CHAPTER 9

BETWEEN MYTH AND HISTORY

REAL AUTOMATA AND LIFELIKE ARTIFICES IN THE ANCIENT WORLD

SO FAR WE have considered how the ancient Greeks imagined—through mythology and artworks—artificially created life, animated statues, beings that were not biologically born but manufactured, fantastic technologies, and augmented human powers. We saw how people in antiquity portrayed Daedalus, Medea, Prometheus, and Hephaestus as supergeniuses, picturing them employing familiar tools and methods but with miraculous capabilities to construct marvelous things far beyond what could be achieved by mortals.

Except for the bronze robot Talos and the first humans made by Prometheus, practical details and inner workings of divinely crafted artifices are missing in the mythic narratives and fragments that have come down to us. But the wide of range of stories about *biotechne* reveal that the idea of *making* artificial life was conceivable in antiquity, portrayed as stupendous feats of ingenuity and craft. Some divine devices in myth might have arisen as metaphors for innovations in technology, while others may have been exaggerations of more modest counterparts in historical times. Earthly, simple approximations of some of the mythical marvels might have been practicable with available tools, materials, techniques—and formidable intelligence—in antiquity. Even so, it is important to resist the temptation to project modern motivations and assumptions about technology onto the ancient world.[1] Although many of the ancient myths and ideas about artificial life certainly call to mind and seem to foreshadow later inventions, one cannot project direct lines of influence from antiquity to modern biomechanics and robots.

The history of real mechanical designs and practical inventions, from artillery, the catapult, and theatrical technologies involving pulleys, levers, springs, and winches to self-operating devices, from the Mediterranean world to China, has been intensely and comprehensively studied.[2] From the wealth of well-documented ancient concepts and designs of automata and machines in the history of ancient technology, I have selected examples for this chapter that echo or resound in some way with the self-moving objects, animated statues, and other ways of imitating life from the realms of mythology discussed in the previous chapters. As we move from myth to history, keep in mind that it is inevitable that elements of popular folklore and legend have seeped into some surviving and fragmentary accounts of actual inventions. The historical incidents in the following pages do not constitute an exhaustive survey but are meant to give an idea of the various kinds of lifelike replicas and automata—some deadly, some grandiose, others charming curiosities—that were really designed and/or tested between the sixth century BC and about AD 1000.

Historians of robotics suggest that automata fall into three basic functions: labor, sex, and entertainment or spectacle. These features appeared in the ancient myths and legends about artificial life. Self-operating devices resembling living beings could be used to amplify human capabilities, to dazzle and awe, to trick and deceive, to injure and kill. Automata could serve as trappings and manifestations of power, sometimes in benign ways but other times with malicious intent.

In Greek myths, Zeus is portrayed as a spiteful tyrant who takes joy in devising a hideous torture for Prometheus and dispatches the seductive artificial woman, Pandora, to inflict suffering on all humankind. These torments required the technological expertise of Hephaestus, who also constructed King Aeetes's bronze bulls, to burn Jason, and King Minos's bronze killer Talos. A pattern stands out in these and other myths about devices made to inflict pain and death: each artifice was commissioned and/or deployed by a despotic ruler, as a means of displaying arbitrary absolute power. As it turns out, a similar pattern can be traced in historical antiquity: a good number of real tyrannical rulers used wickedly clever contraptions and artifices that mimicked nature to humiliate, harm, torture, or even kill their subjects and enemies.[3]

As Ovid (*Metamorphoses* 8.189) envisioned the myth, Daedalus created his human enhancement of flight by imitating the power of birds. He made rows of real feathers, assorted by size in a curve, and arched the structures to imitate real bird wings. Then, attaching them to his back and arms, he "balanced his body between the wings and hung poised, beating the air." Unlike the supernatural, effortless flight of the gods that defied time, physics, and space, however, his artificial wings required the physical effort of pumping one's arms to soar like a bird.

For a human being to attempt to fly by flapping man-made wings is of course aeronautically unsound, sure to end badly. That brute fact figured in a sadistic punishment using imitation bird wings meted out annually in ancient Leucadia (modern Lefkada), an Ionian island famed for its sheer sea cliffs. There, the ancient Greeks had "one regular opportunity to experiment with such flying devices without keen regard to safety."[4] Strabo (10.2.9) described the ancient custom on Leucadia known as Criminal's Leap. Each year, as a sacrifice to Apollo, the Leucadians would force a condemned man to "fly" from the island's white limestone cliff (the cliff was later known as Sappho's Leap, after the poetess's fabled suicide, and is now called "Lovers' Leap").[5] Like Icarus of myth, the man was fitted with a pair of artificial wings. And for good measure, all sorts of live birds were fastened to him as well, to add to the spectacle. Spectators on the cliff and in small boats below watched the hapless victim flapping with all his might while surrounded by helplessly fluttering birds.

During the Roman Empire, it was a popular sport to demean, torture, or execute people in amusing scenarios that re-created tragic Greek myths. The emperor Nero was a master of such perverse public entertainments in the Circus and at his banquets (AD 54–68). Two such performances were related by the imperial historian Suetonius (*Life of Nero*). For the play called *The Minotaur*, the individual forced to play Pasiphae was made to crouch "inside the hindquarters of a hollow wooden heifer" while an actor disguised as a bull mounted her. For a ballet reenacting the myth of Daedalus and Icarus, Nero commanded the man cast in the role of Icarus to fly with his artificial wings from a high scaffold. Suetonius records that the man fell "beside Nero's couch, splattering the emperor with blood."

Contriving artificial human enhancements based on bird wings for torture and entertainment was not confined to the ancient Mediterranean world. In China, Gao Yang/Wenxuan, the first emperor of the Northern Qi dynasty in AD 550–559, was feared for his erratic bloodthirsty rages. He enjoyed executing prisoners by harnessing them to great wings woven of bamboo or paper kites in the form of birds, large enough to carry a man. He forced the victims to "fly" from the 108-foot-high Tower of the Golden Phoenix (in the Qi capital, Ye) and laughed at the spectacle of doomed men attempting to stay aloft. Apparently the killer kites were also manipulated by skilled men on the ground holding the strings—the idea was to keep the victim in the air as long as possible. It was reported that hundreds of involuntary "test pilots" died for the emperor's amusement. But one man, Yuan Huangtou, an Eastern Wei prince, won fame for surviving the ordeal in AD 559. Strapped to an ornithopter kite shaped like an owl, he managed to take off from the Phoenix Tower and glided a mile and a half to the Purple Way at Zimo, where he landed safely. Presumably he was aided by the kite-holders on the ground.[6]

In the Greek myth, Daedalus escaped from King Minos of Crete by flying to Sicily with his bird wings. As we saw, once in Sicily Daedalus continued to create wonderful inventions for King Cocalus in Acragas, including the boiling hot pool used to murder Minos (chapter 5). Daedalus also designed an amazing temple and the impregnable citadel at Acragas for his royal patron. With these mythic stories in mind, we turn to a real-life inventor in the actual history of the city of Acragas (Agrigento). This inventor constructed a torture apparatus for the tyrant of Acragas that bears some resemblances to certain mythic creations by Daedalus and Hephaestus.

Acragas was founded by Greeks from Crete and Rhodes in about 580 BC. An ambitious, wealthy citizen named Phalaris undertook the construction of the grand temple to Zeus Atabyrios (named for the highest peak on Rhodes) at Acragas. Phalaris parlayed his status into military power and became an absolute dictator. Detested for his savage brutality, Phalaris was finally overthrown in 554 BC. During his iron rule, a shrewd Athenian bronze smith named Perilaus, seeking favor with Phalaris and knowing his penchant for torture, forged a lifelike statue of

bronze bull. It was hollow, with a trapdoor or hatch big enough for a man to enter.

Perilaus presented this handsome bull statue to Phalaris and explained how it worked. "Should you wish to punish someone, lock him inside the bull and build a fire under it. As the bronze bull's body heats up, the man roasts within!" Then Perilaus described the fiendish mechanism in the bull's interior. Perilaus had installed a system of pipes to amplify the victim's screams. While smoke flowed from the bull's nostrils, the tubes directed the sounds of the victim to issue from bull's mouth, transforming the shrieks of agony into the "most pathetic bellowings of a bull, music to your ears." Impressed, Phalaris slyly requested a demonstration of the special sound effects. "Come then, Perilaus, show me how it works." As soon as Perilaus crept inside to yell into the pipes, Phalaris locked the door and built a fire under the bull. The bronze smith was roasted to death (some say he was baked and then thrown from a cliff).

