interdependence of science, technology, and the imagination in medieval culture and between medieval culture and modernity.

Medieval Robots identifies and explores the multiple kinds and functions of automata in the Latin Middle Ages, and demonstrates that these objects

have long been used to embody complex ideas about the natural world. Automata were the products of both intellectual and artisanal labor, and could draw their power from demons, the movement of the cosmos, the secret powers of natural substances, or mechanical technology. They epitomized the transformative and threatening potential of foreign knowledge and culture, and were only gradually decoupled from such problematic origins and inscribed into a Latin Christian cultural patrimony. As people living in the Latin Christian West developed the ability to build complex machines similar to those they encountered in foreign places, they began to interpret these objects within a framework of mechanical technology, although magical and demonic causality remained equally plausible. The different methods by which automata—actual or imagined—were or were imagined to be created in this period raise important questions concerning the boundaries between licit and illicit knowledge, and between experiential and textual knowledge. The long history of medieval automata demonstrates also that the turn toward mechanism—to using mechanical models to explain and understand the body, the universe, and the laws that govern both—which is usually taken as one of the hallmarks of modernity of seventeenth-century natural philosophy, stretches back to antiquity.[1] Thinking with automata persisted throughout the Byzantine regions and the Islamicate world through late antiquity and the medieval period. Yet in the Latin Christian West, mechanistic thinking largely disappeared as a way of knowing until the turn of the fourteenth century. Before that, mechanical objects from outside the Latin West were understood within it according to a different intellectual framework, one in which magic predominated. The chronological scope of this book encompasses this intellectual transformation: I begin at the start of the ninth century, with the arrival of the first mechanical automaton in the Latin West, from Baghdad, and conclude in the middle of the fifteenth century, when mechanical knowledge in Europe allowed for the design and construction of automata within a framework of local, familiar knowledge.

All the objects in this book have two things in common: they were apparently self-moving or self-sustaining manufactured objects, and they mimicked natural forms. Medieval writers, artisans, and artists did not have a fixed term, or even a set of terms to refer to these objects. "Automaton" is an early modern coinage. It came into popular use in sixteenth-century France after Rabelais used "*automate*" to denote a machine with a self-contained principle of motion in *Gargantua* (1532), and it ramified in the twentieth century to encompass a variety of more specialized terms, including "robot," "android," and

"cyborg."[2] The objects I refer to as medieval robots or automata thus comprise a group that is broader and more heterogeneous than current usage suggests. While our own definition of automata focuses on mechanical (and, increasingly, electronic) objects, because the medieval category was not limited to mechanical causality, it allowed for more variation in terms of structure and operation. Despite the multiple forms and causes of medieval automata, and despite the fact that medieval writers did not have a fixed set of terms to refer to them, these seemingly disparate objects display a powerful cultural coherence and are often grouped together in medieval texts. In legend, drama, and historiography, medieval sorcerers use magic to create prophetic metal heads or statues, and these appear alongside copper archers or golden musicians. The makers of these strange wonders also embalmed the corpses of dead heroes, encasing them in gold; no longer alive, but not consigned to death. Artisans built elaborate fountains and mechanical angels based on reports of similar objects as well as fantastical objects from legend and romance.

The medieval period is central to understanding the cultural associations of modern robots. Automata are the focus of recent literary and art historical scholarship and that of the history of science.[3] Most of this excellent scholarship focuses on automata either in antiquity or from the early modern period until now. By excavating the missing millennium, *Medieval Robots* extends the historical context for thinking about the cultural and imaginative work that machines undertake. This book also engages with several key recent works in medieval studies on marvels and geography in which automata figure, enriching those conversations by delving further into the cultural, chronological, and philosophical contexts.[4] However different from the robots and cyborgs of modernity, medieval robots also sponsor inquiry into the definitions of life, the natural, and the artificial. In any age, automata are potent symbols of human understandings of nature. Automata permeate multiple discourses as embodiments of foreign craft, scientific superiority, and guile. They externalize the awesome and morally dubious powers of medieval philosophers; they serve as manufactured representations of political prestige. They are mimetic objects that dramatize the structure of the cosmos and humankind's role in it.

