

EDISON'S EVE

A Magical History of the  
Quest for Mechanical Life

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NEW YORK  
2002

CHAPTER ONE

## The Blood of an Android

*To examine the causes of life, we must first have recourse to death.*

—Mary Shelley, *Frankenstein*

He was sure it was to be his last trip. The philosopher René Descartes had been summoned by Queen Christina of Sweden, who wanted to know his views on love, hatred, and the passions of the soul; but although he was happy to correspond with the Queen, Descartes was loath to become part of her court. He felt, he said, that “thoughts as well as waters” would freeze over in Sweden and, since that winter was particularly harsh, he believed he would not survive the season. He even feared, he wrote to a friend, “a shipwreck which will cost me my life.” But Christina’s whim was his command. Filled with foreboding, he packed his bags, taking all of his manuscripts with him.

He was travelling, he told his companions, with his young daughter Francine; but the sailors had never seen her, and, thinking this strange, they decided to seek her out one day, in

the midst of a terrible storm. Everything was out of place; they could find neither the philosopher nor the girl. Overcome with curiosity, they crept into Descartes's quarters. There was no one there, but on leaving the room, they stopped in front of a mysterious box. As soon as they had opened it, they jumped back in horror: inside the box was a doll—a living doll, they thought, which moved and behaved exactly like a human being. Descartes, it transpired, had constructed the android himself, out of pieces of metal and clockwork. It was indeed his progeny, but not the kind the sailors had imagined: Francine was a machine. When the ship's captain was shown the moving marvel, he was convinced, in his shock, that it was some instrument of dark magic, responsible for the weather that had hampered their journey. On the captain's orders, Descartes's "daughter" was thrown overboard.

It's hard to know if this story is true. Descartes did go to Sweden, and did, as he had feared, die there, six months later. He had, in fact, attempted to build some automata earlier in his life (one of his correspondents reported that Descartes had plans for "a dancing man, a flying pigeon, and a spaniel that chased a pheasant"), and he continued to be interested in mechanical toys. But the events on the ship read like a too-perfect fable—about science falling prey to the God-fearing crowd, about the threatening, uncanny power of machines, about the rational philosopher who has an almost superstitious relation to the product of his own mind: he names it, he calls it his daughter—and whether or not the story is made up of literal facts, it must, in a sense, be true to some metaphorical purpose: what is the use of telling it? (It has been told many times since Descartes's death.)

Descartes did have a daughter, and her name was Francine, but by the time this story is said to have taken place, Francine had been dead for many years. She was born in 1635, to a servant named Hélène Jans, whom Descartes never married. She lived with her father, at least some of the time, in the Netherlands, and he was planning to take her with him to France, when she died of scarlet fever, at the age of five. He told a friend that her death was the greatest sorrow of his life.

Seen from this angle, the Descartes of the story comes across, not as the reasoning philosopher, but as a fallible human being, distraught, nine years later, by the death of his child. Unable to mourn her, he constructs a simulacrum of the girl, gives it the power of motion, names it after her. If death was, as the following century liked to call it, "suspended animation," then Descartes, in animating this doll, had defied mortality and resurrected his daughter. Perhaps he had even done something, symbolically, for his own lifespan. Some years earlier, when he had been focusing his work on medicine, Descartes had written that he thought he could live to be a hundred. Francine died shortly after that. The making of the doll might be seen as an attempt to counter the terrible dashing of his hopes of extended life; and it seems fitting then that the ageless clockwork figure should have been destroyed on the trip where he was eventually to meet his end. This would suggest that the sailors might have been right to fear the object, not in itself, but because of Descartes's strange attachment to it.

Perhaps, however (since we cannot be sure of Descartes's intentions), the story can only be understood as one put about by later generations, in which case what is interesting is the confusion of the culture behind it. The fable is a new configu-

ration, built up out of anxiety. It describes, in the mind of the storyteller, and in that of the audience, an uncertainty about categories. What is the difference between a person and a machine? Where is the line between a child and a doll, between the animate and inanimate—in other words, between life and death? Will reason win out over randomness? Will God get the travellers to Sweden? What can we know for sure?

It seems barely surprising that these concerns should have been traced back to, or posthumously inserted into, the life of Descartes, who is often referred to as the father of modern philosophy. They are philosophical problems (philosophy, until the nineteenth century, included all branches of science: mechanics, astronomy, botany, chemistry, anatomy, and so on), but they were relevant to everyone. Descartes's contemporaries and, more particularly, his immediate successors were moving from an age inhabited by alchemists and charlatans to one in which science was to be made transparent and accessible to all. A story is told about a Dutch cobbler who was teaching himself mathematics and wanted to discuss Descartes's method with him. Twice he visited the philosopher, and twice he was turned away by servants, who looked at his scruffy clothes and assumed he was a beggar. He rejected their master's offer of money, insisting that he only wanted "to speak of philosophy." On the third visit, Descartes welcomed him amongst his friends, and the cobbler, according to one of Descartes's biographers, "became one of the foremost astronomers of this [the seventeenth] century." It was also said of Descartes that he entertained the sick with mathematics.

The shift from exclusive knowledge and dark quackery to universal enlightenment was, however, an uneasy one. There

was an abundance, in the eighteenth century, of manuals destined to train "ordinary minds" in the ways of physics and other related subjects. They had titles like "Philosophical Amusements" and "Mathematical Recreations"; they were meant both for pleasure and education, or education as pleasure. But although the Enlightenment project was to remove the veil from what the charlatans had previously peddled, the contents of these manuals were still on occasion called magic—and the general public, one imagines, must have found it hard to distinguish between sorcery and science.

Descartes had laid the foundations for one of the central ideas of that period: the notion, taken up by anatomists and philosophers alike, that man is a machine, and can only be understood as such. You could say that androids were a crucial part of Descartes's thought—his *Treatise on Man*, which was published after his death, is founded on a comparison between a human being and a hypothetical "statue or machine," which operates like a clock or a hydraulic fountain. He had already put forward a "beast-machine" hypothesis, in which he argued that animals were machines, made up of mere matter, and that all of their faculties could be explained by mechanical means. The difference between beasts and men, he said, was that humans possessed a "rational soul," whereas animals were incapable of reasoned thought (the *cogito*, "I think therefore I am," sets out what separates us from matter). However, the idea that the soul was the source of human life was to become very contentious, and the atheist philosophers of the eighteenth century stretched Descartes's beast-machine premise to include human beings as well. It was even suggested that Descartes had meant to say this all along, but had been too

afraid: his hypothetical moving statue was not an analogy, a later thinker said, but plainly a description of ourselves. His masking rhetoric was just a clever "ruse," "to get the theologians to swallow a poison."

So the man most famous for the dictum "I think therefore I am" was as interested in the way bodies worked as he was in the function of the mind (whilst Descartes was conducting his own anatomical investigations, the local butcher would deliver animal corpses for him to dissect at home). Neither the idea that men are machines, nor, conversely, the machines that were constructed to look like men, can be properly understood without him.

Jaquet-Droz's writing automaton in Neuchâtel is known to have scrawled, on some occasions, the words "I think therefore I am." At other times, it has written a more ironic tribute: "I do not think . . . do I therefore not exist?" It's a perfect riddle, of the kind many automata conjure up. The writer, a mere machine, is able to declare that it cannot think. Clearly, however, it does exist: and if it is able to communicate the fact that it cannot think, is it possible that it can think after all? Might the machine be lying? What is the difference between the automaton that writes "I do not think" and a person who, having lost the power of speech, is obliged to write that sentiment or its opposite on paper?

In this context, what the fable about the ship finally represents is the throwing overboard of one of Descartes's great contributions to philosophy, anatomy, and mechanics. Science was cast out to sea.

Indeed, for the supporters of these ideas, there was much to fear. The power of the church was oppressive, and would

remain so for some time. Descartes had originally written *The World*, of which the *Treatise on Man* is the second part, in the early 1630s, but he had abandoned it on hearing of the fate of Galileo, who had been put under house arrest by the Roman Inquisition after supporting the claim that the earth moved around the sun. What would have been Descartes's first book became his last. He was not an atheist, but some of his ideas were seen as such, and he understandably feared the fickle interpretations of the church. He wrote to a friend of Galileo's conviction,

I was so surprised by this that I nearly decided to burn all my papers, or at least let no one see them. For I couldn't imagine that he—an Italian and, I believe, in favour with the Pope—could have been made a criminal, just because he tried, as he certainly did, to establish that the earth moves . . . I must admit that if this view is false, then so too are the entire foundations of my philosophy, for it can be demonstrated from them quite clearly. And it is such an integral part of my treatise that I couldn't remove it without making the whole work defective. But for all that, I wouldn't want to publish a discourse which had a single word that the Church disapproved of; so I prefer to suppress it rather than publish it in a mutilated form.

No matter how Descartes tried to appease the devout, however, the opposition between philosophy and religion was set. An eighteenth-century nobleman, speaking both of that philosopher's accessibility and the stubbornness of the monks,

commented with chauvinistic wit that "fifteen years after the printing of Descartes' works, ladies reasoned much more sensibly in metaphysics than three-fourths of the nation's theologians."