The story evokes the ironic folk motif of an inventor/criminal killed by his own invention/plot. Yet such sadistic behavior in real-life despots is hardly unknown (two Roman examples were the emperors Nero and Caligula). The existence of the Brazen Bull of Phalaris is not in doubt; it was described in numerous extant and lost ancient sources. And Phalaris became the prototypical evil dictator. In fifth-century Greece, the poet Pindar could assume that everyone knew the "hateful reputation" of Phalaris who, "with his pitiless mind, burned his victims in a bronze bull" (*Pythian* 1.95). A century later, Aristotle twice referred to Phalaris's tyrannical rule as common knowledge.[7]

In the first century BC, Plutarch told of Phalaris's bronze bull in which he burned people alive, citing an earlier lost historian. The historian Diodorus Siculus also expounded on the bull. Pliny (first century AD) criticized the sculptor Perilaus (Perillus) for conceiving of such a horrid use for his art and approved of his fate as the bull's first victim. According to Pliny (34.19.88) the sculptor's other statues were still preserved in Rome "for one purpose only, so that we may hate the hands that made them." In the second century AD, the satirist Lucian composed a humorous essay pretending to defend the reputation of the loathsome Phalaris.[8]

The bull spawned other roasting devices. Plutarch's *Moralia* referred to a lost history by Aristides, who described a very similar Sicilian invention in the city of Segesta, but in the shape of a realistic bronze horse, forged by

one Arruntius Paterculus for a cruel tyrant named Aemilius Censorinus, known to reward artisans for inventing novel tortures.[9] Diodorus Siculus, a native of Sicily, mentions another deadly statue, this time in the form of a bronze man, also set up in Segesta but by the vicious tyrant Agathocles, who ruled in about 307 BC (Diodorus 20.71.3; see fig. 5.1, plate 6, for the celebrated Bronze Ram of Syracuse, which belonged to Agathocles).

Diodorus returns to the infamous Brazen Bull of Acragas several times in his history. He notes (19.108) that the statue was located on Phalaris's stronghold, a hill on Cape Ecnomus ("wicked, lawless"). Diodorus describes how during the First Punic War, the Carthaginian general Hamilcar Barca looted costly paintings, sculptures, and other artworks from the cities of Sicily. The most valuable prize was the Brazen Bull of Phalaris in Acragas, which Hamilcar shipped to Carthage (Tunisia) in 245 BC. A century later, at the end of the Third Punic War, the Brazen Bull actually returned to Acragas. When the Roman general Scipio Aemilianus finally defeated Carthage in 146 BC, he restored all the plundered treasures to the cities in Sicily, including the Brazen Bull. Polybius (*Histories* 12.25), writing in the second century BC, confirms that the bellowing bronze bull was taken to Carthage and later returned; Polybius notes that the trapdoor on the bull's back was still operative in the second century BC. In 70 BC, Cicero (*Against Verres* 4.33) states that among the treasures recovered by Scipio from Carthage was the great Brazen Bull of Acragas, which "the most cruel of all tyrants, Phalaris, had used to burn men alive." Scipio took that occasion to observe that the bull was a monument to the barbarism of local Sicilian strongmen, and that Sicily would be better off ruled by the more kindly Romans. Diodorus goes on to affirm that one could still view the notorious Brazen Bull in Acragas, when he was writing his history, sometime in 60–30 BC.[10]

The Brazen Bull of Phalaris continued to exert a morbid appeal into the Middle Ages. According to Christian legends, the martyrs Eustace, Antipas, Pricillian, and George were each burned in a variety of red-hot bronze or copper bull statues in the first to fourth century AD. The final incident appears in Visigoth chronicles, and this time the victim was a hated despot. Burdunellus, tyrant of Zaragosa, Spain, was executed in Toulouse in AD 496 by being "placed inside a bronze bull and burnt to death."[11]

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PLATE 1 (FIG. 1.4). "Death of Talos," Ruvo vase detail. Album / Art Resource, NY.

PLATE 2 (FIG. 1.5). Medea watches as Jason uses a tool to unseal the bolt in Talos's ankle held by a small winged figure of Death, as Talos collapses into the arms of Castor and Pollux. Red-figure krater, 450–400 BC, found at Montesarchio, Italy. "Cratere raffigurante la morte di Talos," Museo Archeologico del Sannio Caudino, Montesarchio, per gentile concessione del Ministero dei Beni e delle Attività Culturali e del Turismo, fototeca del Polo Museale della Campania.

2

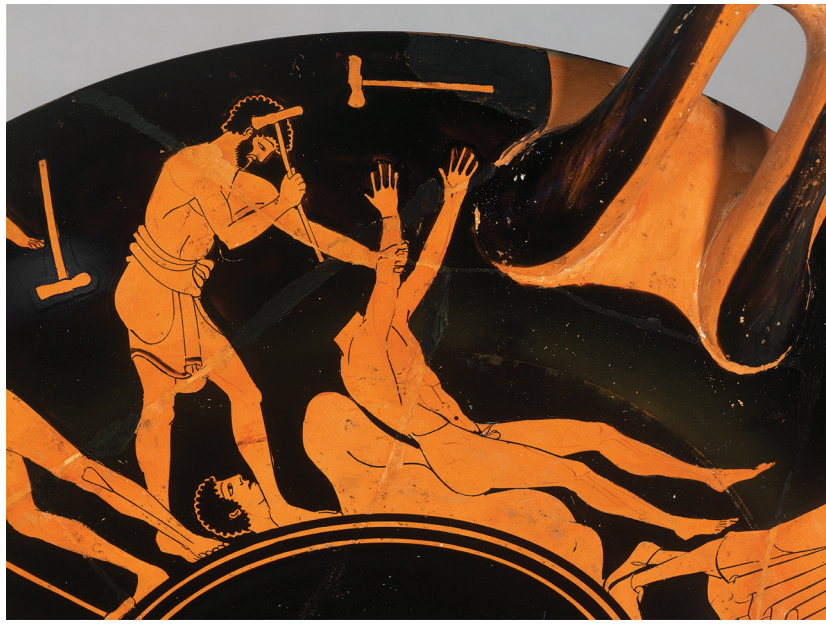

PLATE 3 (FIG. 1.9). Foundry scene, artisans making a realistic bronze statue of an athlete, in pieces, surrounded by blacksmith tools. Attic red-figure kylix, from Vulci, about 490–480 BC, by the Foundry Painter. Bpk Bildagentur / Photo by Johannes Laurentius / Antikensammlung, Staatliche Museen, Berlin / Art Resource, NY.

PLATE 4 (FIG. 7.4). Blacksmith at work, with tools, red-figure kylix, late sixth century BC, 1980.7. Bpk Bildagentur / Photo by Johannes Laurentius / Antikensammlung, Staatiche Museen, Berlin / Art Resource, NY.

PLATE 5 (FIG. 2.1). Medea, looking back at old Pelias (left), waves her hand over the ram in the cauldron. Jason places a log on the fire, and Pelias's daughter, right, gestures in wonder. Attic black-figure hydria, Leagros Group, 510–500 BC, inv. 1843,1103.59. © The Trustees of the British Museum.

PLATE 6 (FIG. 5.1). Realistic bronze ram. Was the sculptor of this life-size ram inspired by the story of Daedalus's true-to-life ram dedicated to Aphrodite in the time of King Cocalus? Bronze Ram of Syracuse, Sicily, third century BC, Museo Archeologico, Palermo, Scala / Art Resource, NY.

PLATE 7 (FIG. 5.5, LOWER RIGHT). Athlete, fourth to second century BC, recovered off the coast of Croatia in 1996, Museum of Apoxyomenos, Mali Losinj, Croatia. Photo by Marie-Lan Nguyen, 2013.

PLATE 8 (FIG. 7.7, TOP). Hephaestus (Sethlans) and assistant (Etule) making an artificial horse (Pecse), Etruscan bronze mirror, fourth century BC, from Orvieto, BnF Cabinet des Medailles, Bronze.1333.

PLATE 9 (FIG. 7.8). Athena making a clay model of a horse; she is holding a handful of clay and there is a pile of clay at her feet. Above left, a saw, drill, and bow drill. The horse's back leg is unfinished. Athenian red-figure wine jug, about 460 BC, F 2415. Bpk Bildagentur / Photo by Johannes Laurentius / Antikensammlung, Staatliche Museen, Berlin / Art Resource, NY.

PLATE 10 (FIG. 6.8). Prometheus, seated, constructing the first human skeleton, using a mallet to attach the arm bone to the shoulder. Carnelian intaglio gem, date unknown, perhaps Townley Collection, inv. 1987,0212.250. © The Trustees of the British Museum.

PLATE 11 (FIG. 6.11). Prometheus using a mallet to make a skeleton, chalcedony gem, first century BC, Thorvaldsens Museum, Denmark, acc. no. 185.

PLATE 12 (FIG. 8.3). Epimetheus and Pandora, right; on left, Zeus and Hermes exchange a conspiratorial smile. AN1896–1908 G.275 attributed to the Group of Polygnotos, Attic red-figure pottery volute-krater, about 475–425 BC. Image © Ashmolean Museum, University of Oxford.

PLATE 13 (FIG. 8.4). Zeus holding Pandora, with goddess (Athena?) and Hermes. Attic black-figure amphora, Diosphos Painter, about 525–475 BC, F 1837. Bpk Bildagentur / Photo by Johannes Laurentius / Antikensammlung, Staatliche Museen, Berlin / Art Resource, NY.

