MAN THE MACHINE

A history of a metaphor from Leonardo da Vinci to H.G. Wells

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Abstract: During the Italian Renaissance, artists and anatomists compared man to various mechanical devices, in an attempt to uncover knowledge about the structure and processes of the human body. In so doing, they drew on ancient Greek notions of instrumentality and proportion. During the early Scientific Revolution, the metaphor of Man the machine played a key role in the development of mechanistic philosophy. During the Enlightenment, it served views on materialism and atheism. By the nineteenth century, when the Industrial Revolution was in full swing, a fundamental change in the relationship of man to machine had come about. Whereas, for Protagoras, man had been the measure of all things, now suddenly the machine was the standard by which the capacities and limits of man were judged. Man the machine was a key feature in the development of the totalitarian ideology of Communism. Moreover, for over a century now, the technocratic viewpoint has guided many technological innovations. Tracing a history of this metaphor, through Leonardo, Vesalius, Harvey, Descartes, Hobbes, Leibniz, La Mettrie, d'Holbach, Marx and Wells, places man's relationship with technology and his gradual loss of identity since the Renaissance in a new context.

Résumé de recherche: Pendant la Renaissance italienne, des artistes et anatomistes ont comparé l'homme à plusieurs outils mécaniques, dans le but de dévoiler la structure et les processus du corps humain. En ce faisant, ils ont puisé dans les notions de l'instrumentalité et de la proportion chez les Grecs de l'Antiquité. Au début de la révolution scientifique, la métaphore de l'homme machine a joué un rôle clé dans le développement de la philosophie mécanique. Ensuite, pendant le siècle des Lumières, la métaphore a été mobilisée pour appuyer des thèses matérialistes et athées. Au dix-neuvième siècle, lorsque la Révolution industrielle battait son plein, la relation de l'homme et la machine s'est transformée. Là où Protagoras avait dit que l'homme était la mesure de toute chose, soudain la machine est devenue la norme servant à juger les capacités et limites de l'homme. Ce développement est à la base du développement du communisme, idéologie totalitaire. D'ailleurs, depuis plus d'un siècle maintenant, la vision technocratique oriente beaucoup d'innovations technologiques. C'est ainsi qu'à travers une histoire de cette métaphore, dans les œuvres de Léonard, Vésale, Harvey, Descartes, Hobbes, Leibniz, La Mettrie, d'Holbach, Marx et Wells, apparaissent dans un contexte nouveau la relation de l'homme et de la machine ainsi que la perte graduelle de l'identité humaine depuis la Renaissance.

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MAN THE MACHINE – INTRODUCTION[1]

A distinction has long been drawn between man and machine. That distinction is being blurred now, in the early twenty-first century, as we grow accustomed to machines that replicate, re-engineer and surpass certain human functions. Humanity and technology once seemed fairly distinct, but now appear to be converging at an increasing rate. This unprecedented situation is proving a challenge to humanity's age-old value systems, which recognize humans as unique beings endowed with a spirit and superior intelligence, and invested with a special mission to perform on planet Earth.

Machines sometimes appear to be "telling" us otherwise. Advances in artificial intelligence are providing us with "smart" machines that talk to us and can listen to us in return, that can point out and correct our mistakes, and that are constantly offering to reorganize and redefine our relations with other humans, with culture and with the world about us. Many advances in computer technology have been made possible by computer architectures that mimic the neural networks of the human brain.[2]

Such advances in computer technology are remarkable. They lead some observers to see the computer as a universal machine, a perfected device that can perform just about any operation that is desired. But such novelties also present humanity with dilemmas. Some people fear computers are dehumanizing, are capable of codifying every aspect of life, and may well end up reducing complex human relations and interactions to series of algorithms.[3] And what if computers succeed in replicating and surpassing human functions – could they one day become intelligent and even spiritual machines?[4] Could the virtual world of computerized fantasy and order one day prove more satisfying than the real world of experience and moral choice, of human trial and error, of living, loving, ageing and dying? Could computers one day seem more real than we ourselves? Could they be used to codify the inner life and personality of humans, to manipulate desires and emotions and to control individual liberty? Could they stifle the spirit itself?[5]

The distinction between man and machine is also being blurred in other areas, such as genetic engineering, biomedical engineering and the application of artificial intelligence to medicine. Genetic theory has been used to re-interpret human beings as biological machines for which blueprints exist somewhere.[6] In the early twenty-first century, a wide range of genetic and genomics technologies is challenging societal attitudes to human life and death as well as health and disease. Since life can be created in the laboratory, selectively sustained, manipulated, re-engineered, frozen, banked indefinitely and/or terminated, here again, machines are undergoing a transition from the mechanical to the organic/microscopic. The mechanical model for human bodies seems plausible, at a time when human bodies can be repaired using "spare" parts, consisting of tissue and organs recycled from other humans or other animals, alive or dead, or which have been manufactured in a laboratory or factory.

The Human Genome Project is cataloguing the entire genome map of mankind. It is proving to be one of the greatest scientific and technological enterprises ever undertaken. According to the new genomics interpretation, the digital instructions contained in the human genome were worked out by Nature over the course of some five hundred million years of evolutionary time; this digital book of life is inherited by each one of us; and it governs all our biological characteristics, from the way we grow and reproduce, to our susceptibility to disease. Our entire biological structure – down to the strings of our 3 billion DNA bases and our 30,000 or so genes – can be represented digitally.