Hence Descartes's careful insistence that the machine in his treatise is not a man, but only "a statue or machine . . . which God forms with the explicit intention of making it as much as possible like us." This machine is composed of a body and a soul: in the *Treatise on Man* he describes the body without the soul, and intended to describe the soul separately; but since this latter part of the treatise has been lost, what we are left with is a mechanical interpretation of everything in us except reason. And—though this conclusion may not have been intended—reason seems barely necessary, since not only do our lungs work like bellows and our blood flow as in a hydraulic system, but our memory, dreams, sleep, passions, hunger, pain, dizziness, and sneezes can all be accounted for mechanically. The treatise is a philosophical proposition stated in the language of medicine, an anatomical map of our insides, a description of the functions of human nature as if they were the various, linked junctures of a pinball machine. Descartes writes in conclusion: "I desire . . . that you should consider that these functions follow in this machine simply from the disposition of the organs as wholly naturally as the movements in a clock or other automaton follow from the disposition of its counterweights and wheels."

Mechanistic philosophy found a number of supporters, but the most radical and most openly atheistic upholder of the man-machine thesis was an eighteenth-century physician named Julien Offroy de La Mettrie. Curiously, La Mettrie had

intended, early on in his life, to enter the church. He studied philosophy and natural science at a distinguished school (also attended by the future editor of the *Encyclopédie*, Denis Diderot), which, during the time he was there, had begun to teach the works of Descartes, until then banned from most curricula.

A family friend advised him to go into medicine, and persuaded his father to accept this more lucrative alternative to theology. La Mettrie went to Holland to study under the physician Herman Boerhaave, who laid a great deal of emphasis on clinical instruction and deduction from practical experiment. Boerhaave aimed to interpret medicine according to the laws of mechanics: when it came to understanding the function of a particular organ, he wrote, it was the mechanics whose "oracles should be consulted." Boerhaave was to have a lasting influence on La Mettrie, who later translated many of his teacher's works into French.

La Mettrie went on to set up a local practice in Brittany; he wrote medical treatises on vertigo and venereal disease, and was employed as a doctor to the French national guards. After writing a controversial, mechanistic treatise entitled *The Natural History of the Soul*, he lost his job, and all copies of the book were condemned to be burned by the public hangman. From then on, it seems, La Mettrie built up quite a collection of enemies: he had alienated the theologians, then he satirized other doctors; he was ostentatiously hedonistic, and wrote books on laughter and sexual pleasure, all of which behaviour caused further offence.

He was forced to flee to Holland to publish his next book, even though it was published anonymously. *L'Homme machine*

(literally, "The Man Machine," but translated as *Man a Machine*), La Mettrie's most famous work, appeared in Leyden in 1747, and the publisher was immediately forced by the church to deliver up all copies for burning. As soon as the author's identity was suspected, La Mettrie had to escape once again, this time to Prussia, where he was welcomed and supported by Frederick the Great. Frederick, who wrote a eulogy to him after his death, made La Mettrie his personal physician, appointed him to the Royal Academy of Sciences, and was thought to have shown him a degree of favouritism that made him the envy of others in the King's circle.

In all this time La Mettrie's decadence showed no signs of letting up; his excessive gaiety, he once implied, masked a certain amount of sorrow. One night in 1751, after consuming a large amount of pheasant and truffle pâté at the home of an ambassador he had recently cured, La Mettrie fell ill, and died some days later. His sudden demise—as if from hedonism or gluttony—was met with triumph by his pious opponents, who thought it a fitting punishment for his life. So the man who was one of the key figures in the Enlightenment became, for more than a century, a joke, known only for the manner of his death.

*L'Homme machine*, whose influence on the materialist *philosophes* has since been given its due weight, took certain crucial steps beyond the position espoused by Descartes. La Mettrie attempted to show how like beasts men are, comparing humans with apes, and even suggesting that apes might be taught to speak. According to that principle, the idea that beasts are machines ought also to apply to men.

Other parts of his argument were the result, as Descartes's

had been, of important advances in contemporary science. William Harvey had already proved in the 1620s that blood circulated in the body; Descartes was much indebted to this discovery. By the time La Mettrie came to write *L'Homme machine*, a scientist named Abraham Trembley had recently found that the freshwater polyp, long classed as a plant rather than an animal, had the ability to regenerate itself when divided: it would, without intercourse, turn into as many polyps as there were parts. La Mettrie relied on this information to show that life is a property of matter, not dependent on a separate entity called a soul.

Another discovery that became central to La Mettrie's thesis was what is known as the principle of irritability. Albrecht Haller had been able to show that muscles move of their own accord—they respond individually if directly stimulated, rather than being reliant on "animal spirits," which Descartes believed in, and which were thought to cause the entire muscular system to move. Though Descartes had understood the body as a mechanically moving machine, he did not see it as a self-moving machine; that is, he did not think, as La Mettrie did, that the human body contained within it the principle of its own life. Through Haller's discovery, La Mettrie was able to argue that man was an automaton, or, as he put it, a "self-winding machine, a living representation of perpetual motion."

The soul, he wrote, was nothing but "an empty word to which no idea corresponds"; it should never be used to mean a source of life, but only to mean the mind, "to name the part in us that thinks . . . Where is the seat of this inborn force in our bodies?" he went on.

Clearly it resides in . . . the very substance of the parts, excluding the veins, arteries, and nerves, in short, the organization of the entire body, and . . . consequently, each part contains in itself springs whose forces are proportioned to its needs. Let us consider the details of these springs of the human machine. Their actions cause all natural, automatic, vital, and animal movements. Does the body not leap back mechanically in terror when one comes upon an unexpected precipice? And do the eyelids not close automatically at the threat of a blow? . . . Does the stomach not heave automatically when irritated by poison, a dose of opium and all emetics? . . . Do the lungs not automatically work continually like bellows?

The words "automatic" and "mechanical" are fundamental here, loaded terms that carried within them an inflammatory philosophical debate, pitting materialists against theologians. Although La Mettrie was a physician, and aimed to use medical experience in order to prove his arguments, he was also greatly influenced by progress in other branches of science, and mechanics in particular. Clocks, telescopes, microscopes, and various measuring devices were becoming ever more sophisticated. Descartes had already referred in his treatise to the mechanical fountain Tomaso Francini had built at the Royal Gardens in St. Germain en Laye in about 1600, as he suggested how the body was infused with animal spirits. In *L'Homme machine* La Mettrie, doing away with the spirits, mentions Huyghens's planetarium, a moving model of the solar system, and the automata of Jacques de Vaucanson.

On the subject of these creations, La Mettrie points out: "If more instruments, wheelwork and springs are required to show the movements of the planets than to mark and repeat the hours, if Vaucanson needed more art to make his *flute player* than his *duck*, he would need even more to make a *talker*, which can no longer be regarded as impossible, particularly in the hands of a new Prometheus."

What La Mettrie is proposing is that the more human the machine, the more complicated its mechanism. Humans may contain more springs and wheels than animals, say, but they do not contain anything other than springs and wheels; and the closer eminent mechanics like Huyghens and Vaucanson came to reproducing the world and the body in clockwork, the more they seemed to prove that man and the world were little else. "However greatly these proud and vain beings desire to exalt themselves," La Mettrie wrote disdainfully of his fellow men, "they are at bottom only animals, perpendicularly crawling machines."

The mechanical, or artificially animated, human became a common trope amongst La Mettrie's compatriots; and although La Mettrie set it down to most dramatic effect, the idea was already in the air. Aram Vartanian, who wrote an introduction to *L'Homme machine*, quotes an anonymous article written in a widely circulated journal, published three years before La Mettrie's book:

If you had never seen anything but mounds of lead, pieces of marble, stones and pebbles, and you were presented with a beautiful wind-up watch and little automata that spoke, sang, played the flute, ate and

drank, such as those which dextrous artists now know how to make, what would you think of them, how would you judge them, before you examined the springs that made them move? Would you not be led to believe that they had a soul like your own, or at least like that of an animal, and would you not be led to wager that this very soul was the cause of their *activity*? Nevertheless, there is nothing in these automata but matter.

Diderot took up these thoughts in an unfinished treatise: "What difference is there between a sensitive and living watch, and a watch made of gold, iron, silver or copper?" The philosopher Etienne Bonnot de Condillac wrote a book arguing that the senses were a form of knowledge; his central image is a marble statue coming to life, sense by sense, from smell to touch. And the Greek myth of Pygmalion and Galatea underwent an extraordinary renaissance in the eighteenth century: Diderot, Rousseau, Voltaire, Rameau, and Deslandes were amongst the many writers who produced modern versions of the story, in which a sculptor falls in love with his statue and is rewarded when Venus brings Galatea to life.

Androids, or automata in human form, brought the figures of the clock and the statue together. They influenced these thinkers, as is clear from La Mettrie's mention of them, and they also seemed to be concrete proof of what the philosophers proposed. Men understood as machines and machines built to resemble men went hand in hand—it hardly mattered which had come first. Androids were more than mere curiosi-

ties: they were the embodiment of a daring idea about the self. Or, as Simon Schaffer has memorably put it, they were "both arguments and entertainments." It was the golden age of the philosophical toy.