PLATE 14 (FIG. 8.7). Detail, Pandora admired by gods and goddesses, on the red-figure calyx krater by the Niobid Painter, about 460 BC, inv. 1856,1213.1. © The Trustees of the British Museum.

FIG. 9.1. Phalaris, the tyrant of Agrigentum, Sicily, burns the clever craftsman Perilaus in his own creation, the Brazen Bull. "Perillus condemned to the bronze bull by Phalaris," sixteenth-century woodcut by Pierre Woeiriot de Bouze. HIP / Art Resource, NY.

The horror of the Brazen Bull has a familiar ring, sounding mythic echoes from previous chapters. A hyperrealistic bull statue brings to mind the artificial cow created by Daedalus for Queen Pasiphae (chapter 4). Like Pasiphae's fake heifer, Phalaris's Brazen Bull was animated by the living human encased inside.[12]

Even more compelling mythic comparisons to the Brazen Bull would be the two deadly bronze automata created by Hephaestus for other powerful royal patrons. King Aeetes hoped to incinerate Jason with his awesome pair of fiery bronze bulls. And recall that King Minos's bronze automaton Talos could heat his body fiery-hot and crush victims to his chest, roasting them alive. Did the mythic parallels to Phalaris's bronze bull also occur to people in antiquity? In the absence of any surviving texts expressing direct links to the myths, that is unknowable but not implausible. Ancient tales and traditions about bronze bulls and heated metal statues were certainly pervasive in popular culture by the time of Phalaris.

Moreover, it turns out that artificial bulls were prominent talismans in the founding mother city of Phalaris's Acragas. Acragas was founded by colonists from Rhodes; Phalaris's father was born there. The island was well known for extraordinary feats of mechanical engineering, such as the Colossus of Rhodes (chapter 1). Evidence indicates that the complicated bronze astronomical calculating machine with thirty gears, the Antikythera mechanism, known as the world's first analogue computer, was made between the third and first centuries BC in Rhodes.[13] As we saw in chapter 5, Rhodes was also renowned for its animated bronze statues, celebrated in Pindar's poem (*Olympian* 7.50–54):

> The animated figures stand
> Adorning every public street
> And seem to breathe in stone
> Or move their marble feet

Among the wonders of Rhodes were two life-size bronze bulls. Were these bulls the prototypes for the Brazen Bull created for Phalaris of Acragas? The bronze bulls of Rhodes stood guard on the island's highest peak, Mount Atabyrios. (Guardians made of bronze were common in antiquity, chapter 1). We know that Phalaris was involved with the construction of the Temple of Zeus Atabyrios in Acragas, which was named for the mountain in Rhodes guarded by a pair of bronze bulls. But even more striking, the bulls of Rhodes were ingeniously manufactured to bellow. The bull sentries served as signal horns—they "bellowed loudly to warn the Rhodians of the approach of enemies."[14] A configuration of tubes in the bulls amplified the voices of human watchmen stationed on

the mountain. It is not impossible that the Brazen Bull of Acragas was perversely designed with similar pipes to transform the victim's screams into bellowing sounds.

Signal horns and other megaphonic devices to augment the human voice were devised in various cultures of the ancient world. The artificial amplification of human voices to convey messages was attributed to Alexander the Great, who employed an enormous bronze horn or megaphone suspended on a large tripod to send signals in any direction to his army, several miles distant. The instrument was named after the prodigiously loud herald named Stentor in the mythic Trojan War (Homer *Iliad* 5.783). An exaggerated stentorophonic device also turns up in medieval legends about Alexander, whose phenomenally loud war trumpet, sometimes called the Horn of Themistius, could summon an army sixty miles away.[15]

More melodious mechanized sounds were also possible, emanating from a number of statues and automata, recalling the legendary singing maidens on the temple at Delphi (chapter 7). One example of a noisemaking statue is particularly appropriate here, namely, the statue of Athena created by the sculptor Demetrios (fourth century BC). According to Pliny (34.76) the statue was dubbed the "musical" or "bellowing" Athena (*musica* or *mycetica*—the manuscript is unclear). Strange sounds were said to emanate from the writhing serpents in the hair of the fierce Gorgon on the goddess's shield.[16]

A fascinating archaeological discovery in Cairo, Egypt (1936), reveals how some speaking and singing statues worked in antiquity. A large limestone bust of the sun god Ra-Harmakhis has a cavity in the back of the neck from which a narrow canal leads to an opening on the right jaw under the ear. The archaeologists speculate that a priest hiding behind the statue spoke into the cavity and tube, which modified his voice to make it seem that the god delivered oracles.[17]

A sublime song at dawn was said to issue from one of the Colossi of Memnon in Egypt, a pair of gigantic seated stone statues, sixty feet high,

which were a tourist attraction in antiquity. Amenhotep III (Eighteenth Dynasty) erected the twin statues of himself in about 1350 BC at his temple on the Nile at Thebes. The Egyptians called the "singing" statue Amenophis, Phamenophes, or Sesostris; the Greeks called it Memnon. It was the northern statue—broken after the earthquake of 27 BC—that produced a marvelous tone or "voice" at dawn. In Greek myth, Memnon was the son of the goddess Eos and her undying mortal lover, Tithonus (chapter 3). As king of the Ethiopians, Memnon allied with the Trojans in the Trojan War. Some observers fancied that the speech or song uttered by Memnon's statue at sunrise was meant to console his mother, Eos, "Dawn." The rays of the sun made his eyes gleam, and the sound was heard "as soon as the sunbeam reached his lips." Visitors experienced the eerie sense that Memnon was on the verge of rising from his throne to greet the new day.[18]

The Roman historian Tacitus (*Annals* 2.61) noted that when struck by the sun's rays, Memnon "gives out the sound of a human voice, while the pyramids, made by the vast wealth of kings, loom like mountains in the impassable wastes of shifting sand." Some proposed that the sound was the result of the sudden expansion of the stone from the heat of the rays of the rising sun, perhaps activating internal levers that were attached to vibrating strings. (Perhaps a similar effect caused the Golden Charmers to "sing" at Delphi, chapter 7). Visiting the statues at sunrise in about 26 BC, the geographer Strabo and his friends (17.1.46) heard the sounds but could not be sure whether they came from the statue or from someone standing at the base. The main character in Lucian's satire *Philopseudes* (33; second century AD) claims to have heard a "prophecy" uttered by Memnon at dawn,

FIG. 9.2. The Colossi of Memnon, Thebes, Egypt, photo by Felix Bonfils, 1878. HIP / Art Resource, NY.

although "most visitors only hear unintelligible sounds." In AD 80–82, a Roman centurion named Lucius Tanicius inscribed the dates and times when he heard the song on thirteen visits. Many other ancient tourists left graffiti on the singing colossus—the last datable inscription is from AD 205. Some commentators maintained that after Emperor Septimius Severus restored the statue in AD 200, Memnon's song was never heard again, but the Christian Fathers Theodoret, Jerome, and others insisted that all the old Egyptian idols ceased to speak when Jesus was born.[19]

As we've seen, there were many ways to cause statues to appear to move, speak, or give the illusion of being alive.[20] Paul Craddock (an expert on ancient Near Eastern metallurgy) speculated that such "temple tricks" might have included making an idol that produced a tingling sensation when touched. Craddock's theory attempted to account for the enigmatic objects known as "Baghdad Batteries" discovered in 1936–38 in Iraq. The artifacts are thought to be either Parthian (ca. 250 BC to AD 240) or Sassanian (AD 224–640). The objects are controversial: some historians take them as evidence of early Persian experimentation with electricity. Unfortunately, the artifacts vanished in the looting of Baghdad's Iraq Museum in 2003, but written descriptions, diagrams, and photographs provide the details.

The small terra-cotta jars, each about five inches long, contain cylinders made of iron rods encased in rolled sheets of copper, sealed at the top with asphalt (bitumen) and at the bottom with a copper disc and asphalt: the copper-wrapped iron rod projects above the asphalt at the top. The jars' inner walls show evidence of corrosion. No wires were recovered: they may have been overlooked or corroded away. It is worth noting that very thin bronze "needles" have been found with similar jars (lacking cylinders) in the same region. The materials and construction seem to suggest a primitive galvanic cell. Modern experiments demonstrate that replicas of the Baghdad batteries produce a feeble 0.5 volt current, using a 5 percent electrolyte solution, with substances available in antiquity such as grape juice, vinegar, wine, or sulfuric or citric acid. If strung together and connected, a cluster of the jars might produce a higher output, enough to give a mild shock akin to static electricity.