According to the Nobel laureate Sir John Sulston, the chief promoter in the United Kingdom of the Human Genome Project, the set of instructions to make humans is digital: "It is quite remarkable that we can put a limit on the number of bits required to make a human being. But now we have to ask what is meant by 'making a human being'. [The genome] is the set of instructions to make our structure, or at least to start it off. Of course, from the very moment of conception, one is subject to environmental influences, both in the womb and then later on the outside. One has to realize, and we are all very well aware, that what we are most significantly as human beings, what we are in our heads, in our thought processes, in our interactions, in our building experiences, is not something which is coded and programmed from the start. We humans, probably more than any other living organism on Earth, are learning devices. We educate ourselves and we change. It is important to be aware of that when one thinks of artificial intelligence. And it is interesting that the progress being made in artificial intelligence takes in this concept."[7]

Genomics is expected to lead to the development of revolutionary diagnostics and therapies to locate and treat "defective" genes and "errors" in DNA which account for health conditions and disease – to solve bugs in the coded programme we carry around with us, everywhere we go. According to Sulston, humans start off as digital instructions, then grow and develop because they are highly sophisticated learning devices.

In the view of Jean Weissenbach, director general of France's genome centre, "there can be no doubt that the cell is a machine, which, at every moment calculates a whole range of parameters which are concentrations found within the cell, then takes external signals into account and integrates them. The cell is a true calculator, but far better than the computer, since its operations are not centralized. All these elements contribute to its ability to calculate, and help the cell induce an appropriate response based on its state. It is an absolutely fantastic mechanism. Man is an assembly of cells, so the problem is the same as with the cell, but at a far more complicated level."[8]

This machine-model for studying the human genome has also been applied by the World Health Organization, in a report published in 2002.[9]

Massive computer networks – seamlessly interconnected webs of inanimate machines, working alongside picking robots – have been used to reveal the mechanisms and machinery of the human genome – a vast code containing the digital instructions of our species. Without computers and robots, it would never have been possible to map the genome in the first place. In other words, the machine metaphor is being reinforced by ever more sophisticated technologies that automate and greatly accelerate human functions.

Now that artificial intelligence and genomics are being applied to medicine, they are opening up new vistas of knowledge and understanding. Such technologies can greatly benefit humanity, by being used to identify and selectively target genes, proteins, and enzymes – the very stuff of life. They can also be used in ways that alleviate needless suffering. Yet they raise concerns: these new technologies may profit only the wealthy; they may serve as the basis for totalitarian eugenics; they may concentrate far too much private information in the hands of interested parties; these new technologies may grossly oversimplify the reality of the world, modeling human behaviour and changing societal attitudes in unforeseen and possibly undesirable ways.

Contemporary artificial intelligence and genomics both implicitly draw on the *metaphor* of "Man the machine". We use the term "metaphor" in its original ancient Greek meaning of "transfer" or "exchange." According to Aristotle, it will be remembered, "Metaphor consists in giving the thing a name that belongs to something else; the transference being either from genus to species, or from species to genus, or from species to species, or on grounds of analogy."[10] At the same time, according to Paul Ricoeur, metaphors are complex figures of speech that involve aspects both of resemblance and of reference, and even, in some cases, of the "substitution" of one thing for the other.[11]

The role of metaphor in the development of scientific ideas deserves more scholarly attention.[12] Scientists often intuitively use metaphors to provide interpretative frameworks for phenomena they cannot rationally explain. In addition to Aristotle's analogy, and Ricoeur's resemblance and substitution, metaphors may be used as intuitive *descriptions*, as *equations* (or identities) between two terms, and as *prescriptions* of how things ought to be. The difficulty with metaphor is that these crossovers from description to equation to prescription seem to operate at an unconscious level. According to the *Encyclopaedia Britannica*, "The metaphor makes a qualitative leap from a reasonable, perhaps prosaic comparison, to an identification or fusion of two objects, to make one new entity partaking of the characteristics of both."[13] The "qualitative leap" from comparison to identification to fusion has proven to be important – and dangerous – in the case of Man the machine.

This latter metaphor has a long, rich and largely unexplored heritage. The metaphor of Man the machine has provided an interpretative framework time and again for scientific and philosophical research from the Renaissance onwards, in many different settings, from *la philosophie mécanique* to French materialism and the sex machines of Sadism, from the monstrous excesses of communism and fascism, to the instrumental-naturalist world-view[14] and today's unfulfilled dreams of technocracy. With the exponential development of technology over the last few centuries, the evocative power of the metaphor has grown as well. There has been a marked shift from the Renaissance descriptions of some machine-like functions in humans to totalitarian and technocratic prescriptions of how we ought to be. This shift, as we shall see, has its dangers. Totalitarianism and technocracy alike have ended up treating the person as a machine, subject to playing a cog-like role, lost in the workings of the Automated State, which is invested with total power and legitimacy. In its narrow emphasis on the "facts" of observation and experiment, neopositivism is a form of reductionism ideally suited for exaggerated use of the machine metaphor.