The reigning genius of this mechanical world was Jacques de Vaucanson. Though Vaucanson achieved most notoriety as the producer of a high-society spectacle, in which an android played the flute and a mechanical duck was seen to digest its food, there seems little doubt that he was keen to align himself with philosophers and anatomists, and sought to contribute to the debates of his time. His magnificent creations were admired by audiences all over Europe; they were praised by kings and applauded by scientists. During the hundred years they were in circulation, they were exhibited in fashionable showrooms, at carnivalesque fairgrounds, and in private cabinets of curiosities: Vaucanson's automata crossed many boundaries, and might be seen as emblems of the Enlightenment, full of instructive clockwork and covered in gold, the legacy of mathematicians and alchemists. Both Voltaire and La Mettrie labelled him a "new Prometheus." Like the Greek Titan, he had the power, it seemed, to create life, to fashion men out of new materials. He was, as his biographers André Doyon and Lucien Liaigre point out, an early cybernetician, and though his career would later stray from this Promethean path, his wildest and most secret ambitions were to remain in the realm of artificial life.

Jacques de Vaucanson's earliest mechanical influences came from the church. He was the youngest of ten children (born in Grenoble in 1709), and his Catholic mother would

take him with her every time she went to confession. While his mother was with the priest, Jacques stared at the clock in the adjoining room. Soon he had carefully calculated and memorized its mechanism, and was able to build a perfect copy of it at home. His father, a master glovemaker, died when Jacques was seven, and the boy was sent away to be schooled at a monastery, where he arrived clutching a metal box. He didn't get on with the other boys, and couldn't concentrate on his lessons, which he spent drawing strange lines on pieces of paper. Eventually, the Father Superior was forced to open the box. He found wheels and cogs and tools, next to the unfinished hull of a model boat. When confronted, Jacques refused to do any studying until he could make his boat cross the school pond. He was locked in a room for two days as punishment, but he spent the time making drawings so exceptional that the mathematics teacher, who was later to be lauded by the Royal Academy of Sciences, decided to help him.

Of course, a story exists about the youthful genius of all famous men. What is curious here is that all of Vaucanson's early efforts as a mechanician were connected in some way to religion. The clock was seen at confession; the maths teacher was a monk. He went on to be taught by Jesuits, and, on leaving school, became a novice in the religious order of the Minimes in Lyon. This was the only way, he thought, that he would be able to pursue his scientific study, given the limited finances of his widowed mother. At the time, there was no reason to suspect anything to the contrary; many members of the Royal Academy of Sciences carried the word "Abbot" before their name, and some of the cleverest people in the country were to be found in religious institutions. Indeed, Vaucanson was

given his own workshop in Lyon, and a grant from a nobleman to construct a set of machines; but his talents were only encouraged up to a certain point. In 1727, to celebrate the visit of one of the heads of the Minimes, he decided to make some androids, which would serve dinner and clear the tables. The visitor appeared to be pleased with the automata, but declared afterwards that he thought Vaucanson's tendencies "profane," and ordered that his workshop be destroyed.

Why was some clockwork tolerated when this was not? The so-called profanity was connected, surely, to the shape, or the function, of the automatic waiters. What was dangerous, then, was not the element of mechanism, but the element of man in these constructions. To liken man to a machine was unacceptable. Expecting the support of his fellow monks, Vaucanson had unwittingly stepped into the very ground that La Mettrie was to know, some years later, would make him a wanted man. From this point on, Vaucanson realized he was involved in a risky business. He went home to Grenoble, and, offering the excuse of an "unmentionable illness," pleaded with the Bishop to be withdrawn from the order. As soon as he was free, he ran away to Paris.

However elegant or genteel his inventions might seem to us now, it should not be forgotten that Vaucanson, along with many contemporary philosophers and surgeons, was treading a fine and dangerous line. As his automaton-making career progressed, he became as distanced from his former calling as it was possible to be. Many years later, Vaucanson found himself in Lyon once again; this time, however, he was there not as part of the monastery, but in order to introduce new technology that would transform the manufacture of silk. The silk

workers rioted, and, under threat of terrible violence, Vaucanson was forced to flee the city. In his search for a disguise, he lighted on an outfit he had once worn in good faith, but which had now become the emblem of his philosophical opposite. Vaucanson escaped by night, undetected: no one could have guessed that an atheist mechanician was hiding beneath the habit of a Minime monk.

Little is known about Vaucanson's activities around the time he left for Paris. It is thought that he attended classes in anatomy and medicine at the Jardins du Roi (the Royal Gardens), subjects that he continued to study on a visit to Rouen. In Rouen he probably met Claude-Nicolas Le Cat, who had just been made head surgeon at the hospital there. Le Cat, as we shall see, was involved in the construction of an artificial man, and it's possible that Vaucanson made an automaton under his tutelage. One of Vaucanson's early machines, which represented different animals in motion, was powered by fire and water, and he had soon produced enough work to go on an exhibition tour of Brittany. In Tours he met one of his main financial backers, and returned to Paris with enough money to dress in floral garments and carry a sword—in short, to gain a gentlemanly entry into high society. He met Voltaire and other philosophers; he was introduced to the future finance minister, Bertin; he came into contact with the best musicians in France. All of these people would support him in one way or another in the years to come.

Just as he was preparing to construct the automaton he had been sponsored to make, however, Vaucanson fell seriously ill. He was bedridden for four months, and could not eat for half of that time. Surgery sank him deeper into debt. In his delir-

ium, he dreamed up an android that could play the flute, an android in the shape of a famous marble statue by the royal sculptor Antoine Coysevox, then on display in the Tuileries Gardens. He rose from his bed and drew up designs for every part, handing them out as he went along to various craftsmen and clockmakers. As soon as the pieces were joined together, the automaton could be heard to play the flute, as perfectly as any human being. It was as if the marble statue had come to life.

Vaucanson rented an elegant showroom in a grand mansion in the centre of Paris, the Hôtel de Longueville. The walls were covered in mirrored panels and gilded ornaments, with frescoes over the doorways; two six-panelled windows gave out on to a central courtyard. The room was called the Salon des Quatre Saisons, and Vaucanson, taking on airs which would guarantee him a fashionable audience, began to have his post sent there.

The Automaton Flute Player was first exhibited in that room on 11 February 1738. The price of entry was three livres, a week's wages for a manual labourer. Vaucanson demonstrated the object himself, to groups of ten to fifteen people at a time. The show was a huge success: by April that year, there were seventy-five visitors a day, and the Academy of Sciences, who had initially responded half-heartedly to what they assumed was yet another piece of trickery, had given their full approval. As if to confirm its lasting success, a lengthy description of the Flute Player's mechanism appeared over several pages in the first volume of Diderot and d'Alembert's *Encyclopédie*, under the entry "*androïde*," defined as: "an automaton in human form, which, by means of certain

well-positioned springs, etc. performs certain functions which externally resemble those of man."

The figure was made of wood, and painted white to look like Coysevox's marble. It was life-size—five and a half feet tall—and was supported by a large pedestal measuring four and a half feet in height and three and a half in width. The flute, as Vaucanson had learned from his musical acquaintances, was considered one of the hardest instruments to play in tune—notes are produced not just by fingers and breath but by varying amounts of air blown into the flute, and different shapings of the lips. He had set himself an apparently impossible task, and emerged with a machine that could play twelve different melodies. At first, spectators believed the sounds must be coming ready formed from inside the figure—they had seen musical toys before, but never had an automaton actually played an instrument as a human being would. The virtue of this Flute Player, and the reason it seemed an ideal Enlightenment device, was that Vaucanson had arrived at those sounds by mimicking the very means by which a man would make them. There was a mechanism to correspond to every muscle.

The account of it he gave to the members of the Academy of Sciences, and which he subsequently published, illustrated with an engraving by the well-known book-illustrator Gravelot, was broken down into two sections. First, he spoke about his investigations of the German flute itself, and exactly which muscles were required to play it, offering an anatomico-musical analysis of what it took to produce different notes, to jump an octave, to pause, to alter the pace, to play loud or soft. Then he explained, in almost dizzying detail, the mechanism

he had created for his artificial man. The figure was constructed so that it could be opened to show its secret strings as Vaucanson spoke. "The entire mechanism," he wrote, "is to be seen uncovered, since my intention is to demonstrate, rather than simply to show a machine."

The mechanism, needless to say, was extremely complicated—full of screws and pivots, barrels and bars—and I shall explain it only briefly here. The heaviest elements were to be found in the front and back parts of the pedestal. In the front, several wheels were set in motion by a weight, which in turn carried around a steel axle attached to cranks, which were attached to six bellows. In the back, there was a series of different-sized pulleys, which were connected to three more bellows. The strings on some of the pulleys led to levers and valves, which eliminated noise or excessive movement when air was pumped through. The nine bellows were attached to three separate pipes that led into the chest of the figure. Each set of three bellows was attached to a different weight to give out varying degrees of air, and then all pipes joined into a single one that was equivalent to a trachea, continuing up through the throat, and widening to form the cavity of the mouth. The mouth, though the smallest part, contained the most intricate apparatus. The lips, which bore upon the hole of the flute, could open more or less depending on the amount of air that was to be passed into the instrument, and they could move backwards or forwards. For each of these four movements there was a separate mechanism. Inside the mouth was a moveable metal tongue, which governed the air let through and created pauses. There were four levers to operate the tongue and to modify the wind. Other devices ruled the player's fingers;

all of these motive forces were hidden in the pedestal, and were made up of a cylinder, a key-frame, fifteen levers, and numerous steel wires and chains.

Vaucanson's intention, he said, was to compare these motions and effects with "those of a living person," and it is striking that his description bears a strong resemblance to the point-by-point map of the human body offered by Descartes a century earlier. The bellows, the clockwork, the pipes are there in both. Vaucanson's levers and valves are not so far from Descartes's tubes and membranes, and the latter likened the flow of animal spirits to that of a wind passing through the body—as it does through the Flute Player. Descartes's description is full of analogies with mechanical or musical contraptions (a hydraulic fountain, a church organ), just as Vaucanson's is a comparison with the workings of the human body. In other words, reading the anatomical description of the "human machine" and reading the mechanical explanation of an artificial man are very similar experiences.