The Legacy of Ancient Automata

The first automata in the Western intellectual tradition appear in ancient Greece. According to Homer, Hephaestus, the smith-god of the Greeks, made

twenty tripedal servants to serve the gods on Mount Olympus, mounting them on golden wheels "so they could scurry of their own accord to the gods' gatherings."[5] In addition to these wheeled servants, he forged two golden female assistants, endowed with sense, speech, and strength, to help him in his workshop.[6] By the third century before the Common Era engineers and architects based in Alexandria began designing automata to illustrate mechanical principles, and documenting their creations in texts that detailed their construction.[7] Ktesibios (fl. ca. 300–ca. 270 B.C.E.), the earliest engineer of the Alexandrian school, wrote a technical manual that described the construction of a force pump, a catapult powered by compressed air, a water-powered organ, and pneumatic birds to sound the hours on a water clock.[8] Philo of Byzantium, who flourished during the latter half of the second century B.C.E., may have been familiar with Ktesibios's oeuvre; certainly his own books, which detail the building of an air pump and a compressed air-powered catapult, cover similar ground. Philo's work brought pneumatic principles to life with automata, including a singing bird and a mechanical wine-servant.[9]

Hero of Alexandria, the latest of the Alexandrian school of automaton-makers, flourished in the second half of the first century of the Common Era and wrote treatises on pneumatics, mirrors, catapults, and mechanical principles. In his extensive work, *On Automaton-Making*, he cites a now-lost treatise of Philo's on automata as the "best 'and most suitable to didactic purposes.' "[10] *On Automaton-Making*, a detailed treatise, describes how to build two kinds of automata: the first is a mobile shrine to Dionysus, with small figures of the god and attendant maenads. The second is a small fixed theater that stages a complete tragedy, complete with proscenium, changing scenery, and sound effects.[11] The motive power of Hero's automata (and, one assumes, of Philo's) is a counterweight enclosed in a tube or shaft. The flow of small grains through a hole, as in a sand-glass, regulates the descending counterweight, and the energy of the falling weight makes the automata move. Like some of his other mechanical constructions, Hero's automata were designed to illustrate physical principles such as leverage and the transformation from one kind of motion to another, as well as to elicit amazement and wonder.[12]

The lone surviving automaton from antiquity is the Antikythera Mechanism (ca. 80 B.C.E.), a precisely geared analog computer, about the size of a briefcase. It dates from roughly the same period as Hero's designs, and was discovered in a shipwreck in the Aegean Sea at the start of the twentieth century. It seems to have been powered by a hand crank, and it was likely intended to model complicated celestial movements and predict astronomical

events, such as eclipses.[13] The existence of the Antikythera Mechanism and the detailed designs in the texts from the Alexandrian School (and the changes the authors made to previous designs) are sufficient proof that these objects were actually built in the ancient period. The Alexandrian texts were not fully translated into Latin until the late fifteenth century. Before then, automata built in the Latin Christian West were not directly influenced by the textual tradition of the Alexandrian School.[14] However, the Alexandrian treatises were, at least in part, the basis for the theory and practice of automaton making in the Byzantine Empire and the Islamicate world, and automata from these places were the inspiration for objects eventually built in medieval Europe. Caliphs and emirs had mechanical animals and lush fountains installed in their palaces, and Byzantine court ceremony included automata. The rapid expansion of Islam in the seventh and eighth centuries brought many areas where Greek culture had remained vibrant under Muslim political control. Scholars in the Dar al-Islam amended, challenged, and enriched many ideas set forth in Greek texts and incorporated them into an intellectual framework that also drew from Persian, Sanskrit, and Hebrew textual traditions.

Although automata were not built in far western Eurasia until the late thirteenth century, they appear there as a result of military, diplomatic, or commercial encounters with foreign powers as early as the start of the ninth century. These automata captivated and tantalized Latin Christians with the potential of scientific knowledge from long ago or far away. They incarnated technological savvy, extensive knowledge of and power over natural forces, and material wealth and luxury. Yet automata originated in places that Latin Christians viewed with a mixture of envy and suspicion. At least until the fourteenth century, most automata and the knowledge needed to create them were associated with places viewed as repositories of scientific knowledge and natural wonders, but also of un- or anti-Christian beliefs. This tension dramatically shaped the ways automata were portrayed in medieval European texts.