The purpose of the cells is unknown; some suggest a medical function, while others propose a magical or ritual use. In Craddock's speculative scenario, if the jars were really electrical cells and were hidden and activated somehow inside a metal statue, the figure would seem charged with mysterious life and power. Anyone who touched it would be awed by a sensation of warmth, a strange buzzing vibration, and perhaps even a subliminal blue flash of light in a darkened chamber.[21]

Between the third century BC and the first century AD, fluctuating notes that imitated birdsong were made to issue from the beaks of realistically painted models of birds designed by Philo and Heron, famed inventors in Alexandria, Egypt, whose works are further described below. But even earlier, people were excited by an artificial bird capable of flight. This automaton was attributed to a philosopher-scientist-ruler named Archytas (ca. 420–350 BC), an associate of Plato. Archytas lived in Tarentum, a colony founded by Greeks in the heel of southern Italy.[22] Admired for his intelligence and virtue, Archytas was elected to the office of *strategos*, general, and he is thought to have influenced the idea of philosopher kings in Plato's *Republic*. Aristotle refers to Archytas's theories in several treatises, but Archytas's own writings no longer survive except in scraps.[23]

Horace addresses a poem to Archytas (*Ode* 1.28, "the Archytas ode"), and many ancient sources discuss Archytas, but a work by Aulus Gellius (writing in the second century AD) is the only extant text to describe the first self-propelled flying machine in the shape of a dove. What Archytas "devised and accomplished is marvelous" but not impossible, comments Aulus Gellius (*Attic Nights* 10.12.9–10). Aulus Gellius quotes "the philosopher Favorinus, a studious researcher of ancient records," who stated that Archytas "made a flying wooden model of a dove in accordance with mechanical principles." The Dove was "balanced with counterweights and moved by a current of air enclosed within it." The bird flew some distance, but "when alighted it could not take off again." Here, I'm sorry to report, the passage breaks off, and the rest of the text is lost.

Archytas's pathbreaking work on mechanical mathematics, cubes, and proportions allowed the creation of scale models. Much has been written by modern philosophers and historians of science on Archytas's

principles of mechanics. The Dove appears to have been a plausible historical device. Mechanical engineers speculate that Archytas's Dove may have been tethered to a cord or stick and powered by steam or compressed air in a tube or metallic bladder controlled by a valve. It had to be reset after each flight (there is no evidence that the Dove had movable wings). A "reasonable reconstruction" of the Dove discussed by Carl Huffman in 2003 suggests that the bird was "connected by a string to a counterweight through a pulley" and its "motion was initiated by a puff of air that caused the dove to fly from a lower perch to an upper perch." Another hypothetical reconstruction, by Kostas Kotsanas, uses steam or compressed air to launch an aerodynamic bird.[24]

It is interesting to compare Archytas's Dove to two other historical mechanical devices from the fifth and fourth centuries BC, in the district of Elis in the Peloponnese, Greece, where the Olympic Games were held. The first mechanism featured a bronze eagle and dolphin. These figures were the moving parts of the ingenious starting gate for horse and chariot races in the Hippodrome at the Olympic Games. The eagle-and-dolphin mechanism was still operating in the second century AD, when Pausanias (6.20.10–14) described the starting gate. An official operated the machinery from an altar at the gate. To signal the start of the race, the eagle with outstretched wings suddenly flew up in the air and the dolphin leaped down, in view of the spectators. The device was originally made by the Athenian sculptor-inventor Cleoetas (480–440 BC) and later improved by Aristeides, a fourth-century BC artisan. Much admired for his hyperrealistic human statues with minute breathtaking details, such as inlaid silver fingernails, Cleoetas worked with the renowned Athenian sculptor Phidias to create the colossal gold and ivory statue of Zeus at Olympia in 432 BC (their workshop was discovered by archaeologists in the 1950s at Olympia; Phidias also created the enormous chryselephantine Athena statue in the Parthenon, chapter 8). It is likely that the eagle and dolphin on the starting gate were quite lifelike and, like Archytas's Dove, they must have been somehow tethered.

Elis also boasted a spectacle that took place during the Dionysia festival celebrating the god of wine. According to Pseudo-Aristotle (*On Marvelous Things Heard* 842A123), festival goers were invited into a building about a mile from the city to examine three large, empty copper cauldrons. When the people came out, the Elean officials then

ostentatiously locked and sealed the building. After a while, the doors were unlocked and visitors allowed to reenter the building. They were surprised to find the three cauldrons now "magically" filled with wine. "The ceiling and walls appear to be intact, so that no one can discern any artifice." The trick apparently involved a hidden hydraulic technology of pumping the wine into the vessels. The date is unknown, but the description appears in a collection of notes gathered by Aristotle's students and followers.

As for Archytas, alongside his military, political, and scientific accomplishments in mathematics, geometry, harmonics, and mechanics, he was also credited—by Aristotle—with inventing a popular children's plaything, the clacking noisemaker known as the "clapper."[25] His toy clapper and his technological showpiece, the flying Dove, demonstrated mechanical principles while providing a delightful diversion—a welcome alternative to the cruel automata of other rulers.

A deceptively frivolous automaton of an invertebrate creature was constructed in Athens under oppressive Macedonian rule in the late fourth century BC. Demetrius of Phaleron was appointed to govern Athens by the Macedonian king Cassander in 317 BC. A well-educated orator who was a younger contemporary of Aristotle, Demetrius was sole ruler of Athens until he was forced into exile in 307 BC. He ended up in Alexandria, Egypt, where he was involved in establishing the great library and museum of Alexandria, where many inventors worked (see below). Demetrius later fell out of favor in Alexandria too, and was exiled to the hinterlands where he died of snakebite, about 280 BC.[26]

As tyrant of Athens, Demetrius was arrogant, given to excess and extravaganzas. Naturally, he despised democracy and he disenfranchised poor citizens. According to a lost history of the time by Democharés, a rival Athenian orator who defended democracy, in 308 BC Demetrius commissioned a moving replica of a giant land snail that "worked by some internal contrivance."[27] The Greek historian Polybius (12.13) tells us that this Great Snail led the traditional ceremonial procession of the Dionysia, Athens' great drama festival. Moving from Plato's Academy outside the city walls to the Theater of Dionysus, it traveled a distance

of about 1.8 miles. The composition of the snail and its inner works are not detailed in Polybius's account. But the phrase "internal contrivance" suggests some self-propelling mechanism. In 1937, Alfred Rehm proposed that a man walking on a treadmill and another to steer were concealed inside the model of the large mollusk. Treadmills existed in antiquity; the massive, mobile "city-taker" siege machine, built in 323 BC by Posidonius for Alexander the Great, might have relied on a treadmill, and a Roman relief of the first century AD shows a huge construction crane powered by many men inside a large treadmill. But Rehm's theory is still debated.[28]

Why bother to create a gigantic moving replica of a lowly snail? One might note that the Dionysia festival was held in winter, when the rains begin and dormant land snails emerge in large numbers to crawl about, so real snails on the move would be conspicuous everywhere in Athens. Demetrius's oversized snail was so "realistic" that it even left a trail of slime as it inched along the route. This special effect would be easily achieved with a reservoir of olive oil released from a hidden pipe.

The most significant detail is the fact that the Great Snail was followed by a group of donkeys in the procession. This pairing of snail and asses would be part of the snide joke. Snails were proverbially slow, and because they carried their homes on their backs, they stood for impoverishment. Donkeys were associated with dull-witted, lazy slaves who work only when beaten.[29] As Democharis remarked (Polybius 12.13), the point of Demetrius's spectacle was to taunt "the slowness and stupidity of the Athenians." The Great Snail itself was harmless, but it was a dramatic and public way for the tyrant to humiliate the Athenians, whose democracy was being crushed by Macedonians and their collaborators.

A century later, in 207 BC, in Sparta, southern Greece, a malevolent dictator named Nabis seized power and ruled until 192 BC. His reign was long remembered for his barbarous acts, exiling, torturing, and killing masses of citizens. Nabis and his imperious wife, Apega (probably Apia, daughter of the tyrant of nearby Argos), collaborated to extort valuables and money from people under their rule. Their story is told by Polybius,

FIG. 9.3. Portrait of Nabis on silver coin, ruler of Sparta, 207–192 BC, inv. 1896,0601.49 © The Trustees of the British Museum.

a native of southern Greece who was born around the time of their overthrow. According to Polybius, Apega "far surpassed her husband in cruelty." When Nabis dispatched Apega to Argos to raise funds, for example, she would summon the women and children and then personally inflicted physical torture until they gave up their gold, jewels, and costly possessions (Polybius 13.6–8, 18.17).

As tyrant, Nabis welcomed a stream of nefarious characters, including pirates from Crete, to his kingdom.[30] Perhaps it was one of these opportunists who manufactured, on Nabis's orders, a mechanical Apega, a "machine" made to "resemble his wife with extraordinary fidelity" (Polybius 13.6-8, 16.13, 18.17). Inspired by his wife's deeds, "Nabis invented a female robot as evil and deceptive as Pandora," comments Sarah Pomeroy, a historian of Spartan women. The automaton was clothed in Apega's expensive finery. We can imagine that the artisan painted a plaster cast or wax model of Apega's own face to carry off the effect.