Vaucanson's android inevitably raised questions about what it meant to be human. It seems that its primary uncanny effect stemmed from the fact that it operated by breathing. Clearly, almost any other instrument, requiring only physical pressure in order to produce a sound, could be played simply by clockwork (there had been automated bell-ringers and lute-players, and later that century Henri-Louis Jaquet-Droz was to construct his famous Musical Lady, which played the keyboard). This automaton *breathed*. Even though the art of mechanics was sophisticated enough by then to make a machine perform many other movements, and even though Vaucanson unveiled the fact that this breath was created by

bellows, the very act of breathing, seen in an inanimate figure, continued to cause a stir well into the following century. The first mechanized waxwork in Madame Tussaud's was Sleeping Beauty, who was said to have been modelled on Louis XV's mistress Mme. du Barry, and whose sole mechanical feature was a heaving chest. In 1833 a breathing model of the late Napoleon did the rounds of London showrooms and was said to be "the astonishment of the medical world."

The Flute Player, however, also raised questions about perfection, and what was understood by it. A year later Vaucanson exhibited a figure that played a pipe and drum. It received little attention, partly because it was accompanied by a much more memorable automaton, and partly because it was so similar to the Flute Player people had already seen. But there was a crucial difference between the flute- and pipe-players: the pipe was played so fast that it exceeded the speed any living person could achieve (only a mechanical tongue could move that quickly), and it was also the instrument known to be most exhausting to the human chest—the android, however, never got tired. So the Pipe Player embodied one idea of perfection, the idea that humans were messy, imperfect, fallible, and that a perfect machine would correct those flaws, improve on humanity. The Flute Player, on the other hand, was meant to approach humanity as much as possible—perfection, in this case, being as close a replica of human imperfection as there could be. The evidence for this lies in a small problem Vaucanson encountered as he was making the android.

He had designed the seven levers corresponding to the fingers, and he had ensured that there was the appropriate range of angles for the mouth; but although the actions were all cor-

rect, and the passage of air was under control, the sound was not quite right. Vaucanson discovered that wooden fingers could not play a metal flute the way a man or woman could: the difficulty was that the machine was just not soft enough. Vaucanson looked around for a material that would accurately simulate the effect, and he found it. The glovemaker's son covered his android's fingers in skin.

It is possible that the material was leather, since the word *peau* in French makes no distinction between animal and human skin; but Vaucanson certainly never specified one or the other, and in any case, the point is the same: pure mechanics were not enough, and Vaucanson had to import organic matter into his dead creation. It's as if, in trying to come close to humanity, Vaucanson had crossed a line—a machine could not be truly like a man unless it borrowed from a man, unless it arrived at its mechanical concert dressed in skin. From this perspective, robbing graves to make a monster seems a small enough step, and the Flute Player leaves the theologians some room for argument: as a later commentator sarcastically put it, "What a shame the mechanic stopped so soon, when he could have gone ahead and given his machine a soul!"

In 1739, when attendance at the exhibition was flagging, Vaucanson added to the Flute Player two other machines, which he had, in all likelihood, constructed earlier and kept in reserve. One was the pipe-and-drum figure, and the other was a mechanical duck. If the Flute Player imitated life with human flaws and particles, then the duck went even further towards reproducing those parts in us for which a machine would have no need—because what was remarkable about this

duck was that it ate food out of the exhibitor's hand, swallowed it, digested it, and excreted it, all before an audience. It became Vaucanson's most famous creation; without the shitting duck, Voltaire commented wryly, there would be nothing to remind us of the glory of France.

It was made of gold-plated copper, but it was the same size as a living duck, and moved just like one. Aside from its main digesting function, it could drink, muddle the water with its beak, quack, rise, and settle back on its legs, and, spectators were amazed to see, it swallowed food with a quick, realistic gulping action in its flexible neck. In a single wing alone, it was later revealed, there were more than 400 articulated parts. Vaucanson added an appendix about the duck to his "Memoir" of the Flute Player. It took the form of a letter to his friend, the influential journalist Abbé Desfontaines and, once again, was very precisely anatomical. One part of it described the duck's wings at great length, in order to give an example of the careful study involved in the construction of the machine:

I do not believe the Anatomists can find anything wanting in the construction of its wings. Not only has every bone been imitated, but also all the Apophyses or Eminences of each bone. They are regularly observed as well as the different joints: the bending, the cavities, and the three bones of the wing are very distinct. The first, which is the *Humerus*, has its motion of rotation every way with the bone that performs the office of *Omoplat*, *Scapula* or *Shoulder-blade*; the second bone, which is the *Cubitus* of the

wing, has its motion with the *Humerus* by a joint which the Anatomists call *Ginglymus*; the third, which is the *Radius*, turns in a cavity of the *Humerus*, and is fastened by its other ends to the little end of the wing, just as in the animal. The inspection of the machine will better show that Nature has been justly imitated than a longer detail, which would only be an anatomical description of a wing.

The description was so elaborate, and the final ironic throw-away so effortless, that two people who handled the duck later in its life were led to believe, independently of one another, that Vaucanson had perfected the rhetoric of a magician. The duck did not function as he said it did, they thought, and his casual talk had served to obscure this fact.

The rest of Vaucanson's letter read like a brief treatise on the nature of digestion. There was some debate at the time over whether the process of digesting food involved "trituration" (grinding) or dissolution, with gastric juices, or a combination of the two. By presenting his duck to the French public Vaucanson, though not a doctor or a philosopher, was actively contributing to that debate. "Food is digested in its stomach," he wrote, "as it is in real animals, by dissolution, and not by trituration, as many natural philosophers contend." He was clear, however, about what his artificial duck could and couldn't do: "I do not pretend to offer this digestion as a perfect digestion, capable of producing blood and nutritional elements for the animal's continuing health; I believe it would be churlish to reproach me for that." By being so specific, Vaucanson was guaranteeing that his audiences would believe that

the duck was in fact performing these allegedly limited, though clearly extraordinary, feats.

He went on to give details of the duck's insides: not only was the grain, once swallowed, conducted via tubes to the animal's stomach, but Vaucanson had also had to install a "chemical laboratory" to decompose it. It passed from there into the "bowels, then to the anus, where there is a sphincter which permits it to emerge." Elsewhere in the tract he described how the digested matter was "driven away at Pleasure through circumvolutions of pipes," leading an American observer to make a speculative drawing of the duck's insides, often supposed to have been drawn by Vaucanson himself. The drawing reminds us how strange it was for Vaucanson to create these "circumvolutions," which look very much like intestines, when he could just as easily have laid down a straight pipe to carry the food to the other end of the duck. The fact that he chose to emulate the form when he need only have copied the function implies that there may have been some sort of projection, or identification, involved.

Of course, it was a peculiar project altogether. As Voltaire must have meant, France now had as its glorious mascot a golden creature that was famous for its excrement—ingenious, yes, and full of mechanical marvel, but also a reminder that civilization could not be separated from its waste. There was mess involved in even the least fleshly pursuits. Indeed, the most immediate wonder of Vaucanson's duck was that it performed functions that would never be expected of a machine; it was beyond a machine, it was a highly skilled joke. Had the duck been an artificial defecating man, there would no doubt have been a more complicated, less rapturous response; but,

aside from his contribution to fashionable debates, the question of why Vaucanson should have wanted to manufacture such an artefact remains.

Vaucanson, it must be said, was a man much preoccupied by the state of his body. We know that he designed an automaton whilst plagued by an illness that had prevented him from eating. Though details of his condition would otherwise be superfluous, it is worth noting, given Vaucanson's language in describing his duck, that he was suffering from a fistula of the anus. It was a painful affair, which the medical profession took very seriously—Louis XIV had been the victim of one as he was dying, and the *Encyclopédie* contains, in its section on surgery, diagrams for operating on it. The mechanician's particular mention of the bowels, anus, and sphincter of the duck—parts audiences may have preferred to imagine for themselves—might be seen as a reflection of his own personal preoccupations.

This notion is purely speculative, but it is supported by two other occasions when Vaucanson used his apparently weak physical health as an excuse. The first was when he wanted to leave the Minimes: he told the Bishop of Grenoble that the vegetarian diet the order was committed to was not good for his delicate digestion (presumably, his "unmentionable illness," if real, was related to his digestive system). The second was after the duck had been exhibited. In 1740, Frederick the Great, recently having acceded to the Prussian throne, and following the suggestion of Voltaire, invited Vaucanson to join his Academy of Sciences, as he later did La Mettrie. Vaucanson wanted to stay in France, but he would not let patriotism be his

only answer. He had to stay, he told Frederick, because of his fragile health—he did not go into detail.

Whether or not Vaucanson's health really was that feeble is uncertain. What is clear is that his immediate response, when looking for a way out, was to plead illness, to make reference to his malfunctioning body. His machines, on the other hand, were flawless, superhuman things. They were, perhaps, imaginary prostheses: unlike its creator, one of them had a digestive system that ran like clockwork.