Automata in Medieval Texts

After Harun al-Rashid, the caliph of Baghdad, sent Charlemagne, the Holy Roman Emperor, an elaborate water clock with moving figures in the early ninth century, descriptions of automata began to appear in Latin annals and travel narratives. By the twelfth century fictional automata, located at distant courts or based on historical accounts of foreign devices, appeared in romances

and *chansons de geste*. Legendary or fantastic automata were also mentioned in twelfth-century encyclopedias, chronicles, and philosophical treatises, which described their creation and puzzled over their moral and intellectual legitimacy. Some of these texts formed the basis of magnificently illuminated manuscript books, which include spectacular paintings of automata of all sorts. By the second half of the thirteenth century, European artisans began to devise and build their own automata. Very few mechanical automata from the medieval period are extant; however, archival documents detailing their construction do survive.

I use all these sources to document the prevalence and persistence of automata in medieval culture, and to explore the essential issues that they embody. Drawing on such a wide array of sources inevitably raises questions concerning the relationship between literary genres and between "factual" and "fictional" materials, and the ways that medieval writers configured these concepts, however alien they may seem to modern readers. Imaginary or legendary automata that appear in twelfth- and thirteenth-century texts reveal as much about medieval attitudes to natural knowledge as the actual objects that were created to enliven courtly pageantry or to adorn monumental clocks in the fourteenth and fifteenth centuries. Many of the accounts of automata in natural history treatises, travelogues, encyclopedias, and chronicles contain elements that are very similar to, and often just as fantastic as, descriptions of such objects found in medieval romance. This is evidence of a capacious understanding of causality. To a medieval audience natural, preternatural, and supernatural events had different causes (manifest and hidden powers of natural objects, demons, or divine intervention), and occurred with varying frequency. They did not, however, differ in their plausibility. Miracles, such as the parting of the Red Sea, were just as possible as sorcerers' use of astrology or demonic magic to create prophetic statues.[15]

There were real generic differences between fiction and nonfiction: Isidore of Seville (ca. 560–636) included all literary endeavors, including history, as part of grammar, and divided all prose into *fabula* (things that had not happened, but had been invented) and *historia* (a narrative of past deeds).[16] Some *fabulae* have no purpose other than to delight an audience, but other *fabulae* offer an interpretation of natural things or the customs of humankind. Tales intended merely to captivate are commonly called "fiction."[17] According to Isidore, history refers to events that did happen; drama to events that did not happen, but could have; and *fabula* to events that could not have happened, because they recount things that are contrary to nature.[18] Some romances, such as the

romans antiques (stories of the ancient world that were fashioned into origin-myths for French and Anglo-Norman nobility in the second half of the twelfth century) were set in the distant past and took ostensibly historical events as their subjects. They were based on prior literary texts, such as the *Aeneid*, and on historical sources. By the same token, travel narratives, like histories, often relied on a mixture of personal testimony—either of the author or of people to whom the author had spoken—and prior written sources, neither of which may have been factual. The boundary between fiction and nonfiction genres was marked and often policed by medieval writers; however, fiction and nonfiction alike report and accept as true many types of events that many modern readers do not recognize as credible, such as tales of demons, witchcraft, miraculous healing, divine intervention, and astral portents.

The resemblances among these genres highlight strong links between them. Historiography, often in the form of historical chronicle, is one of the genres that contributed to the development of romance. Latin chronicles and annals provided not only a set of conventions, but also *matière*—characters, events, narrative devices, and colorful details and digressions—for vernacular authors. The sources for historiography and romance could be the same; previous historical accounts, epics, and legend could be recounted as deeds from the past or joined with a specific plot to entertain or instruct. Writers of historical narrative (as opposed to annals) do indeed display self-consciousness about their methodology and disparage fictional accounts of historical events.[19] Because accounts of automata in historical chronicles, travel narratives, and encyclopedias emerge from the same wellspring as accounts of automata in romances, epic poems, and drama, all can be read as historical texts that offer insight into medieval beliefs and practices.

Many of the examples of medieval automata in this book are from French texts, were found at French-speaking courts, or were written about by French-speaking authors. The linguistic Frenchness of literary texts in which automata play a role is striking and meaningful. Automata do appear in the literature of other European vernaculars, but generally later than in French.[20] What accounts for the strongly French character of literary texts and automata in the early and high medieval period? I still find this question puzzling and provocative—and address it in more detail in my second chapter—but I believe the answer lies at least in part in the sheer size and diversity of the medieval Francophone world, which encompassed much of northern and western continental Europe, England, parts of Italy, and the Mediterranean. This large geographic area, unified to some degree by a shared language and textual heritage,

enabled the exchange of books, ideas, and artifacts that in turn promoted the appearance of automata in narrative texts, and later at courts. The cultural prestige and reach of the French language also meant that some English and Italian writers, in England and Italy, wrote in French.