This abuse of a metaphor is important. According to Protagoras (c. 490-420 BC), "man is the measure of all things." For some observers today, "the machine is the measure of all things" – it has become the norm, by which humans are to be judged.

At the same time, the metaphor of Man the machine tells us as much about the man-like functions of machines as it does about the machine-like functions of man. The story of this metaphor is, in some respects, a guided tour of technology and our relationship with it.

The convergence of Man and machine is nothing new. The sense of wonder, the ambivalence and the confusion surrounding the relationship of Man and machine have been long in the making. This is a case where the study of History – the long view – provides a rich and valuable perspective. In a sense, tracing the history of this metaphor enables us to illustrate the lasting influence both of thinkers of classical Antiquity and of the *Bible* on scientific thought from the sixteenth century onwards, that is, in the main period under consideration in this study. The historical context in which Man the machine developed, as well as the relationships between Man the machine and other anticipations/interpretations help to explain the potential and the dilemmas offered to us by man-like machines (and machine-like humans) in the early twenty-first century.

While a parallel between Man and machine was rarely, if ever, *explicitly* drawn in Antiquity, we may note six ways in which it was *implicitly* drawn, ways which proved particularly influential in the period opening with the early modern scientific revolution.

(1) *Materialists.* In the view of Democritus (fifth century BC), the world is made up of imperceptible and indivisible atoms, which move about in space. Changes in things can thus be explained by the impacts that these atoms have on each other, and by the shape of the unchanging atoms themselves. Human beings are

thus particular configurations of atoms, and can be considered as matter in motion in a highly deterministic world. Epicurus (died 270 BC) modified this early form of atomism, by postulating that atoms were subject to chance movements, which in turn made atomism indeterministic and supported individual free will.

Lucretius (99-55 BC) gave poetic expression in Latin to Epicurean philosophy, when he sought to explain the main principles of the atomic universe, both the atomic structure and mortality of the soul, the nature of sense perception, and the creation of the world and natural phenomena. In *On the Nature of the Universe*, Lucretius wrote of the random nature in which matter comes together: "our world has been made by nature through the spontaneous and casual collision and the multifarious, accidental, random and purposeless congregation and coalescence of atoms whose suddenly formed combinations could serve on occasion as the starting-point of substantial fabrics – earth and sea and sky and the races of living creatures."[15] Moreover, for Lucretius, "the atoms rush in and out among one another on atomic trajectories, so that no one of them can be segregated nor its distinctive power isolated by intervening space. They co-exist like the properties of a single body. In the flesh of any living thing there are regularly scent and colour and taste; and yet from all these there is formed only one corporeal bulk.... There is nothing in our bodies more fundamental than this, the most vital element of their whole vital spirit."[16] It should be noted, in this respect, that organic life for Lucretius was merely a special case of the infinite possibilities of mechanical events; human bodies are made up of innumerable combinations of everlasting atoms; yet humans have recourse to voluntary movements.[17] Although he did not go out and say so, man was a kind of mechanism for Lucretius, a mechanism consisting of matter, randomly organized as a congregation of atoms, but nevertheless capable of free will.

(2) *Plato.* In the *Republic*, Plato (427?-347? BC) advocated the creation of an ideal State, one where the happiness of the whole rather than of any particular class would be guaranteed by social controls exercised by guardians, law would serve as the ally of the whole city, and everything would be held in common – education, children, property, pleasures and pains. Plato expressed the proportions of this ideal, closed State in mathematical terms, assigning numbers to such abstract notions as the interval between the good king and the tyrant – the former living seven hundred twenty-nine times more pleasantly and the latter seven hundred twenty-nine more painfully than the interval.[18] Sir Karl Popper saw in this ideal State the foundation of modern totalitarianism, in the philosophies of Hegel and Marx.[19]

(3) *Aristotle.* According to Aristotle's teleology, the structure of an organism can be explained most importantly by the final cause, the purpose for which the organism exists. A key passage of Aristotle on the final cause is to be found in the opening statement of *On the Parts of Animals.* "The causes concerned in the generation of the works of nature are, as we see, more than one. There is the final cause and there is the motor cause. Now we must decide which of these two causes comes first, which second. Plainly, however, that cause is the first, which we call the final one. For this is the Reason, and the Reason forms the starting-point, alike in the works of art and in works of nature. For consider how the physician or how the builder sets about his work. He starts by forming for himself a definite picture, in the one case perceptible to mind, in the other to sense, of his end – the physician of health, the builder of a house – and this he holds forward as the reason and

explanation of each subsequent step that he takes, and of his acting in this or that way as the case may be. Now in the works of nature the good end and the final cause is still more dominant than in works of art such as these, nor is necessity a factor with the same significance in them all..."[20]

For Aristotle, the implications of the final cause in the works of nature are clear: things are the way they are because they have been designed that way; their purpose underlies their entire structure; and it is the task of the investigator to discern that purpose and to relate it to the structure being investigated. As such, Aristotle's final cause seemed to support the rational design of the human body, and can be considered an anticipation of Man the machine. It was also implicitly related to Aristotle's idea of the order of the heavens, and so contained the myth of the microcosm.[21] This teleological view lay at the foundation of Aristotelianism, which informed much proto-scientific and scientific investigation for two thousand years, from Greece and Rome, through the Islamic world, the European Middle Ages and the Renaissance itself.