Nabis would summon wealthy citizens and ply them with wine while urging them to turn their property over to him. If any guest refused to comply, Nabis would say, "Perhaps my lady Apega will be more successful in persuading you." At the appearance of the replica of Apega, the inebriated guest would offer his hand to the seated "lady." She stood up, which triggered springs to raise her arms. Standing behind Apega, Nabis manipulated instruments in her back to cause her arms to suddenly clasp the victim. Working levers and ratchets, Nabis then tightened the false Apega's deadly embrace, drawing the victims closer by degrees. The fancy clothing hid the fact that the palms of her hands, her arms, and her breasts were studded with iron spikes, driven deeper into the victim's body by the increasing pressure. With this impaling device in the form of his wife, "Nabis destroyed a good number of men who refused his demands," wrote Polybius (13.6–8).[31]

By the time Nabis and Apega came to power, the late third century BC, many inventors and engineers in the Mediterranean world were already designing animated statues and other clever devices for peace and war. An example of a fourth-century apparatus, the ingenious *kleroterion* (a "randomization" device for selecting citizens to serve in civic offices) has survived. Along with the aforementioned Antikythera device, this lottery machine represents the tip of the iceberg; a great many other practical technological experimentations and other innovations have left no physical traces but were described in ancient texts.

By the fourth and early third centuries BC, military engineers in Italy, Carthage, and Greece had developed crossbow artillery and powerful torsion catapults, based on complex mechanical formulas and springs, for rulers such as Dionysius of Syracuse and Philip II of Macedonia. For his attempted conquest of Rhodes in 305 BC, Demetrius Poliorcetes, "Besieger of Cities," had his engineers construct the tallest mechanized siege tower ever built. Equipped with 16 heavy catapults and weighing about 160 tons, the iron-plated wooden "City Taker" required relays of more than 3,000 men to activate. Demetrius also deployed a gigantic battering ram manned by 1,000 soldiers. Archimedes of Syracuse is perhaps the most famous engineer of the Hellenistic era, devising numerous geometry theorems and designing a host of amazing machines utilizing levers, pulleys, screws, and differential gears, and ranging from astronomical apparatus and odometers to heat rays that ignited invading navies and the Claw, a massive grappling hook on a crane to grab and sink enemy ships.[32]

Given this rich legacy of classical and Hellenistic inventions, it seems safe to assume that Nabis's lethal Apega machine was modeled on technological precedents. The Apega replica was self-moving owing to springs that caused her to stand up and raise her arms; Nabis controlled the mechanisms to give the impression that the figure was operating under its own power. The Apega automaton was not heated but could kill victims by forcible embrace, recalling the way the mythical bronze robot Talos crushed people to his chest. Some historians have wondered whether the Apega device was an inspiration for the Iron Maiden, "Eiserne Jungfrau," the imaginary medieval torture/execution device, a metal cabinet shaped like a female with a spiked interior.

After the assassination of Julius Caesar in 44 BC, Rome was in turmoil. Marc Antony delivered the dramatic funeral oration over the bier in which Caesar's ravaged corpse lay out of sight. The historian Appian (*Civil Wars* 2.20.146–47) described the effects of the speech on the populace. Declaiming "in a kind of divine frenzy" and carried away by "extreme passion," Marc Antony grabbed a spear and with the point lifted the robe from Caesar's body and held it aloft so all could see the bloodstained cloth pierced with dagger thrusts. The mourners raised loud lamentations.

But the theatrical performance was not over. A hidden actor impersonating Caesar's voice recited the names of his murderers, further roiling the audience. Then from the coffin slowly rose the ravaged body of Caesar. It was an effigy made of wax, realistically displaying the twenty-three brutal knife wounds. The pièce de résistance followed, as the effigy rotated "by a mechanical device to display the pitiful sight." Crazed with rage and grief, the crowd rushed out to set fire to the Senate where Caesar was slain and tried to burn down the houses of the assassins. The sensational stagecraft of an automated, bloody, wax mannequin in Caesar's image was carefully orchestrated by Caesar's allies to manipulate the populace.

Some monarchs in the ancient Greco-Roman world were enthusiastic patrons of science and devised spectacles of animated statues in order to demonstrate their vast power and grandeur. Such wondrous machines told the world that the king could achieve the impossible.

One thwarted example of a Hellenistic ruler's attempt to glorify himself by means of a mechanized spectacle occurred during the reign of King Mithradates VI of Pontus, known for his prodigious ego and love of marvelous machines. Mithradates attracted the best craftsmen, scientists, and engineers to his court in the first century BC. His engineers built stupendous naval and siege machines, and the famous Antikythera device was looted from his kingdom by the Romans (70–60 BC). In about 87 BC, to celebrate his defeat of Roman forces in Greece, Mithradates commissioned a grandiose pageant. Bearing in mind classical Greek images of the winged goddess Nike hovering over victors' heads, the royal engineers created an immense statue of the goddess, suspended on cables

out of sight. Similar deus ex machina technology was used on the stage in classical Greek theatrical performances, but this scheme was off the scale. At the climax of the festivities, the massive Winged Nike would dramatically descend, by a series of pulleys and levers, stretch out her hands and place a victor's crown on Mithradates's head, and then majestically ascend to the heavens. That was the plan. But the cables failed and Winged Victory smashed to the ground. The miracle was that no one was harmed, but the terrible omen was inescapable.[33]

A memorable, and in this case wildly successful, display of an autocrat's power took place in third-century BC Egypt, orchestrated by Ptolemy II Philadelphus (283–246 BC), of the powerful Hellenistic Macedonian Greek dynasty that ended with the famous queen Cleopatra in 30 BC. The Ptolemies were avid supporters of the arts and sciences at the new international research center in Alexandria, the library and museum complex founded in about 280 BC (it was mostly destroyed by fire in about 48 BC). Under the Ptolemies, Alexandria became the hub of scientific investigation, and the birthplace of machines, with mechanized public showpieces for theaters, processions, and temples, especially animated statues and automated devices.[34]

Ptolemy II Philadelphus married his sister, Arsinoe II, in 278 BC. As we saw, after her death he declared her a goddess and commissioned a miraculous floating statue of her (allegedly using magnets, chapter 5). But Ptolemy II's reign from 283 to 246 BC is most remembered for the outrageous splendor of his Grand Procession of 279/78 BC, a seemingly endless parade of exotic creatures, living tableaux, costumed dancers, and stunning automated displays that took place over several days. According to descriptions in a history of Alexandria by Callixenus of Rhodes (a contemporary of Ptolemy II who may have attended the event), the magnificent panorama included two dozen golden chariots drawn by elephants, followed by ostriches, panthers, lions, giraffes, and other animals, and a multitude of massive carts or floats, hundreds of performers dressed as satyrs and maenads and other mythic figures, larger-than-life realistic statues of divinities (including Alexander the Great), and engineering marvels. Sadly, like so many ancient texts

crucial to our understanding of artificial life and automata in antiquity, Callixenus's works have vanished. But parts of his extensive account of the parade are preserved by the second-century AD author Athenaeus (*Learned Banquet* 5.196–203).[35]

Ptolemy's Grand Procession celebrated the Greek god of wine, Dionysus, and featured scenes from his mythology. Observers were dazzled by an enormous statue of Dionysus, 15 feet tall, holding out a huge golden goblet overflowing with wine, surrounded by a crowd of satyrs and Bacchantes, singers, and musicians. Another float bearing an immense winepress, about 30 feet long and 20 feet wide, was pulled by 300 men, while 60 men disguised as satyrs trampled the grapes. There was a vast wineskin made of leopard pelts borne on a heavy cart pulled by 600 men, while a continuous stream of wine poured out along the route. Yet another float featured two fountains gushing wine and milk (like those attributed to Hephaestus in Greek myth). The profusion of amazing and costly automated objects and statues on such a staggering scale evoked ancient versions of Uncanny Valley sensations. They fostered the illusion that all these constructions were being animated by the gods and goddesses themselves, giving the impression that Ptolemy could summon divine presences to celebrate his coronation.

After the cart carrying Dionysus, another astounding sight hove into view: a float with a gigantic seated female statue of Nysa, wearing a golden crown and draped in yellow-dyed garments covered in gold spangles. This Nysa was a true self-moving mechanical automaton. Periodically along the route Nysa stood up, poured a libation of milk from a golden *phiale*, and sat down again. She did this "without anyone putting their hands on the statue," commented Callixenus.

Who was Nysa? Nysa was the name of the mountain where the infant Dionysus was raised, nourished by rain nymphs. In the Hellenistic period, the mountain was personified as Nysa, Dionysus's nursemaid, so it was logical that she accompanied the god, dispensing milk.

The huge Nysa automaton, 12 feet high when seated, and the large reservoir for milk would have been heavy. Indeed, Nysa's cart was reportedly 12 feet wide and pulled by 60 men. Like the other oversized statues, Nysa was not bronze or marble but fabricated of terra-cotta, wood, plaster, and wax and realistically painted. To operate faultlessly and in a dignified manner for the entire length of the slow-moving procession

(estimated to have been about 3 miles long), the automaton mechanism, as modern engineers agree, must have been technologically robust.