Organization of This Book

The narrative of *Medieval Robots* proceeds both chronologically and thematically: it traces the story from the appearance of automata in the medieval Latin West, as gifts from foreign courts, to the literary manifestations of these objects, to the eventual creation of elaborate mechanical automata in medieval Europe. In the early medieval period, elaborate hydraulic clocks with moving figures came as gifts to Christian rulers from foreign courts. Pilgrims, soldiers, and diplomats wrote of the apparently self-propelled artificial humans and animals they saw at foreign palaces. Writers and scholars grappled with the alien origins of these objects and worked to place them in a Latin Christian context and to understand them according to a scientific framework that did not privilege mechanical knowledge. Automata from historical texts were translated to literary texts, and then reinscribed into historical legend and biography. Automata populate twelfth- and thirteenth-century literature, where they are most often represented as the products of astonishing erudition in the liberal arts and natural philosophy. The men who made them were philosophers as well as sorcerers, while medieval philosophers with particular interests in the *quadrivium* in later periods were characterized as sorcerers for having created automata. By the middle of the fourteenth century, artisans and engineers began to create richly ornamented self-moving machines that incorporated human and animal figures as centerpieces for courtly pageantry or for the glory of the Church. During this period, the elaboration of mechanical devices such as gears, levers, and counterweights permitted the fabrication of increasingly complex mimetic machines.

This chronology reveals three themes. The first is the relationship between the Latin Christian West and places beyond it: the Islamicate world, and the Byzantine and Mongol empires. Because automata appeared in those places much earlier than in the Latin West (though not the Hellenic world of antiquity), and because they first entered the Latin West as gifts or in the pages of travelogues, automata were explicitly foreign. Latins regarded them in much the same way as they viewed foreign places, people, and customs—with amaze-

ment, suspicion, desire, and fear. Furthermore, throughout much of the medieval period, automata in Europe remained linked to their distant origins. It was not until the mid-fifteenth century, almost a hundred and fifty years after the construction of the first mechanical automata, that they were fully disconnected from their associations with foreign knowledge. Second, automata are important liminal objects. They identify and patrol boundaries of many different kinds: between courtly and churlish behavior, between good and evil, living and dead. In many cases automata also comment on categories, often calling them into question by their very existence. In all cases, they reveal their own in-betweenness: surpassingly lifelike copies of natural objects, or eternal bodies that hover between life and death. Third, medieval automata complicate the natural/artificial binary, as when mechanical monkeys are disguised to appear alive. These themes enrich and complicate the chronological narrative about the evolving understanding of natural knowledge in medieval Europe, including its potential, its limitations, and its risks.

Each chapter is devoted to one kind of automaton and the topics it raises. These include the nature of marvels, the constitution of natural knowledge, the text-based transformation of Latin intellectual culture, definitions of life and death, the spectacle of court, and the mechanics of the universe. Throughout, medieval robots enact interest in and concerns about the importation of knowledge from outside Christendom into a Latin Christian framework. At the same time, they reveal concerns about mimesis and manufacture, and the morality of these undertakings. Automata interrogate the boundaries between life and death and pose important questions about the nature of human identity and individuality.

The first chapter examines medieval automata as objects that symbolize the movement of knowledge across cultures, because automata first entered the Latin West as gifts from foreign rulers. Prevailing scientific theories that rationalized the connection between geographic location and powerful natural substances allowed scholars and writers in the Latin West to explain these mechanical objects in ways that reflected contemporary ideas about natural laws, and exposed anxieties about alien technology. These theories also accounted for the different kinds of knowledge available outside the Latin West and for the persistent view of automata as inherently foreign and marvelous objects.