(4) *Vitruvius*. A very different anticipation of Man the machine is to be found in Vitruvius, who wrote about symmetry in bodily proportions and in architecture in the first century BC. Vitruvius was a Roman civil engineer with a Hellenistic outlook. His celebrated handbook on architecture was divided into ten parts: urban planning and architecture in general; building materials; temple construction and the use of the Greek orders; public buildings (theatres, baths); private buildings; floors and stucco decoration; hydraulics; clocks and astronomy; and civil and military engines.

In *Ten Books on Architecture,* Vitruvius developed a highly idealized view of the human body, whose perfect proportions are a reflection of divine order, and should be replicated in sacred buildings. This view was an extension, in civil engineering terms, of a familiar tenet of classical Greek philosophy (from Pythagoras by way of Plato and the Neoplatonists), that the body and the world alike could be interpreted in terms of number, quantity, shape and space; they could be abstracted, measured and idealized in art; and the body itself, as a reflection of divine perfection, was worthy of study in and of itself. Vitruvius established that the proportions of the "well shaped man" could be reduced to number, and that they underlay the principles of architecture, the "well shaped man" providing an ideal model for the design of a temple. "Proportion is a correspondence among the members of an entire work, and of the whole to a certain part selected as standard. From this result the principles of symmetry. Without symmetry and proportion there can be no principles in the design of any temple; that is, if there is no precise relation between its members as in the case of those of a well shaped man.... Since nature has designed the human body so that its members are duly proportioned to their frame as a whole, it appears that the ancients had good reason for their rule, that in perfect buildings the different members must be in exact symmetrical relations to the whole general scheme."[22]

The origins of the Vitruvian ideal of symmetry lay in number: "It was from the members of the body that they [the ancients] derived the fundamental ideas of the measures which are obviously necessary in all works, as in the finger, palm, foot, and cubit. These they apportioned so as to form the 'perfect number' ... and as the perfect number the ancients fixed upon ten. For it is from the number of the fingers of the hand that the palm is found, and the foot from the palm. Again, while ten is naturally perfect, as being made up of the fingers of the two palms, Plato also held that this number was perfect because ten is composed of the individual units.... Therefore, if it is agreed that number was found out from the human fingers, and that there is a symmetrical correspondence between the numbers separately and the entire form of the body, in accordance with a certain part selected as standard, we can have nothing but respect for those, who, in constructing temples of the immortal gods, have so arranged the members of their works that both the separate parts and the whole design may harmonize in their proportions and symmetry."[23]

It is possible that St. Paul, a Roman citizen in the first century AD, living in Hellenistic Asia Minor, had imbibed some Aristotelian and Vitruvian values. Some of St. Paul may be interpreted as an indirect restatement of the instrumentality of the body (although it is the Body of Christ), as well as the myth of the microcosm.[24]

Under the influence of Christianity, the Pauline tradition combined with Gothic civilization, to hold the human body in contempt. But then at the Renaissance, after centuries of neglect, the Vitruvian ideal made a startling comeback. Indeed, one of the most remarkable features of Renaissance art is that after a long hiatus, the human body came to be seen once more as it had been in ancient Greece: an ideal form, which could unabashedly be represented in terms of "divine" mathematical proportions, as in the example of Leonardo's *Vitruvian man*, and could serve as a model for architecture.

(5) *Galen.* Vitruvius was not the only figure of Antiquity to influence the Renaissance in this respect. Galen (c. AD 129-216) had a determining influence on medical theory and practice right up to the seventeenth century. He affirmed the importance of anatomy as the foundation of medical knowledge, although social taboos on human dissection meant that he could only dissect animals such as the

Barbary ape, pig and goat and draw inferences about human anatomy. Some of his inferences about human anatomy would ultimately be discredited during the Renaissance. Galen was an heir to Plato, Aristotle and the Hippocratic corpus. The cornerstone of his work, however, was Aristotle's teleology, and the latter's dictum that "Nature does nothing in vain". For this reason, Galen wrote of the instrumentality of the human body, in terms that would resonate right up to the Renaissance, and flatly contradicted the mechanistic views of Lucretius and other atomists.

"Man is the most intelligent of the animals and so, also, hands are the instruments most suitable for an intelligent animal," Galen wrote. "For it is not because he has hands that he is the most intelligent, as Anaxagoras says, but because he is the most intelligent that he has hands, as Aristotle says, judging most correctly. Indeed, not by his hands, but by his reason has man been instructed in the arts."[25]