How did the Nysa automaton work? In 2015, historians of mechanical engineering Teun Koetsier and Hanfried Kerle analyzed and diagrammed several hypothetical designs. If the statue was 12 feet high when sitting, it would have been 15 feet tall when standing. Assuming it was powered by mechanical means and with components available at the time, they conclude that a complex arrangement of cams, weights, and a sprocket chain or gear wheels were carefully timed to make Nysa rise from her chair, pour milk, and sit down in a slow, stately manner.

Who made the unprecedented Nysa automaton, one of world's first working robots? The ancient sources do not say. One candidate was the engineer Ctesibius, thought to have been the first director of the museum at Alexandria. No writings by Ctesibius survive, sad to say, but his inventions, based on hydraulics (pumps, siphons) and pneumatics (compressed air), were very highly regarded, described by Vitruvius, Pliny, Athenaeus, Philo of Byzantium (who worked in Alexandria), Proclus, and Heron of Alexandria. Ctesibius was active in 285–222 BC, and he created a pneumatic drinking horn in a temple honoring Ptolemy II's late wife, Arsinoe II. Ctesibius, or some of his colleagues, would seem to be the most likely builders of the Nysa robot in Ptolemy's Grand Procession.[36]

What about Philo of Byzantium (Philo Mechanicus), the eminent Greek engineer and writer who lived most of his life in Rhodes and Alexandria? His exact dates are unknown, but it is now believed that Philo was born about 280 BC, making him a bit too late for Ptolemy II's Grand Procession. Philo's impressive list of machines and plans for self-moving devices in the forms of humans and animals were greatly admired in antiquity and the Middle Ages and are still studied today.[37]

Philo's compendium of mechanical works ranged from siege towers to theatrical machines, and he designed a host of devices and automata. Most of his treatises have been lost, but the plans and instructions were preserved in later sources, by Heron and Islamic writers.[38] We've already met Philo's version of the god Hephaestus's robotic assistants, a realistic life-size serving maid with the ability to pour a cup of wine and then

dilute it with water (chapter 7). That self-moving mechanical woman of the third century BC has been hailed as the first man-made "robot," although the Nysa automaton preceded her by some years. Philo preferred to make cunning miniature mechanisms, all the more astounding because of their small scale.

One of Philo's pieces features an artificial bird that chirps when an owl turns to face it and falls silent when the owl turns away. The mechanism depends on water poured into a vessel to displace air, which is forced out through a small pipe to the bird's beak; oscillating wavelengths produce notes with different frequencies. A rotating shaft controlled by the water level causes the owl's rotation. Philo also designed a bird that raises its wings in alarm as a snake approaches its nest. Pouring water into a reservoir lifts a float connected by a rod to the bird's wings. Yet another enchanting automaton depicts a dragon that roars when a figure of Pan faces it, and relaxes when Pan turns away (a variant features a deer drinking while Pan is turned away).[39]

Philo was a strong influence on another leading Alexandrian inventor, Heron of Alexandria (AD 10–70), many of whose writings and designs for engines, machines, and automata still survive. Heron assembled amazing machines enacting charming mythic vignettes, using hydraulics and other mechanisms to make them move in complex ways. He also created "Dionysian" devices that appeared to produce wine spontaneously, recalling the self-filling cauldrons in Elis and the wondrous spectacles in Ptolemy's Grand Procession, described above. Heron famously advised fellow engineers to make small automata so that no one could suspect that they were worked by a person hidden inside. In his treatises *On Making Automata* and *Pneumatica* Heron describes stationary and moving devices with complex forms of motion, including "snake-like" movements. His instructions and specifications permit engineering technicians to construct working models.[40]

A typical assemblage designed by Heron features a bronze Heracles shooting an arrow at a bronze serpent that hisses when struck. Heron also devised miniature automatic theaters. The theater rolled onto a stage by itself, stopped, and performed with "fires flaring on altars, sound effects, and little dancing statues"; then it rolled offstage. It has been called the first programmable device.[41] To initiate the chain reactions that create a series of sights and sounds on the little stage, the operator simply pulls a

string to activate a steadily descending lead weight in a sand *clepsydra* (a mechanism based on liquid or sand draining at a steady pace) and then steps aside as spectators observe the spellbinding show (see fig. 9.4 for a working replica of the theater). The stage doors automatically open and close on five scenes of a little Trojan War tragedy titled *Nauplius*. First, shipbuilders are seen and heard hammering and sawing wood. Next the men push the ships into the sea. Now rocking ships sail on a rough sea with leaping dolphins. A torch signal lures the ships to a rocky shore at night, and in the last act the Greek hero Ajax is seen swimming amid wrecked ships while Athena appears on the left and disappears stage right. Suddenly lightning strikes Ajax and he vanishes in the waves.[42]

These exquisitely constructed mechanical dramas made by Philo and Heron reproduced in reality some of the phantasmagoric imaginary panoramas on Pandora's golden crown and Achilles's shield made by Hephaestus. As described in Homer's *Iliad* and *Odyssey*, the god constructed lifelike miniature people and creatures that seemed to move and make sounds (chapters 5, 7, 8).

Many of the designs for automata devised by Philo and Heron were preserved in early medieval Arabic and Islamic texts—for example, by the Banu Musa brothers in Baghdad (ninth century AD, Iraq) and al-Jazari in the twelfth century. These Hellenistic and medieval Near Eastern influences on European automata and machines of the Middle Ages have been extensively studied.[43] Mechanical innovations in early China are also well documented by historians. By the third century BC in China, for example, Qin dynasty (221–206 BC) artisans had developed mechanized puppets and other devices. In about AD 250, the engineer Ma Jun invented a precise south-pointing figure in a gear-driven chariot and a puppet theater powered by a waterwheel.[44]

During the Tang dynasty (AD 618–907), technological advances resulted in a profusion of sophisticated automata and self-operating devices. Typical examples include an iron mountain with hydraulic pumps to spew liquor from a dragon's mouth into a goblet and a fleet of moving boats with automated servants to pour wine. Tang engineers created many automatic devices for Empress Wu Zetian (r. AD 683–704). A Buddhist convert,

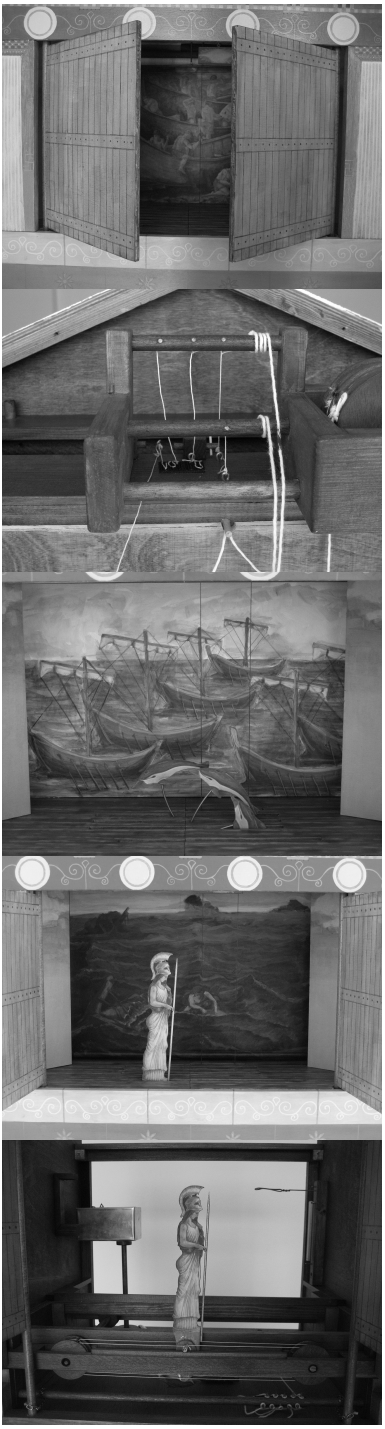

FIG. 9.4. Replica of the automated Theater of Heron of Alexandria, based on Philo's designs. Top, the theater doors open to reveal the sights and sounds of shipbuilders hammering and sawing, controlled by inner workings. Center, ships rock on the choppy sea with leaping dolphins. Next, Ajax drowning amid the wrecked ships, with Athena moving in the foreground. Bottom, mechanism for moving Athena. Working model constructed by Kostas Kotsanas, courtesy of the Kotsanas Museum of Ancient Greek Technology.

Empress Wu sought to emulate and surpass the veneration of Buddha's relics in India by King Asoka, the great ruler of the Mauryan Empire in the third century BC. Many legends had grown up around Asoka and were brought back to China by Chinese Buddhist pilgrims. One of the most intriguing legends about Asoka involves mechanical beings.[45]

Robotic guardians appear in Buddhist legends set in India during the time of the historical kings Ajatasatru and Asoka. Both rulers were entrusted with safeguarding the precious relics of Buddha, whose death occurred sometime between 483 and 400 BC. The Indian legends are remarkable, not only because they describe mechanical warriors defending the bodily remains of Buddha, but because the stories explicitly link the robots to automata invented in the Hellenistic Greco-Roman world. This unexpected historical and geographical connection invites deeper investigation.