By 1741 Vaucanson had had enough of his automata. He wanted them to be shown in England, where there was a substantial audience for mechanical exhibitions, but he did not want to take them there himself. He had never seen himself as a mere entertainer, and in any case by then he had been given another, rather grand job. So he packed off his three machines with three Lyonnais businessmen, who paid over the odds for the privilege, and who later bought the automata outright. They disappeared from their inventor's view, and embarked on a new stage of their mechanical lives.

Since the act of telling time seemed to emulate a certain kind of intelligence, the clock became the ideal machine for the Age of Reason. But it also contained an ironic catch. As Aram Vartanian observes in his book on La Mettrie, "If on the one hand the clock is able to tell time, it remains on the other totally oblivious to time; and this very resistance to an inner shaping by virtue of duration is, in fact, what permits it to perform its task so admirably." Men are mortal, clocks are not. Vaucanson aged even as he constructed his ageless creations. They passed from

one owner to another, and survived the death of those who possessed them; and so the history of Vaucanson's automata after their sale is one of disappearances and detective work, of improbable travels and sudden resurrections. The Flute Player left few traces, but the duck appears to have risen now and then, like a clockwork phoenix.

The ringleader of the Lyonnais trio was a man named Dumoulin, a perfumier and glovemaking like Vaucanson's father. He travelled with the machines throughout England and Holland, then back through France and Germany. He tried to sell them in 1754 to a relative of Frederick the Great, but the buyer couldn't find the cash. So Dumoulin pawned them in Nuremberg, and left for Russia, where he exhibited other curiosities. There are traces of his shows in St. Petersburg and Moscow, and though he was employed as a mechanic by the University of Moscow, he was sacked after six years, for incompetence. He died in St. Petersburg in 1781, leaving Vaucanson's automata still in the hands of the pawnbrokers.

At this point, they were seen, packed up in boxes and kept in an attic, by the German writer Christian Friedrich Nicolai, who published an account of his European travels in 1783. He reported that they had apparently been well preserved, though after "28 years of captivity" the cost of repairing them would be impossible to calculate. Before he left, Dumoulin had stored them in such a way as to make it impossible for anyone to exhibit them with any success. He had taken the two androids to pieces, and mixed up parts of the Flute Player with parts of the Pipe Player. The duck was intact, but Dumoulin had carefully positioned its internal chains in reverse, so that they would break if the duck was set in motion. Nevertheless, the

mechanism of the duck was the easiest to see and, on closer inspection, Nicolai found that it did not digest its food at all. There was no "chemical laboratory," he revealed—the food was simply aspirated into the neck with the aid of bellows and tubes, and a separate substance made to look like the digested version was held at the ready in another compartment near the bird's rear end. This was "expelled at the desired moment by a piece of mechanism."

The result of Nicolai's report was that the machines were rescued by an extraordinary man whose father had told him about them when he was a boy. He had always wanted to own automata like them, he said, and when he was finally in possession of the very same objects he declared them to be "the greatest masterpieces of mechanics that humankind has ever created."

The man was Gottfried Christoph Beireis, doctor to the Duke of Brunswick, chair of Medicine at the University of Helmstadt, collector of curiosities and reputed master of alchemy. As a young medical student, Beireis had developed a taste for alchemical experiments and tricks of natural magic. He was an avid reader of a twenty-volume, late-eighteenth-century German work by Johann Christian Wiegand, entitled *Instruction in Natural Magic, or, All Kinds of Amusing Tricks*, which mentioned Vaucanson's automata in its opening volume. E. T. A. Hoffmann also possessed a copy, and it was this book that contained the automaton-making instructions Hoffmann attempted to follow before he set out to write his stories "The Automata" and "The Sandman."

After finishing his studies, Beireis went on a long journey and returned extremely wealthy, leading his acquaintances to

suppose that he had discovered how to turn base metal into gold. He did nothing to dispel these rumours, and developed a signature line in social magic tricks. On one occasion he was invited to dinner at the home of the Duke of Brunswick, where several dignitaries were in attendance. Beireis arrived wearing a bright-red coat, which he refused to remove. During the course of the meal, the coat turned completely black and fell to pieces on the floor. At that same moment, the Bishop of Hildesheim, who was sitting across the table, found that his wine had turned to vinegar.

Beireis was made Professor of Philosophy and Medicine at Helmstadt when he was still very young. He bought a large house with a garden, and filled it with musical instruments, rarities of natural history, jewels, paintings, anatomical exhibits, and mechanical objects. He was a gifted fencer, and quite a dandy; he wore early-eighteenth-century clothes, with diamond-encrusted buttons and buckles for special occasions, until his death in 1809. When he bought Vaucanson's automata, he wasted no time in dressing the two androids in gold and silver outfits.

In 1805, Goethe went to visit Beireis, lured by the legend of "the old wonder-worker," as he called him. His description is well worth quoting at length:

Hofrath Beireis, an eccentric, problematic man, already for many years notorious in so many respects, had been so often named to me; his neighbourhood, remarkable possessions, strange behaviour, and the secret brooding over all, so often described to me, that I could not but reproach myself with the fact that I

had not seen with my own eyes, and in personal intercourse endeavoured to fathom, in a certain measure at least, this most singular personality, which seemed to point to an earlier, transitory epoch . . . Professor Wolf being in the same predicament in this respect with myself, we determined, knowing the man was at home, on undertaking a journey to the mysterious griffin who presided over extraordinary and scarcely conceivable treasures.

Goethe and his companions were greeted by a man who was "not tall, well-built and agile, the legends of his fencing skill may well be believed; an incredibly high and vaulted forehead, quite out of proportion with the lower and finely contracted parts, indicated a man of singular spiritual force." They were shown his art collection—paintings by Titian, Raphael, Correggio, Rubens, Dürer—and saw, in the middle of a large hall devoted to natural history, a series of stuffed birds, "all eaten to pieces by moths, feathers and vermin lying heaped up on the stands." They found our artificial bird there too, in no better condition: "A great deal of his former possessions," Goethe reported,

the name and reputation of which were still fresh, we found in the most lamentable state. The Vaucansonian automaton was utterly paralysed. In an old garden-house sat the Flute Player in very unimposing clothes, but his playing days were past . . . A duck without feathers stood like a skeleton, still devoured the oats briskly enough, but had lost its powers of digestion.

With all this, however, Beireis was by no means put out, but spoke of these obsolete, half-wasted things with much complacency, with an air of much consequence, as if he thought that mechanism had since produced nothing new of greater importance.

On Beireis's death it became apparent that Napoleon had offered him money for the Vaucanson machines, but that Beireis would not let go of them. In 1810, his heirs offered to sell them back to France; in February that year there was some correspondence between various noblemen about this, inquiring whether Napoleon's interest still held. "Monsieur le Duc," Count Beugnot wrote to the Duke of Berg,

The cabinet of Mr. Beireis contains amongst other curiosities the three automata of Jacques Vaucanson. His Majesty the Emperor and King wished to bring back to France these surprising productions which had left the country, and offered to buy them from professor Beireis six years ago.

But this *savant*, renowned as much for the strangeness of his character as for the extent of his knowledge, turned down a proposal whose intention and dignity he was unable to appreciate.

Count Brabeck . . . informs me that professor Beireis has recently died and that his heirs are willing to cede to the desire which his Majesty deigned to express, and to give him back the Vaucanson pieces. He adds that the professor has also left a collection of gold medals and some anatomical preparations.

I thought it my duty to report to your Excellency Count Brabeck's message. He is not as yet able to indicate what price professor Beireis's heirs have put on these items of his collection: but if his Imperial Majesty still desired to enrich France with their presence, his minister at the Cassel court could undertake the negotiations with the help of Monsieur de Brabeck. Of the three items proposed, the first . . . at least belongs to France. I believe I remember reading the description of it and its praise in the proceedings of the Academy of Sciences, and his Majesty will surely want to reconquer these monuments of French genius which have gone astray.

This time, however, it was Napoleon's turn to reject the offer, and the automata disappeared once again; only the duck has been heard of since. It was found twenty years later in the attic of another pawnbroker, by Georges Dietz, a theatrical impresario and exhibitor of automata. Dietz passed it on for repair to a famous Swiss clockmaker, Johann-Bartholomé Reichsteiner, who spent three and a half years working on the duck, which he said contained several thousand pieces. Reichsteiner concentrated so hard on repairing the automaton that he became quite ill, but eventually Dietz was able to exhibit it once more, at La Scala theatre in Milan in 1843. In the meantime, Reichsteiner, who had whilst studying Vaucanson's creation thought of a number of possible improvements, had built an alternative model. His version (and possibly Vaucanson's as well, after he had fixed it) was covered in real feathers over its gold and copper ones. And since Reichsteiner began to exhibit

his own duck not long afterwards, there remains in the rest of this story some confusion about whether the duck in question was the original or a clever copy. At any rate, Dietz certainly took Vaucanson's duck to Paris in 1844 for the Exposition Universelle at the Palais Royal, where a wing fell out of order.

Also on show at the Exposition were the automata of a celebrated magician, Jean-Eugène Robert-Houdin (the conjuror from whom Houdini took his name). Robert-Houdin had made an automaton that could write and sketch, which was given a gold medal at the Exposition. Dietz asked him to repair the duck's broken wing, and the magician, delighted to have his hands on the famous creature, wrote about the occasion in his memoir. "To my great surprise," he reported gleefully of Vaucanson, "I found that the illustrious master had not been above resorting to a piece of artifice I would happily have incorporated in a conjuring trick." Robert-Houdin discovered what Nicolai had found sixty-three years earlier: the digestion had been faked, and the emitted substance was a premixed preparation of dyed green breadcrumbs, "pumped out and collected with great care on to a silver platter."