According to Galen, the human hand is in every respect so constituted that it would not have been better had it been made differently. Indeed, the uses made of the human body, render the design and instrumentality of the bodily members necessary. Galen referred to the contrivance of Nature, in the abstract, as for example in discussing the prevention of dislocation of the joints;[26] he said that the tendons have been arranged with good reason;[27] and the operations of Nature are described as "marvelous", "skillful", a good arranger and organizer of the important and the less important, providing for the safety of the parts, "admirable", "just" and fearless. At other times, he evoked the works of the Creator, as for example, when he wrote of the stomach: "this storehouse, a work of divine, not human, art, receives all the nutriment and subjects the food to its first elaboration, without which it would be useless and of no benefit whatever to the animal. Just as workmen skilled in preparing wheat cleanse it of any earth, stones, or foreign seeds mixed with it that would be harmful to the body, so the faculty of the stomach thrusts downward anything of that sort, but makes all the rest of the material, that is naturally good, still better and distributes it to the veins extending to the stomach and intestines."[28] Indeed, the Creator has shown wonderful foresight in giving to the lungs a special construction.[29] The human body, according to Galen, is a network of instruments, vessels, tunics, conduits, fibers, liquids, devices, branches, twigs, cords, ornaments and other features, all perfectly suited to their uses, sometimes resembling the lyre, and at other times the pipe, the river, the palisade and the ladder.[30] And if that network of instruments has been perfectly well-constructed, he adds that the "rational soul is lodged in the encephalon; that this is the part with which we reason…"[31] But the female body is inferior to the male body, for the reason that "just as mankind is the most perfect of all animals, so within mankind the man is more perfect than the woman, and the reason for this perfection is his excess of heat, for heat is Nature's primary instrument…. Indeed, you ought not to think that our Creator would purposely make half the whole race imperfect and, as it were, mutilated, unless there was to be some advantage in such a mutilation."[32]

Galen drew a direct comparison between the instruments of the body and human constructions, such as those of civil and naval engineering: "It was reasonable, then, that just as craftsmen first make firm the foundations of a house, the groundwork of a temple, and the keel of a ship and afterwards rear their structures safely on their foundations, so in animals Nature should in the same way cause the different kinds of [fetal] vessels to grow out, each from its own proper source already safely established, and extend them into the whole body."[33]

We may note, in passing, that Galen's views were reinforced by social taboos in Roman Antiquity and during the Middle Ages, as well as the conservative nature of Islamic medicine, which treated Galen's works as an unchanging corpus on which to comment, but not fundamentally to challenge. Thus the highly influential thirteenth century Persian physician Avicenna combined Aristotelian teleology and Galenic medicine, in writing in *A Treatise on the Canon of Medicine* that "Allah most Beneficent has furnished every animal and each of its members with a temperament which is entirely the most appropriate and best adapted for the performance of its functions and passive states. The proof of which belongs to philosophy and not to medicine. In the case of man, He has bestowed upon him the most befitting temperament possible of all in this world, as well as faculties corresponding to all the active and passive states of man. Each organ and member has also received the proper temperament requisite for its function."[34] Had it not been for Islamic civilization, the treasure trove of ancient Greek and Roman knowledge might well have been lost forever.

(6) *Hero*. Beyond Vitruvius and Galen, though, there was another practical application of a machine-like model for man, in the writings of Hero of Alexandria (first century AD). Hero is often remembered for his geometrical formula on the area of a triangle, for publishing the ancient Babylonian approximation of square roots, and for inventing the aeolipile, sometimes considered a forerunner of the steam engine and even the jet engine. Hero, whose works were popular among Islamic scholars and inventors although not Christian ones during the Middle Ages,

devoted considerable attention to automata, that is to machines capable of performing man-like functions. In today's jargon, automata would be called "virtual humans". In his *Treatise on Pneumatics*, Hero provided many illustrations of such automata, some of which reproduced the functions of humans or satyrs: "Libations on an Altar produced by Fire", representing human figures mechanically pouring libations on an altar, "an Automaton which may be made to drink at any time, on a Liquid being presented to it", "a Satyr pouring Water from a Wine-skin into a Washing-Basin, without making the contents overflow", "On an Apple being lifted, Hercules shoots a Dragon which then hisses", "A Trumpet, in the Hands of an Automaton, sounded by compressed Air", and "Figures made to Dance by Fire on an Altar". These innovations were mostly ignored in late Antiquity and during the European Middle Ages, although they were highly prized in the Islamic world, only to be rediscovered in the West at the time of the Renaissance. If one considers that automata are created in the image and likeness of humans, then Hero's automata can be considered the intellectual ancestors of twenty-first century robotics.[35]

Authors in classical Antiquity who anticipated the metaphor of Man the machine	Summary of their anticipations
Democritus, Epicurus, Lucretius	The universe is made up of matter consisting of indivisible atoms; nature, including human bodies, has a random character
Plato	The ideal State, in which private vices, interests, property and families have no place, and which guardians rule wisely in the interests of the collectivity, has perfect mathematical proportions
Aristotle	The final cause explains the perfect design of the human body
Plato and Vitruvius	The perfect design of the human body is explained by the perfect proportions and symmetry in the mind of God
Galen	Medicine is based on an understanding of anatomy, which is grounded in the view that the final cause explains the perfect design of the human body
Hero of Alexandria	Mechanical devices can be made into complex machines reproducing some human functions

It should be noted that these anticipations or implicit statements, pointing towards but not quite articulating the metaphor of Man the machine, did not exist in isolation. On the contrary, they coexisted in Antiquity, as they have coexisted again since Leonardo's time, side by side with several other interpretations of the human condition, some of which are also metaphorical. Moreover, it is important to note that no single individual during classical Antiquity seems to have subscribed to all the different anticipations of the metaphor of Man the machine just identified.