King Ajatasatru of Magadha (northeastern India) reigned from about 492 to 460 BC, in his fortified capital of Pataliputta (the city's ruins lie under modern Patna). According to Buddhist traditions, he met Buddha and became his devotee. After Buddha's death and cremation, Ajatasatru constructed a vast *stupa* (dome) over a deep underground chamber containing the holy ashes and bones. Then, it is said, Ajatasatru devised special defenses to protect Buddha's relics. Traditional Hindu and Buddhist architecture featured armed guardians of doors and treasures (*dvarapalas* and *yakshas*), sometimes sculpted in the form of giant warriors (fig. 9.5).

But Ajatasatru's guardians were extraordinary. He had his engineers in Pataliputta make a set of automaton warriors to defend the remains of Buddha. It is worth mentioning that according to ancient Jain texts Ajatasatru deployed novel military inventions: examples include a powerful catapult that hurled massive boulders and a mechanized, heavily armored war chariot, something like a "tank" or "robot," which wielded whirling maces or blades. His automaton guards were also said to have whirling blades.[46]

The legend relates that it was predestined that Ajatasatru's automaton guards would remain on duty until a future ruler—King Asoka—would discover and disable the robots, gather up the sacred relics of Buddha,

FIG. 9.5. Two traditional *dvarapala-yaksha* guardian warriors armed with spears on either side of a table holding Buddha's relics, panel relief, Kushan, Gandhara, Swat, first to second century AD, inv. 1966,1017.1 © The Trustees of the British Museum. The panel relief is flanked by a pair of six-foot-tall guardian warriors, found at ancient Pataliputta, Mauryan Empire, third to first century BC, plate 13, E. J. Rapson, *Cambridge History of India* (1922). Collage by Michele Angel.

and distribute them among tens of thousands of shrines throughout the realm. King Asoka (304–232 BC) ruled the powerful Mauryan Empire from about 273 to 232 BC in Pataliputta and became a follower of Buddha. During his long reign, Asoka constructed many *stupas* to enshrine a multitude of Buddha's relics across his vast kingdom, fulfilling the prophecy of Ajatasatru.[47]

Several Hindu and Buddhist texts in various translations describe Ajatasatru's automaton warriors guarding the relics until the arrival of Asoka. The wooden androids were said to whirl with the speed of the wind, slashing intruders with swords. Some traditions attribute their creation to Hindu divinities: Visvakarman, the engineer god, or Indra, the guardian god. But the most arresting and mysterious account of the robot guards has come down to us through a tangled route: it appears in the collection of tales known as the *Lokapannatti* from Burma, a Pali (sacred language) translation of an older, lost Sanskrit text, which is itself known only from a Chinese translation. The dating of the *Lokapannatti* is uncertain, perhaps eleventh or twelfth century, but the stories "drew

on a rich store of 'legends' about Asoka," a "large variety" of much older oral traditions and lost texts.[48]

The tale recounts that many *yantakara* (robot makers) lived in the land of the *Yavanas* (Greek-speakers; people of the West) in *Roma-visaya*, the "kingdom of Rome," a generic term for the West, namely, Greco-Roman-Byzantine culture. The *Yavanas*' secret technology of robots (*bhuta vahana yanta*, "spirit movement machines") was closely guarded by their government. In "Rome," robots carry out trade and farming, and they capture and execute criminals. No robot makers are ever allowed to leave "Rome" or reveal their secrets—if they do, robot assassins will pursue and kill them. Rumors of the fabulous Roman robots reached India, inspiring a young artisan-engineer who wished to learn how to make automata. The young man lived in Pataliputta. As noted above, Pataliputta was the large fortified city built by King Ajatasatru in about 490 BC. It reached a peak of prosperity as King Asoka's capital in the mid-third century BC.

By magical plot contrivances the young man of Pataliputta fulfills his vow to be reincarnated in "Rome"—the Greek-influenced West. He marries and has a son with the daughter of the master robot engineer in Rome. He learns the robot maker's craft. Then he steals the plans for making robots, sews the papyrus under his skin, and departs for India. Knowing that he will be killed by pursuing robot assassins before he can reach India, he has already instructed his son to take his corpse back to Pataliputta. His son does so, and retrieves the plans. The son creates an army of automated soldiers for King Ajatasatru to protect Buddha's relics hidden in a deep underground chamber of the secret *stupa*.

The hiding place and the robots fall into long obscurity. Then one day Ajatasatru's descendant, the great emperor Asoka, hears the story of Buddha's hidden relics and the prophecy. Asoka searches everywhere until he discovers the *stupa* with the underground chamber guarded by the fierce android warriors. In the meantime, the Roman emperor learns of the theft of Western technology: Why, he wonders, does the secret technology in India so closely resemble our own? The Roman emperor sends a gift containing a robot assassin to kill Asoka, but it is thwarted. Violent battles ensue between Asoka and the automaton guards in the underground chamber. Finally, Asoka locates the miraculously long-lived engineer's son, who shows him how to dismantle and

control the "Roman" robots. Emperor Asoka now commands a large robot army himself.

In some versions, the whirling guardian automata are driven by a waterwheel or some other mechanism. In one tale, the engineer god Visvakarman helps Asoka, destroying the robots by shooting arrows precisely into the bolts that hold the spinning constructions together.[49] The motif of cleverly disabling the mechanical guardians calls to mind the techno-witch Medea's destruction of the bronze robot Talos, when he threatened to kill Jason and the Argonauts, by removing the crucial bolt in his ankle (chapter 1).

The "science-fiction" saga of the Roman robots guarding Buddha's relics highlights the fear of losing control of artificial beings, an age-old theme that appeared in the Greek myth of the sown dragon-teeth army (chapter 4). "Robots can turn on their makers and kill them," notes Signe Cohen in her study of ancient Indian automata. But the story raises more challenging questions. "Did such technology," she asks, "really exist or are these stories simply religious myths and folktales?"[50]

The story clearly relates the mechanical beings defending Buddha's relics to advanced automata inventions that originated in *Roma-visaya*, the Greco-Roman West. These narratives, remarks Daud Ali, seem to "encode, albeit obliquely, the real movement and circulation of cultures of 'techne,' including both real and imagined objects," between India and the West.[51] How ancient is this kernel of historical reality in the lost Sanskrit tale included in the *Lokapannatti*? Were the legendary robot guardians in the *stupa* modeled solely on working automata created in the late Byzantine or medieval Islamic and European periods, as scholars generally assume? Or is it possible that oral lore about the robot guards could have arisen even earlier, influenced by Indian knowledge of real Hellenistic mechanical marvels like those created in Ptolemaic Alexandria in the third century BC, the time frame of the Asoka story?

The historical setting of the tale points to technological exchange about automata between the Mauryan emperors of India and Hellenistic kings. Evidence from history and archaeology confirms cultural contact by the fifth and fourth centuries BC. Notably, the ancient Jain texts, mentioned above, reported that King Ajatasatru's engineers were constructing military machines in the fifth century BC. Greco-Buddhist syncretism

and mutual influence in philosophy and art intensified after Alexander the Great's campaigns in what is now Afghanistan, Pakistan, and northern India.[52] We know that around 300 BC, the two Greek ambassadors, Megasthenes and Deimachus, arrived in the Mauryan court, and they resided in Pataliputta—a city with outstanding Greek-influenced art and architecture. Pataliputta, we recall, was the hometown of the engineer who obtained the plans for making robots from "Rome."[53]

King Asoka lived in the third century BC, at a time when automata and other devices were proliferating in Alexandria and other centers of technology in the West. Throughout his kingdom, Asoka left many inscribed pillars and rock inscriptions, some written in ancient Greek and others referring to Hellenistic kings by name, attesting to ongoing cultural exchange and trade with the West. Asoka sent emissaries and corresponded with several Hellenistic rulers, including Ptolemy II Philadelphus in Alexandria, whose spectacular procession in 279/78 BC featured marvelous displays of robotic mythic figures like Dionysus and Nysa. Asoka's envoys came to Alexandria, and Ptolemy II sent his own ambassador, a Greek named Dionysius, to Asoka's court in Pataliputta.[54]

Further evidence of long-lasting cross-cultural influence comes from the journal of the Chinese monk Fa Hsien, one of many Buddhist pilgrims who traveled to Pataliputta, Asoka's city, in about AD 400. Fa Hsien witnessed the traditional annual procession celebrating Buddha, presumably begun in Asoka's day. The monk describes the magnificent parade of large four-wheeled carts bearing colossal structures, imposing replicas of *stupas* five stories high, a succession of towering images of Buddha, Bodisattvas, and other divine beings of gold, silver, and lapis lazuli, with colorful silk banners and canopies, attended by hosts of singers, dancers, and musicians. Fa Hsien does not mention mechanized statues (although automated Buddhist figures were displayed in parades in China in this era).[55] One has a sensation of déjà vu, so closely does the scene in Pataliputta resemble the Grand Procession of Ptolemy II Philadelphus in Alexandria in 279 BC, a half century earlier.