It should be borne in mind that many of the stories in Robert-Houdin's memoirs were rather far-fetched—as late as 1928, the authors of the most scholarly book on automata, Alfred Chapuis and Edouard Gélis, refused to believe Vaucanson could have cheated. Robert-Houdin's reaction, however, was to admire the late inventor even more: "Clearly, Vaucanson was not just my master in mechanics—I must also bow before his genius for trickery . . . Far from diminishing the high opinion I had of Vaucanson, this artifice, on the contrary,

made me admire him doubly, for his knowledge and for his know-how."

Subsequent traces of the duck are scarce—a mechanical one was said to be in the possession of a certain Blaise Bontems, who manufactured singing birds, in 1863. Another rumour had it that the duck had met its end in Nijni Novgorod. In 1882 someone wrote a letter to a German newspaper claiming they had seen the duck in Krakow in the summer of 1879. He and his wife had been to see the cabinet of a Mr. Gassner, the letterwriter said. Gassner was exhibiting a collection of wax figures, antiques, and a blueprint of Thomas Edison's phonograph, which had been invented the year before, along with a duck he claimed had belonged to Vaucanson. They were delighted by the show; but a few days later, as they were sitting in a garden nearby, the man and his wife smelled burning. When they went to investigate, they found Gassner's museum razed to the ground—a small flame had made the waxworks catch fire, and the blaze had spread out of control. Amidst the ashes, he reported, they found a pair of misshapen metal wheels, "the pitiful remains of our glorious bird."

More recently, however, some mysterious photographs have come to light, and have been preserved in the archives of the Conservatoire National des Arts et Métiers in Paris (which was founded after the mechanician's death in order to house his remaining machines, and is situated on a street now called rue Vaucanson). They show a crude, featherless bird, made of spring-like windings of wire and perched on a huge wooden frame that contains a mechanism resembling a watermill. They are extraordinary views, reminiscent of the sorry skeleton

Goethe described, and give the impression that the figure is some sort of prehistoric find, better suited to a museum of natural history than to one of arts and crafts.

The provenance of the photos, however, and the true identity of what they depict, are still in question. They were found in a drawer by the museum's conservator in the 1930s, and they were marked "images of Vaucanson's duck, received from Dresden." There was no further explanation, though the archives possess a letter written by an Italian man to the museum's director in 1899, offering him not only the photos, but the machine as well (so if this were Vaucanson's duck, a different one must have been destroyed in Krakow). The director's reply was that the condition of the object was too poor, and the price proposed too high, for him to consider buying it. This is all the information we have. The present director of the museum does not believe the bird in the pictures is the original duck; Doyon and Liaigre, Vaucanson's biographers, believe it is. Either way, these photographs, the last fragments of possible evidence, tell their own story: Vaucanson's artificial beings broke free from their creator and developed an afterlife of their own; they were stripped back and rebuilt, seen through and newly admired—whether in truth or in legend, they continued to survive.

As soon as he had sold his automata, Vaucanson put all his energies into his new job. Louis XV had been a great admirer of the duck, and in 1741 he appointed Vaucanson Inspector of Silk Manufacture in the kingdom. Until then, there had been specific problems in the making of silk: although silkworms were bred in France, there was no effective system for collect-

ing the cocoons or conserving them, and because the mills and wheels were mediocre, the weaving process made the resulting fabric faulty, so the French had resorted to importing the raw materials from Italy. Vaucanson made several lengthy trips to Lyon, the silk-making capital and home of his former monastery. By introducing new regulations and designing new looms (one of which became the basis for the better-known Jacquard loom), Vaucanson revolutionized the industrial process in France. He left the realm of fashionable curiosities, and concentrated on reforming the world of work. Although not strictly automata, these machines were in a sense prostheses—extensions of men—or substitutes for men. In the shift towards industrialization, labourers were valued less as machines were valued more, and Vaucanson played a significant role in the widespread replacement of men with their artificial counterparts.

In his funerary tribute to Vaucanson, the Enlightenment mathematician and philosopher Condorcet defined a mechanician as one who "sometimes applies a new motor to machines, and sometimes makes machines perform operations which were previously forced to be reliant on the intelligence of men; or he is one who knows how to obtain from machines the most perfect and abundant products." This, according to the silk workers of Lyon, was precisely Vaucanson's wrongdoing. They rebelled against his automatic loom by pelting him with stones in the street; they insisted that their skills were needed, that no machine could replace them. In retaliation, Vaucanson built a loom manned by a donkey, from which a baroque floral fabric was produced, in order to prove, as he said, that "a horse, an ox or an ass can make cloth more beautiful and much

more perfect than the most able silk workers." This spiteful performance, surprising in the son of a craftsman, was the reverse of his golden duck: instead of producing excrement from a precious metal, he made luxurious silk emerge from the end of a live animal. The first was designed for man's entertainment; the second was meant to show man that he was dispensable.

The biographers Doyon and Liaigre blame the silk workers for stalling the march of progress, for France's Industrial Revolution lagging behind England's; and Condorcet comments melodramatically that "whoever wishes to bring new enlightenment to men must expect to be persecuted." The point of view of the workers seems to have been sidelined altogether in favour of a grand Enlightenment project. The *Encyclopédie* devoted sixteen pages (not including illustrations) to the making of silk and other stockings. "In what systems of metaphysics," it reads, "does one find more of intelligence, wisdom, consequence, than in machines for spinning gold or making stockings? . . . What demonstration of Mathematics is more complicated than the mechanism of certain clocks?" In the *Encyclopédie's* illustrations, the men are secondary to the machinery. Vaucanson and his contemporaries contributed to a widespread sleight of hand: like wine into vinegar or base metal into gold, men were turned into machines. The new automata were not replicas, but real humans transformed. Throughout the next century, factory workers came to feel they had been reduced to the mechanical pieces they were in charge of producing, hour after hour and day after day.

Vaucanson's reforms were not limited to showy fits of pique. One of the first big organized strikes in French history

erupted in response to new regulations he had put in place. In 1744, makers of silk fabric and stockings—labourers and journeymen, overseers of the manufacturing community, dye workers, carpenters, crochet workers, shopkeepers—and manufacturers of gold and silver cloth revolted. The uprising was so dramatic that the local government quickly took measures to appease the workers, but these were revoked by the King, who responded first by issuing fines, and then by prohibiting the workers, on pain of prison, from gathering in "cabarets, taverns, cafés and places of public games" in groups of more than four. The punishments became even more severe. A crochet worker by the name of Gaspard Jacquet was condemned to appear before the Palace and the Hôtel de Ville, holding a blazing torch, naked except for his shirt, with a sign around his neck that read "seditious crochet worker." After being fined, he was interrogated, on his knees, forced to reveal the names of his accomplices, and made to ask God for forgiveness. He was then hanged to death. Other strikers suffered the same fate; still more were imprisoned. Almost a year later, the King issued an amnesty; but the damage had been done. Vaucanson had tried to replace men with machines; men had died as a result, and he had been forced to escape violence under cover of night, disguised as a Minime monk.

Louis XV was twenty-nine when he saw Vaucanson's duck; he had been king since the age of five. Accounts of Louis's early life portray him as a lonely child—he had lost his great-grandfather, the Sun King, and his mother, father, and brother within the space of three years, and his rank separated him from most other children. Later in life he wrote in a letter of

condolence to someone whose mother had died: "I have the misfortune never to have known what it is to lose a mother." Even when he had the entire palace to himself and ruled all of France, Louis and a few sons of noblemen constructed a kingdom in miniature: they played with his menagerie of toy animals, and, calling himself "Maréchal Duc Louis," he made dukes and marshals of all his friends, who became, collectively, the Order of the Pavilion, after the little outhouse where they sometimes played. (A single leather-covered toy elephant remains from this time, preserved in a German museum.) The fact that Louis had the stature of a child and the status of a king seems to have posed an interesting problem for artists of the period: in many paintings and engravings, in which he greets visitors and members of his court, he looks like a midget, or a dressed-up doll—a small thing of adult proportions, weighed down by gilded clothes and chains. In effect, he had no childhood, except by reducing his world to fit his size and, conversely, he was made into a symbolic, miniature object by others; it's not impossible to imagine that when Louis saw the duck, some part of a lost childhood had been found, in the form of a philosophical toy.

Louis was tutored by the Cardinal de Fleury, whom he later appointed as his regent, though he was old enough by then to rule the country on his own. Fleury taught him Latin, history, astronomy, geography; he took him to the Louvre, where the boy saw relief maps of his kingdom, to the Jardin des Plantes, where he met his great-grandfather's former doctor, and to the observatory, where he delighted in experiments involving magnets. Louis showed a particular interest in stories about voyages, and everything relating to them—globes,

compasses, maps—and he developed a profound fascination for anatomy. Antoine Coysevox was one of his court sculptors, and Philidor, the renowned chess player, was retained as a musician. Louis was to become a great patron of astronomers and naturalists, and a supporter of numerous scientific expeditions. He loved, as is clear from his admiration for Vaucanson, all the mechanical inventions of the time. Although much has been written about the scientific progress made during the period of his reign, as Louis's most recent biographer, Michel Antoine, points out, the King's personal involvement and interest in it has been all but ignored. When Louis died, all sorts of mechanical apparatus were found in his cupboards and drawers: there were eight cases of mathematical instruments, four opera glasses, a portable barometer, a microscope, a telescope, a compass, and eleven watches.