On the contrary, these anticipations only came together during the fifteenth- and sixteenth-century Italian Renaissance. The recovery and correction by Renaissance humanists of many classical texts, led to a knowledge revolution such as the world has rarely seen. Aristotle and Plato were published in the original Greek, and translated directly from that language, which purged them of the errors and misunderstandings that had inevitably cropped up in previous translations from Arabic via Latin. The appearance in 1483-4 of Plato's complete works in Latin, and in 1492 of Plotinus (205-270 AD), stimulated Platonic studies. Leonardo's precursor Leon Battista Alberti (1404-1472) restored Vitruvius in the 1440s, writing an "update" of the great classical work on architecture that was to have broad appeal during the Renaissance. Fragments of Hero's works began to be published in 1501. From the early sixteenth century onwards, Florentine and Roman humanists published definitive editions of Euclid (fl. C. 300 BC) and Archimedes (c. 290-280/212-211 BC). During the same period, philology had its place in the study of medicine, since it helped establish medical nomenclature. For example, François Rabelais (1494-1553) brought out a critical edition of Galen in 1532, making him easier to understand and also to criticize. Long-forgotten or misunderstood figures were reintroduced onto the Renaissance scene, where they had the combined allure of classical prestige, undiminished authority, and intellectual novelty. More than a century later, in imitation of Italian Renaissance humanists, Pierre Gassendi (1592-1655) revived and reinterpreted Epicurean philosophy, a development which was to prove crucial to the emergence of early modern science.

The metaphor of Man the machine first appeared during the Italian Renaissance. One of the key features of that period was that syncretistic values about humanity could be patched together in a synthesis and could result in apparent harmony. Many of the different interpretations of the human condition just identified were considered compatible during the Renaissance, partly due to a strange sort of intellectual glue – what has been aptly termed "the rambling edifice of Neoplatonic and hermetic metaphysics."[36] Moreover, these values were upheld in a multidisciplinary context drawing on anatomy, architecture, art, engineering, geology, natural philosophy, optics, theology and many other disciplines. The *uomo universale* could be expert at all these disciplines simultaneously; he alone had the imaginative power to draw them together in a single synthesis.

Starting at the Renaissance, the various anatomical, architectural, artistic, metaphysical, philosophical, political and religious views of Man the machine were grounded in myth and metaphor, in early intuitive drafts of an idea, overflowing into other ideas. This conceptual framework grew up in the minds of people at an intuitive level, before it became a sort of intellectual programme, passing into fully articulated scientific and technological discourse and discovery.

At the same time, the metaphor of Man the machine underwent something of a transformation during this period. It owed something to Plato's numerology and myth of the microcosm. It also owed something to Aristotle's teleology, according to which a full explanation of organisms must not only consider the material, formal and efficient causes, but also and perhaps most importantly the final cause, the purpose for which the organism exists. But as early modern science developed in the sixteenth and seventeenth centuries, the mechanistic interpretation of organisms evoked the importance of efficient causes alone, and interpreted man as a machine fashioned by the all-powerful intelligence of God. The explicit statement of the metaphor of Man the machine arose during the Renaissance within Western Christianity, migrated to Deism in the seventeenth and eighteenth centuries, and then in the eighteenth and nineteenth centuries broke loose from religious faith altogether to espouse, in many cases, an atheistic materialism.

In the newer mechanistic worldview, however, the universe was open, endless, had no centre; it was irregular, dynamic, composed of matter in motion; and in this rather haphazard universe the Earth was merely one of innumerable celestial bodies; man, a being who could be conceived of as matter in motion, a collocation of atoms, was no longer necessarily a microcosm or a perfectly-designed being in God's image; instead, he occupied a lonely and perhaps insignificant part in this universe; and God might exist but was not necessarily the God of *The Bible* – He was, in any case, nowhere directly to be seen.

Leonardo da Vinci (1452-1519) was a universal man, whose focus was on anatomy and art, architecture and engineering, practical inventions and every aspect of natural philosophy then known, and who dazzled many of his contemporaries, royal and artistic alike, with his anatomical illustrations, mechanical machines, and automata. Indeed, Leonardo's very universality helps explain how he was able to bring together, in a single life work, the perspectives of mechanical theory, the ideal State, Aristotelian teleology, the perfections of the Vitruvian body, Galenic anatomy, and the automata of Hero – and to do all of this in an emotionally and esthetically satisfying way that did not offend the Christian religion. We will show that Leonardo's work was likely known (at the very least via Albrecht Dürer) by Andreas Vesalius (1514-1564), who from his position at the University of Padua published the first modern illustrated encyclopaedic work on human anatomy, setting anatomy on a more experimental basis, after millennia of speculation and inferences from animals. Vesalius, in turn, was one of several Paduan influences on William Harvey