Was the tale of Asoka and the robots known to Empress Wu (b. AD 624) and her engineers in Tang China? There were many real and imaginary automata in her era. A large golden Buddha surrounded by rotating mechanical attendants that periodically bowed and tossed

incense had been created by the engineers Xie Fei and Wei Mengbian for processions in about AD 340. A sixth-century AD Chinese story recounts how workmen ordered to destroy two Buddha statues were attacked by wrathful Vajrapani guardians. Empress Wu knew the monk Daoxuan (AD 596–667) who designed sacred technology for shrines; in his writings Daoxuan described a fantastic Buddhist monastery in India with many automaton guardians in human and animal forms. We know that Empress Wu idolized Asoka, and that her engineers built "celestial" buildings for Buddha's relics, as well as mechanical marvels. It seems possible that the Chinese monks who transported Buddha's teachings, relics, and *stupa* designs from India to China also transmitted the legend of Asoka and the robots—a story that is preserved in a Chinese translation.[56]

IMAGINING ANCIENT ROBOTS

How might we moderns imagine Emperor Asoka's encounter with ancient "Roman robots"? How were the automatons guarding Buddha's relics visualized when the tale was told in antiquity? Traditional guardian *dvarapala* and *yaksha* statues defended Buddhist stupas and shrines from the Mauryan Empire period. These were warrior figures wielding bows, maces, and swords, sometimes monumental (fig. 9.5). But no ancient illustrations of the legendary self-moving guardians of Buddha's relics have been identified.

In Buddhist legends and artworks, the Buddha, his teachings, and his physical relics are protected by Vajrapani, the fierce bodhisattva armed with a lightning bolt. Remarkably, some of the earliest sculptural images of Buddha in Gandharan-style art of northern India (first century BC to seventh century AD) show Buddha in classical Greco-Roman garb and guarded by Heracles, the hero of classical myth. As Heracles merged with the persona of Vajrapani, the muscular, bearded guardian was shown wearing the Greek strongman's signature lion-skin cape, and his club is transformed into Vajrapani's distinctive *vajra*, the lightning bolt (fig. 9.6). Some reliefs show Heracles-Vajrapani carrying a sword, the weapon said to be wielded by the robots in the *Lokapannatti* story.[57] The artistic syncretism that merges the Greco-Roman mythic figure of Heracles with Vajrapani as a defender of Buddha chimes with the Buddhist story that Greco-Roman-style robots served as guardians for Buddha's relics. One might speculate that the automaton warriors defending the relics in the *stupa* might have been imagined as figures that combined classical Greek and Indian features.

FIG. 9.6. Buddha guarded by Heracles/Vajrapani, panel relief, Kushan, Gandhara, Pakistan, second to third century AD, inv. 1970,0718.1. © The Trustees of the British Museum.

The Arhats (Chinese Luohan), four original disciples of Buddha, were charged with defending the faith in early Indian sutras. Later in China, their number rose to eighteen. The earliest known artistic impressions of the Luohans (ninth century AD) depicted them as non-Chinese foreigners from the West. Although no link between the Luohans and the story of the "Roman" robots that defended Buddha's relics has been identified, at some point the Luohans were imagined as fierce bronze automata with fighting skills. The theme appears in the Shaolin kung fu movie *18 Bronzemen* (Joseph Kuo, 1976), set in the Qing Empire.

The fantasy of discovering long-forgotten automaton technology from some archaic civilization views robot technology with a mythological sensibility and lens. Notably, Hesiod suggested that the bronze robot Talos was of an earlier age. The notion of "ancient robots" has become a popular science-fiction theme. In 1958, the fantastical Buddha Park sculpture garden, Xieng Kuan near Vientiane, Laos, was created. The park is populated with colossal Hindu-Buddhist guardian statues (fig. 9.7), some of which resemble vintage robots. Made of concrete, they are deliberately designed to look like weathered antiquities. Meanwhile, in Japan, robots both imaginary and real were embraced with alacrity after World War II, a cultural feature that some attribute to Buddhist spirituality. Masahiro Mori, a devout Buddhist, not only was the first to articulate the Uncanny Valley effect; he also believed that robots could even have a "Buddhist nature." In some forms of Japanese and Chinese Buddhism, moreover, there is no

FIG. 9.7. Imaginary robot-like Buddhist guardians, created in 1958 to look ancient, Buddha Park, near Vientiane, Laos. Left, photo Kerry Dunstone; right, photo Robert Harding; Alamy Stock.

bright line between original and replica, essence and copy.[58]

Popular Japanese manga and anime artistic and literary forms arose after World War II and often featured artificial beings and robots. Notably, the anime-manga series *Mazinger Z* (1972–74; *Tranzor Z* in the United States) describes a super-robot modeled on ancient Talos-type steel prototype automata excavated by archaeologists on a Greek island loosely based on Rhodes. The conceit is that an ancient lost civilization, the "Mycene Empire," deployed these remote-controlled robots in battles. Another more recent example is the anime film *Laputa: Castle in the Sky* (1986, Hayao Miyazaki for Studio Ghibli, Tokyo). Drawing on ancient Hindu epics, the story involves the revival and dismantling of long-lost robot guardians created by a vanished culture. An international group of retrofuturists, mecha artists, and robot model makers fabricate intricate replicas of "abandoned" robots, cast as survivors of antiquity unearthed in archaeological ruins. A typical example is "Whistlefax." According to his fictional backstory, he arose from "the wastes of a world racked by violence," the devastated "ruins of a once great civilization overrun by hordes of haunted robots. Possessed by the souls of angry soldiers, these rusted hulks of an age gone by are given a new purpose, to punish those who plunged the world into conflict without purpose but to the profit of the few."[59]

When did the Buddhist tale of Asoka and the "Roman robots" first arise in India? The narrative appears to reflect genuine knowledge of actual engineering feats in the historical period of Ptolemy and Asoka, by the third century BC. We know that the Mauryan and Hellenistic courts sent envoys to each other, and they exchanged luxurious gifts to show off their cultural achievements. Note that the legend relates that plans for making automata reached India, and the emperor of the Greco-Roman West sent a gift box containing a robot to Asoka. One cannot hope to pinpoint the original date of the legend. But it seems safe to assume that Asoka and his contemporaries would have been familiar with—and perhaps even observed plans or miniature scale models of—automata and other mechanical marvels in the West.

Mechanical devices and automata in mythology and in real life provoked questions about ontology, humans and nonhumans, nature and artifice; they challenged the borders separating illusion, reality, and possibility. A large group of myths show that animated statues were certainly conceivable at a very early date, long before historical mechanical devices proved that imitating life with technology was practical. "Ancient mechanics *surprised* its audience," remarks Sylvia Berryman, and "experience with technology changed views about what results could be produced," about what might be possible. Human imagination and curiosity drive creativity and innovation.[60] Mythological stories about artificial life and as-yet-unknown technology can be considered another, valid kind of "experience." Imaginative scenarios in myth might well have helped shape ancient ideas and speculations about what results *might* be produced, what wonders *might* be possible, if only one possessed the radically superior technology and expertise of a Daedalus, Prometheus, or Hephaestus.

Were some marvels of artificially created life in the mythic traditions cultural fantasies that embellished and extrapolated real-life theories of technology or actual—if simpler—technological experiments? Or, conversely—just as modern science fiction can anticipate future scientific discoveries and sometimes even inspire technological innovations—is it possible that tales of divine and legendary automata and devices challenged and inspired living inventors to design self-moving objects and

machines? Were mythic narratives and scientific imagination interrelated? The AI historian and futurist George Zarkadakis considers the links between old stories about robots and AI research. He proposes a feedback loop, a coevolution between mythic narratives and "scientific endeavors throughout history."[61] Speculations about original influence are impossible to resolve. But one can discern mythical chords within some historical inventions in antiquity. Indeed, it is striking that, just as ancient mythology about artificial life and self-moving devices imagined technological wonders made by divine craftsmen, so many historical inventors crafted automata and mechanisms to illustrate or evoke the ancient myths.

Millennia ago, visionaries initiated a series of "science-fiction" thought experiments about superior beings creating artificial life, expressed in mythical language. These imaginary automata, especially those like Talos and Pandora, with physically realistic forms and quasi-conscious "minds" that could interact with human beings on earth, evoked ambivalent reactions of awe, hope, and terror. Later, a group of brilliant inventors constructed real automata and self-moving devices that replicated natural forms, and their speculations and designs stimulated further experiments and innovations. As in the world of mythology, real automata and machines could be used to dazzle, deceive, and dominate. As we saw in chapter 8, inherent in the Pandora myth and proclaimed in Sophocles's paean to human ingenuity, *techne*, and ambition is a clear warning that these gifts can lead humans to glory or to evil.

The exciting dream of artificial life, first spun in storytelling imaginations, began to be realized in technological designs and engineered machines in antiquity. The next two millennia witnessed immense technological change. Yet by the end of the twentieth century, the journey of human creative vision and innovation had really only just begun. Advances are now accumulating at warp speed. Suspended above the uncanny abyss of replicating life itself, we still swing between hope and terror unleashed by humans' insatiable quest to imitate and improve nature.