Perhaps his most persistent interest, however, was the one on which his life depended. Louis was very close to his two chief surgeons, Mareschal and La Peyronie, the first of whom had attended his great-grandfather, and the second of whom was to remain with Louis for almost thirty years. Louis was nine when La Peyronie was appointed, and, from the time he was a boy, he would continually ask the surgeon questions about anatomy. Michel Antoine believes the King's concern derived from his parents' early death, and from his own persistently fragile health; clearly Louis's curiosity was precocious. Early on, La Peyronie instructed him in anatomy using artificial models of parts of the body, and dissected animals from the royal menagerie before him. Louis applauded these performances, and told everyone in his entourage about La Peyronie's cataract operations, which he had witnessed.

Acquaintances were sometimes shocked by the frequency with which Louis's conversation turned to matters of health, illness, and death. One reported an occasion when he had arrived at the palace, only for the King to announce straight-away that the foreign secretary had died. The foreign secretary had had, in his lifetime, a nervous tic that had made him grimace, and without pausing for his visitor to register the shock of the man's death, Louis said, "Do you know, he's been opened up, and it turns out he had a growth in his liver which made his tic more frequent as it increased in size?"

A famous surgeon later commented that Louis had wanted to know everything about "the very structure of the human machine," and that he could "hold a lengthy conversation with the most learned anatomist." He regularly attended the public demonstrations of apothecaries, was known to send delegations of surgeons to rural towns to stop the spread of epidemics, and he gave more noble titles to medical men during his reign than any other king had before him.

When Louis went to visit Vaucanson after seeing his artificial duck, he had a particular anatomical project in mind. Amazed by what the mechanic could do with the animal's insides, he asked Vaucanson if he could "execute the circulation of the blood in the same way." In other words, if he could make a man-machine.

It was several years before the Swiss physician Philippe Curtius began to model portraits in wax, and many more before he taught his protégée Marie Grosholtz, who would later become Madame Tussaud, but the practice of making anatomical models had been in place for some time. We know,

for example, that Leonardo da Vinci (who once built an automaton in the shape of a lion) had succeeded in making casts of the brain by injecting its ventricles with wax, and Michelangelo later sculpted a number of muscle studies out of the same substance. Until the seventeenth century, these models had been the work of artists rather than anatomists, and they were used to teach art instead of medicine; but then the artists and the anatomists began to come together. The wax-modeller Gaetano Zumbo (whose work is still on display at the natural history museum of La Specola in Florence, along with the later, exceptional wax models of Felice Fontana) worked in collaboration with a surgeon named Guillaume Desnoues. When they went their separate ways, Desnoues set up a museum for the waxworks in Paris, which later moved to London, and on his death the models were sold at auction. At this point, the worlds of anatomy and spectacle collide. The models were kept in one place, in Covent Garden, on a sort of time-share basis: at certain times of day, they were used by surgeons to give anatomy lessons, and at others they were the subject of ghoulish tours for the curious. They went to Paris in 1729, and continued to be shown as a travelling exhibition until at least 1740.

In Vaucanson's time, an Italian couple called Anna and Giovanni Manzolini were making anatomical wax models with great success, and in France a woman named Marie Catherine Bihéron was widely admired among the *philosophes* and their correspondents. Mlle. Bihéron, whose *pièce de résistance* was the dissectible figure of a pregnant woman, was the first to have worked out a way in which her models could be taken apart, so

that each section of the body, and how it connected to others, could be shown individually. Near the end of Mlle. Bihéron's life, Catherine the Great bought her entire collection.

What Louis XV wanted was not a model in wax at all. He wanted to be able to show the blood flowing through the body—not a dead anatomical prop, but a flexible, active automaton: an artificial, bleeding man. As it happens, this coincided perfectly with Vaucanson's own objectives. Until about 1730 he had been working on some automata he called "moving anatomies," intended for the purposes of medical teaching, but he had been forced to abandon them owing to lack of funds, and had turned instead to figures he knew would excite public interest. Now he was being asked by the King to return to his original project, but on a much more monumental scale. If his early androids had displeased the theologians, this one was his most God-tempting yet. He had made machines breathe, he had made them digest food, he had covered their hands in flesh, and now this "new Prometheus" was about to bestow on them the blood of life itself.

Louis had a reason for requesting this particular machine, and it was related to his support for the surgeons. Until the 1730s, surgeons had been regarded by the medical profession as mere craftsmen. They were represented by the guild of barber-surgeons rather than by any professional institution, and so were grouped more with barbers than with physicians. Surgeons, the physicians insisted, were unversed in philosophy or Latin and therefore did not have the intellectual means to establish a theory of their craft. They were just there to assist the physicians with their manual skills.

The surgeons rejected this view vociferously at the begin-

ning of the eighteenth century, and the prime movers on that side of the debate were Mareschal, La Peyronie, and the latter's protégé François Quesnay. Their argument gained support in 1715 when Mareschal, first surgeon to Louis XIV, diagnosed the King's fatal illness early on, and was ignored by his chief physician, Fagon, who allowed the King to die. Fagon was dismissed, and the position of chief surgeon was never again seen as beneath that of the physician. Quesnay argued eloquently and often on the surgeons' behalf, pointing out that traditionally they had in fact been university educated, and not just apprentices to barbers. They had the *philosophes*, and more importantly the King, on their side, and in 1731 a Royal Academy of Surgeons was finally established.

Even then, the surgeons had to fight to be seen as equals, and the continuing dispute was conducted on the basis of certain medical issues, at the core of which was the question of bloodletting, a procedure performed by surgeons that was gaining theoretical ground. Though Harvey had discovered over a hundred years earlier that blood circulated in the body, little work had been done on how illnesses stemmed from troubled circulation, or how malformations of the system arose. "It is surprising," Quesnay wrote in 1730, "that since the discovery of the circulation of the blood, so few authors should have applied themselves to giving all the instructions and clarifications on this subject which can be drawn from the experiments and observations of the great masters."

The arguments over bloodletting were not only conducted in words. Experiments and clarifications came from practical replicas of the circulatory system. The first known model of the blood system was constructed by a German doctor and

announced in the *Journal des Savants* in 1677. In his treatise on bloodletting Quesnay reported that he himself had built "a hydraulic machine" out of tin, which showed that the blood moved according to the laws of hydrostatics.

The head surgeon at the main hospital in Rouen, Claude-Nicolas Le Cat (whom Vaucanson had probably met as a student), was also at work on a machine by which he intended to prove his own theory of bloodletting. Le Cat was a brilliant, often argumentative surgeon and teacher of anatomy who for several years in a row won the annual prize awarded by the new Academy of Surgeons for the best essay on a given surgical subject. He described his machine as "an automated man in which the primary functions of animal economy, the circulation of the blood, respiration, and secretions can be seen to be executed, by means of which the mechanical effects of blood letting can be determined, and several interesting phenomena which do not appear to be susceptible to it can be subjected to experimentation."

In 1733 a young surgeon named Abraham Chovet exhibited in London what was described in the papers as a "new figure of Anatomy which represents a woman chained down upon a table, suppos'd opened alive; wherein the circulation of the blood is made visible through glass veins and arteries." Chovet pumped through the glass arteries and veins a red blood-like fluid, and claimed in the accompanying tract that "any Person, tho' unskilled in the knowledge of ANATOMY, may at one view be acquainted with the *Circulation of the Blood*, and in what Manner it is performed in our living Bodies."

So in asking the master mechanic to construct a model of the circulatory system, Louis was requesting not just a

demonstration model but ammunition for a highly delicate debate. And the issues relating to blood were not confined to doctors and surgeons—they entered, to some extent, the popular imagination: there was even a machine exhibited at a Paris fair in 1736 that was said to "represent exactly the circulation of the blood."

Vaucanson started work straight away. In 1741, while in Lyon to inspect the silk-manufacturing process, he gave a lecture at that city's Academy of Art, of which Quesnay and Voltaire were associate members. The talk, which was highly unexpected, was reported in the Academy's minutes. The secretary noted:

Monsieur Vaucanson, known for various automata which have received the approval of the Royal Academy of Sciences and the applause of the public in Paris, having come to this city, and our Director having given him permission to attend this session, told the Academy of a project he has imagined[:] that of constructing an automaton figure which will imitate in its movements animal functions, the circulation of the blood, respiration, digestion, the combination of muscles, tendons, nerves, etc. The author claims that by means of this automaton we will be able to conduct experiments on animal functions, from which we can make deductions in order to understand the different states of health of human beings and to heal their ills. This ingenious machine, which will represent a human body, may eventually be used for demonstration in an anatomy lesson.

Curiously, however, Vaucanson did not want his paper to be published afterwards. Towards the end of that year, another entry in the minutes explained that the author had not wanted to submit a copy for publication because, he said, "it is nothing but a project which may never be executed." It may have been modesty, or superstition, that prevented Vaucanson from making his idea fully public; but his biographers imply that there was a more calculated reason for his secrecy.