(1578-1647), who conclusively demonstrated the true nature of circulation of blood and the function of the heart as a pump, and whose discoveries had enormous influence on later mechanical or mechanistic philosophy. René Descartes (1596-1650) was a mathematician and philosopher who broke with Aristotle and the Scholastics, made a three-year Italian journey, which proved decisive, established the role of doubt in self-knowledge and scientific experimentation, and philosophized about the mechanical anatomy of humans as a sort of rival to Harvey. Thomas Hobbes (1588-1679), a close friend of Harvey's, was a philosopher and political theorist who also made a Paduan pilgrimage: he wrote on individual security and the social contract from the perspective of the Automated State, his work inspired liberalism and absolutism alike and he was Descartes' rival in claiming to have founded *la philosophie mécanique*. Gottfried von Leibniz (1646-1716), a mathematician, philosopher and political advisor, was noted for his contribution to metaphysics, his invention of differential and integral calculus, and his design of early calculators – his lifework was an attempt to spiritualize matter, in a vast synthesis that would harmonize revealed religion with scientific knowledge. Julien La Mettrie (1709-1751) was an early Enlightenment physician and philosopher, whose theory of psychology eventually was to lead to behaviourism, who attacked Descartes and Leibniz, and played a role in laying the groundwork for modern materialism. Paul-Henri-Dietrich d'Holbach (1723-1789), did not like to acknowledge the importance of La Mettrie, as he was an Enlightenment philosopher in his own right, devoted to atheism and materialism. Following on these French materialists was Karl Marx (1818-1883), the atheist and materialist founder of Marxism, who criticized capital and technology for their role in alienating the individual, but whose communism transformed the individual into an impersonal cog in an Automated State, which had abolished most of the leading historical institutions of society. H.G. Wells (1866-1946) was a science fiction writer, technocratic journalist and historian. He initially saw man as a biological machine who ought to live in an Automated State, but he later came to despair of humanity, technology and politics.[37]

Leonardo, Vesalius and Harvey gloried in the machine-like structure and functions of the human body; Leonardo built automata and Leibniz calculators; Descartes, Hobbes, Leibniz and La Mettrie wrote on cognition in terms that have relevance to enthusiasts of artificial intelligence today; and Hobbes, Marx and Wells devised their own versions of the Automated State, based on the well-ordered machine whose exemplary rational order and purpose made humans seem somehow lacking. Marx and Wells both saw machines as rivals to humanity but also as models worth imitating. It is striking how many of these individuals were associated with the University of Padua.

The metaphor of Man the machine grew over time. At the Renaissance, it was a conceptual framework, a vehicle of expression, an interpretative tool, a way to convey something indirectly which cannot be approached directly. It is not the only metaphor or interpretation with which we shall be concerned in this study. During the Renaissance, some of the first people to use the metaphor of Man the machine – Leonardo da Vinci, Andreas Vesalius and William Harvey – also believed in God; they were often motivated by a belief that man was a microcosm, to be compared to the macrocosm or "machina mundi" of the universe; the humanists among them believed with the Stoics that man was a self-completing individual; and Leonardo at the very least held that human personality had practically unlimited potential. They were in search of qualities such as knowledge, order and a rational explanation of the structure of the body. While Aristotle's teleology and its final causes still held sway, Renaissance thinkers took up the metaphor of Man the machine, since it denoted a certain resemblance between man and the machine: the anatomy of machines could be analysed, just as the inner workings and structure of man could be laid down on paper by means of diagrams, drawings and descriptions. And this was tremendously exciting, because it was quite new. The history of Man the machine starts with the Renaissance, continues through the rise of *la philosophie mécanique*, the conflict between religion and modern science, the rediscovery of materialism, the expression of Sadism, the creation of totalitarian ideologies, and the development of technologies reproducing some human functions.

For the purposes of this study, we have chosen six other interpretations of the human condition, comparing them in several different contexts to the metaphor of Man the machine. Altogether the seven interpretations are summarized in the table below, while more detailed descriptions are provided in the footnotes and later throughout this study: [38]

Interpretation of human condition	Origins
1. Man as a machine	Suggested by atomists (starting in fifth century BC), as well as implicit statements by Plato and Aristotle (fourth century BC), Vitruvius (first century BC), Galen and Hero of Alexandria (first century AD), then grew more widespread during the Italian Renaissance
2. Man in God's image and likeness	Found in many religious traditions, as early as the *Book of Genesis* (whose myths originated in Mesopotamia around 1800 BC), as well as Plato, Aristotle, Galen…
3. Man as a microcosm	Beginning at least with the Presocratics (sixth century BC), developed by Plato and implicit in the *New Testament*
4. Man as a self-mastering individual	Beginning at least with Socrates & Plato (fourth century BC), popular with the Stoics
5. Man as a psychological being with virtually unlimited dimensions to human personality	Expressed by humanists, Leonardo, Shakespeare and others (early and late Renaissance)
6. Man as a being endowed with reason and devoted to the pursuit of happiness	Particularly strong during the eighteenth century Enlightenment
7. Man as a cog within an Automated State	This restatement of Plato's ideal State was made by the seventeenth century philosopher Hobbes, by nineteenth century totalitarian materialists such as Marx, and by the evolutionary collectivist H.G. Wells

This study poses a series of historical questions. How did the metaphor of Man the machine first find explicit expression? How, beginning at the Renaissance, did artists, anatomists, engineers, builders of automata, philosophers, theologians, theorists of the Automated State – whether absolutist or collectivist – suddenly seize on this metaphor and use it as an altogether unprecedented framework for the analysis of the human condition? What contribution did the metaphor of Man the machine play in the modern development of the mathematical and mechanistic universe, from Leonardo right through to Wells? From its first "common-sense" observational origins as a *description* of some human functions, at what point did the metaphor become a *prescription* of what humans ought to be, when fallible humans were compared to increasingly sophisticated machines? What does this mean for us today, in the early twenty-first century?