The second and third chapters explore natural philosophical theories for how automata work and what work they could do in the twelfth and thirteenth centuries. The mechanical arts ranked lowest in the hierarchy of knowledge; instead, natural philosophy, the goal of which was the total understanding

of natural laws and processes, privileged text-based, learned knowledge, generally available only to a very select group of people. The hidden powers of natural substances, like the ability of certain gems to detect or safeguard against poison, which could be used to make moving figures, were available only to those who had spent time studying the liberal arts and the mysteries of Nature. In twelfth- and thirteenth-century literary texts, especially learned men created automata using esoteric knowledge, although the philosophical trope of *Natura artifex* (Nature as artisan) described Nature's labor in artisanal terms. The second chapter demonstrates that this metaphor obscures the rarefied intellectual ability that underpinned ideas about the invention of automata; and it extends the semantic field that denotes automaton-making, exploring the importance of esoteric knowledge to construct these objects. Sorcerers, philosophers, and poets, acting as Nature, were responsible for creating automata that displayed judgment and perception in surveilling and correcting human behavior and in delimiting certain spaces. Automata were a staple of *romans antiques*, and were consciously presented in these texts as part of the legitimate Trojan and Roman legacy bequeathed to the French and Anglo-Norman ruling elites. In this way, writers and their patrons began to claim these foreign objects as familiar, if temporarily lost.

From accounts of fictional sorcerers and philosophers who can create automata I move, in the third chapter, to the legends attached to historical learned men from the twelfth to the fourteenth centuries. This chapter explores another facet of the tension between foreign and familiar knowledge undergirding medieval automata. The tales of philosophers and the oracular metal statues they forged reflect concerns about the rapid importation and assimilation of newly imported astral science into the Latin intellectual tradition. Medieval scholars such as Gerbert of Aurillac, Robert Grosseteste, and Albertus Magnus were widely known for their erudition in astral science, mathematics, and natural philosophy, whether from Arabic sources or ancient sources transmitted to the Latin West via Arabic translations. All were also posthumously reputed to have made, either through demonic or astral magic, oracular heads or statues that would reveal to them both future events and further occult knowledge. Unlike the automata that were part of courtly pageantry in twelfth- and thirteenth-century literature, these legends attest to anxieties about the uses of new knowledge for purposes that were at best hubristic, and at worst diabolical.

The fourth chapter illustrates the imaginative movement from understanding automata within a framework of natural philosophy to one that included

mechanics from the twelfth to the mid-fifteenth century, through an examination of automata, drawn from textual examples, that guard or memorialize the dead. Automata in these settings demonstrate the ways the boundaries between nature and art, between verisimilitude and fraud, and between life and death were contested and negotiated. This chapter opens with twelfth-century literary examples and then moves into a case study of Hector's tomb in three fictional accounts of the story of Troy, documenting the way that increasingly mechanical explanations of Hector's preserved corpse replace magical explanations, and coincide with a heightened emphasis on technical skill. The final example, from John Lydgate's *Troy Book* (ca. 1420), anticipates Hobbes's characterizations of the artificial life of mechanical things and the mechanical nature of the body, as in it Hector's body is kept artificially alive by a complicated system of tubes and wires that replace his nerves and blood vessels.

The growing emphasis on technical skill and fine technology found in Lydgate's version of Hector's preserved corpse reflects the development of complex machinery in the fourteenth century, and the more widespread appearance of mechanical marvels at princely courts in Europe in the fourteenth and fifteenth centuries. Beginning with the notional automata in the notebook of Villard de Honnecourt in the mid-thirteenth century, mechanical automata became more common, albeit still the province of the very wealthy. The fifth chapter probes the consequences of the diffusion of mechanical knowledge in the form of mechanical marvels. I argue that the human and animal automata created for the public display of majesty at the courts of Artois and Burgundy, Richard II of England, and the Valois are central to understanding the reappearance of mechanistic thinking, as well as for the technological developments that allowed for the creation of increasingly complex machines.

Finally, I explore the development of complex mechanical clockwork technology and the link between clockwork and automata. Horological innovations in the fourteenth century enabled the construction of astronomical clocks that were accurate reproductions of the cosmos. These macrocosmic models were conjoined with microcosmic models—mechanical animals and people—to demonstrate the glory of divine creation in its entirety. The most famous example, the clock in the cathedral of Notre-Dame de Strasbourg, used automata to dramatize the interpenetration of sacred and secular time and a cosmology centered on divine majesty and the hope of eternal salvation. Yet this clock and others like it are part of a genealogy that stretches back to an 'Abbasid water-clock and an imaginary palace, to which we now turn.