Vaucanson was to continue work on his artificial man for the next quarter of a century. He knew, of course, that what he had in mind would be difficult, if not impossible, to bring to fruition and, all the time he was engaged in more official pursuits, this artificial man was to be his private preoccupation. Meanwhile, there were many other attempts to build a blood machine, and Vaucanson appears to have seen no reason why he should give his rivals any clues about his own project. Another possibility is that, in keeping a low profile on this front, Vaucanson was able to quietly steal other people's ideas. Chovet's blood machine was in London, Quesnay was more of a theorist; his only serious threat was Le Cat.

Le Cat was happy to make himself unpopular in the service of higher aims. Although the Academy of Surgeons awarded him its gold medal several years in a row, he was never part of that coterie, and always refused to move to Paris from Rouen. Vaucanson was in the better social position by far; but Le Cat had been at work on his artificial man for longer and had more medical experience. He was instrumental in founding a separate Academy of Sciences in his own city (in 1744) and, after much wrangling, also succeeded in establish-

ing a dissection theatre in his hospital, where he gave public anatomy classes that were extremely well attended. He was the inventor of a number of surgical instruments, and had a very public row with another surgeon, in which Le Cat supported more humane operative methods. He was made a nobleman four years before his death in 1768.

The year before Vaucanson gave his presentation in Lyon, word of his intentions had already spread, and Le Cat's supporters rallied round. In November 1740, Pierre-Robert Le Cornier de Cideville, a friend of Voltaire and future member of Rouen's Academy-to-be, wrote to Le Cat:

You are working, so I am told, on your artificial man and you are right in doing so. You must not let Monsieur de Vaucanson accept the glory for ideas he may have borrowed from you. But he has applied himself only to mechanics, and has used all his shrewdness for that purpose—and he is not a man who is afraid to take extreme measures. I would advise you therefore to see, from practical experiment and from the actual construction of your machine, whether it will work in practice before you make your plans known to the public. So many machines strike us by their apparent possibility, only to be found wanting, in practice, in some area we had not worked out enough . . . Do not interrupt your work on this idea, which, if developed, will deserve to be presented to the Academy of Sciences in Paris, on behalf of our own nascent Academy, if in fact it is born.

Clearly, the lines of battle were drawn: Vaucanson had more experience in the manufacture of machines, and Le Cat knew more about the human body. Despite Le Cat's great prowess in the field of anatomy, he risked falling behind in the practical construction of his android, while Vaucanson, who was less worried about practicalities, took all the credit. Le Cat was not to be outdone. Four years later, he presented his cybernetic project at the inaugural session of the Rouen Academy. Cideville reported the occasion in a private letter to the secretary of the Academy of Sciences in Paris. "[Le Cat's] automaton," he wrote, "will have breath, circulation, quasi-digestion, secretions, heart, lungs, liver and bladder, and, God forgive us, everything else. But it will become feverish, it will have to be bled and purged, and it will resemble a man too much."

God forgive us, it will resemble a man too much—this was exactly the problem with the artificial project: it frightened even the most respected thinkers. Le Cat may have meant his version as a demonstration model, but Vaucanson's ambitions seem to have swelled out of proportion—to dwell on it for so long, to be so calculating and secretive, to dream of creating artificial life in the most complete way becomes quite chilling, and is matched by Cideville's phrase, "He is not a man who is afraid to take extreme measures." As it happens, that comment was rather prescient.

Contrary to what Le Cat may have imagined, Vaucanson did have some practical concerns. He was not content to make his android out of glass or tin. He wanted to build a working, moving, artificial man and he knew that a different, more flexible material was required in order to simulate the circulatory

system properly. Until then, the ideal substance was not known to exist. But something was about to be discovered on the other side of the world.

In 1735 Louis had sent the scientist Charles Marie de la Condamine on an expedition to South America, to measure a degree of the meridian. He was accompanied by an astronomer, a doctor, a botanist, and a mechanic, and they remained near the Equator for ten years. The *encyclopédiste* Jean d'Alembert called the trip "the greatest enterprise ever attempted by Science," and La Condamine's exploratory methods proved so successful they became a model for subsequent scientific journeys, including those that attempted to solve the problem of longitude. The travellers went through hurricanes, earthquakes, and volcanic eruptions. When they returned to Paris in 1745, they brought with them a number of important discoveries. Some were geographical (La Condamine had drawn up a map of the province of Quito, in what is now Ecuador), some were clinical (one of the Jussieu brothers, founders of the Museum of Natural History in Paris, came back with cinchona, a bark that had great medicinal properties), others were anthropological or botanical.

Amongst their imported knowledge was the introduction to Europe of a new material: the Amazonian Indians called it "cahuchu," and Linnaeus later classed it as *Hevea Brasiliensis*. Its "discovery" by the French was of course a piece of colonial mythology—Indians in South and Central America had been using it for centuries, and this had been noted by the Spanish conquistadors. But the French were the first to bring any of it back. La Condamine reported that the liquid substance could be moulded into any shape, that once hardened it was resistant

to water, and that its most remarkable property was its great elasticity. It was just what Vaucanson had been waiting for. In other words: rubber.

During his early days in Paris Vaucanson had met Bertin, who was to become minister of finance, and was in charge of all commerce and industry. When Vaucanson heard of the explorers' discovery, he wrote to Bertin asking if some experiments could be conducted on the substance on his behalf. Bertin was also interested in the issues concerning the circulation of the blood, and knew of the King's support for Vaucanson's machine. He agreed to help him, but their inquiries had to preserve the utmost secrecy.

Although La Condamine had been introduced to rubber resin on his trip to Peru, he had not seen the tree it came from, and had little scientific knowledge of the plant. When Bertin came to him for advice, La Condamine referred him to another man, François Fresneau, who was posted in Cayenne, the capital of the French colony of Guyana. Bertin wrote a letter to Fresneau, including the most florid bribes ("I see that you are a good and faithful servant of the King," "I shall not forget to inform the King of your goodwill," etc.), and asking him specific questions about rubber without once mentioning Vaucanson. His initial inquiries were: firstly, if there was a way of resealing works made in the resin when they were pierced or otherwise damaged (for this, read attaching one tube to another, or an artery to a vein); secondly, if anyone in France had the resin, how the tree was cultivated, and whether it could be grown in France (implying that a large amount of the material was required); and lastly, if there was a liquid that could

keep the resin moist but not penetrate or dissolve it (the blood content of the system, perhaps?).

The problem with the resin was that, while it was malleable in its liquid form, it could not be preserved in that form very long, and so, with research into its preservation or dissolution at such an early stage, it would be impossible to transport it to Paris in the quantities required. Fresneau had worked out a way of dissolving the dry rubber in walnut oil over a low heat, but when it reverted to its hardened state it lost all its elasticity, which clearly was of no use to Vaucanson. Fresneau presumed from the nature of Bertin's queries that he planned to make pipes, but he asked no more about his final objectives and set to work on finding the answers to his questions. Unfortunately, Fresneau concluded that the liquid resin was not transportable in large quantities, although spirit of terebenthine might produce the desired effect if the real spirit was available. However, in the course of his research he developed an in-depth knowledge of the plant and, having sent his report to Bertin, asked La Condamine (with whom he had been corresponding) if a copy might be published in the proceedings of the Royal Academy of Sciences. La Condamine, who had been very supportive of Fresneau and had already presented a version of his early findings to the Academy, seemed well disposed to the idea; but it would be two years before La Condamine got hold of a copy of his report, and even then there was a problem. He wrote to Fresneau saying he would have to "excise all mention of the minister [Bertin], who would not think well of being written about . . . It is Monsieur de Vaucanson who made these requests, and they are for some

machine he is planning; I do not think he means large pipes." So now Fresneau knew that Bertin's involvement was to be kept secret, but it had been at the expense of revealing Vaucanson's. His report was returned to him with the words: "Do not speak either of Monsieur Bertin or of the Court."

Fresneau rewrote his account, and re-sent it to Paris. It was never published; and until the late nineteenth century the credit for his research was given to La Condamine. What was the purpose of all this intrigue and deception? Was the project to be kept secret because of Le Cat? Because of other potential competitors? Or simply because the scale of it—the exploration, the botanical research, the chemical analysis and intercontinental correspondence—was so threateningly monumental? It's hard to say, but the project did not stop there.

In 1763, the great French chemist Pierre-Joseph Macquer received a package from Vaucanson. It was Fresneau's report, and it was accompanied by a letter asking him to return it as soon as he had read it. Macquer was brought in on the secret project, and Fresneau's unpublished findings had become the most crucial contraband. In fact, Macquer did discover that the resin could be preserved in carefully rectified ether, which could be allowed to evaporate without harming the rubber's elasticity, but he only managed to collect it in small tubes of about the thickness of a quill pen. The quantities were insufficient. At this point, the conspirators decided that if rubber could not come to Paris, they would go to South America.

In his tribute to Vaucanson, Condorcet wrote that "an able anatomist was sent to Guyana to preside over the work; the King had approved the journey, he had even given orders for it." It is not known how many people went to Guyana, or any-

thing more about the expedition. The project was eventually abandoned.

The lack of further information about the journey leaves a good deal of room for speculation. Why were all these people—the greatest scientists of the Enlightenment, the most powerful men in France, the ruler of the kingdom—so wrapped up in a plan to make life out of nothing? It's as if earthly pursuits were not enough; they had to test the limits of the Promethean dream.

The only reason given for the project's abandonment, after years of work, was that Vaucanson had become "disgusted." With what? With his own ambition? With the terrifying nature of his anatomical plans? It would appear that just as the fantasy, in which so much had been invested, was about to come true, the other side of it was seen; it became monstrous, and crumbled.