As we shall see, these interpretations of Man the machine between the sixteenth and the early twenty-first centuries were not linked together in a continuous chain of cause to effect: they varied according to the preoccupations and technological possibilities of their times. We do, however, offer new evidence of linkages, between Leonardo and Vesalius, between Leonardo and Harvey, and between Harvey and subsequent mechanical and mechanistic philosophers. Even Wells, in the 1930s, was still praising the originality of Leonardo's vision of Man the machine.

Renaissance anatomists like Leonardo, Vesalius and Harvey explored the structure of the human body without seriously challenging the tenets of the Christian faith, but they did not anticipate the materialism of Hobbes, La Mettrie or d'Holbach. It was not until the re-emergence of philosophical materialism in the mid-seventeenth century and particularly in the eighteenth century, that the mechanistic model of Man the machine, drawing partly on Presocratic roots and partly on anatomical discoveries made during the Renaissance, was offered as an alternative to man in the image of God.

At the same time, the place of science was firmly established in human affairs between the sixteenth and twentieth centuries. What has been known since the eighteenth century as "science" is actually an outgrowth of the natural philosophy of classical and medieval times. Since early modern times, science came to be recognized as a new body of knowledge, duly organized and classified, relating to the material universe and its laws. The relevance of science to everyday life grew tremendously. Science stimulated the development of new models of thought processes, and new behavioural and organizational standards.

The professional status of people using the metaphor of Man the machine has also affected the way it has been received. The prestige of the scientist as a knowledge producer has been greatly enhanced since the seventeenth century. Science has in many ways displaced organized religion as the leading intellectual and moral framework of the Western world. And as applied science became identified with the machine, and the possibilities of the machine grew prodigiously, the metaphor of Man the machine took on unprecedented meanings – whether in terms of art, medicine, politics, society or ethics. That is understandable, since, the metaphor of Man the machine has been extremely dynamic: as we shall see, it has likened Man to a bewildering and ever-changing stock of emerging technologies – from pulleys and winches to spurting fountains, from mechanical clocks and brass calculators to spiritualized machines, and from antiseptic operating plants and linotype machine to electric tram-cars and nightmarish mechanical aliens from outer space.

A few points should be made about our point of view. The study of modern History should be grounded in classical Antiquity, since so many ideas, discoveries, perceptions, myths and values in modern times have their roots in ancient Greece and Rome. At the same time, the constituent books of the *Bible* have inspired, oriented, compelled and sometimes blocked thinking about the material universe for thousands of years: the *Bible* deserves a place on the contemporary historian's bookshelf.

Man has two complementary natures, not just one, according to the Anglo-Argentine naturalist W.H. Hudson (1841-1922): "Doubtless man is naturally scientific, and finds out why things are not what they seem, and gets to the bottom of all mysteries; but his older, deeper, primitive, still persistent nature is non-scientific and mythical, and, in spite of reason, he wonders at the change; - it is miracle, a manifestation of intelligent life and power that is in all things."[39]

Spiritual knowledge is direct and intuitive, and may lead to detachment from the senses, personal liberty and contemplative union with God in a cloud of unknowing.[40] Scientific knowledge, meanwhile, is based on sense experience, rigorous observation and experimentation. Spiritual and scientific knowledge are completely different.

Galileo (1564-1642) held that physics and theology are two distinct domains, and physicists should stick to physics, just as theologians should stick to theology: "Who will categorically maintain that in speaking incidentally of the earth, water, sun, or other created thing, the Scripture has ... chosen to limit itself rigorously to the literal and narrow meanings of the words. This would be especially implausible when mentioning features of these created things that are very remote from popular understanding and not at all pertinent to the primary purpose of the Holy Writ, that is, to the worship of God and the salvation of souls."[41]

Despite Galileo's distinction, people often unconsciously mix various interpretations of spiritual and scientific knowledge. Both kinds of knowledge may be considered in their literal, moral and allegorical senses. This distinction was applied to Scripture in the third century AD by Origen, an early father of the Church, and is relevant to knowledge today.[42]

During the course of this study, our admiration for the worldviews of the Renaissance and for some aspects of the Leibnizian system will be increasingly apparent. By the same token, we do not derive any pleasure from more recent materialist, totalitarian and technocratic thinkers. Whatever their limitations, Leonardo, Vesalius, Harvey and Leibniz accepted, acknowledged, harmonized and beautified the diverse dimensions of the human experience. Leonardo in particular portrayed man and woman as creatures whose bodies could be represented mechanically, as spiritual creatures in the divine image who were also comfortable with their sensuous nature, as beings beautiful in their proportions which reflected the harmonies and perfections of the cosmos, as individuals capable of self-mastery and intelligence, as psychological beings with unlimited dimensions – but he would not necessarily have seen men and women as destined for happiness, and certainly not as cogs within an Automated State. We share this Renaissance vision, which brings together, in a compelling whole, the diverse dimensions in our nature.

However, mostly from the time of Descartes onwards, these diverse dimensions have become utterly polarized, and, in some cases, have simply become marginalized and forgotten. The contemporary disintegration of humanity's varying dimensions – man as machine, man in God's image and likeness, man as microcosm, man as a self-completing individual and man as a psychological being – goes a long way towards explaining the ambivalence, confusion and alienation so often encountered nowadays with respect to man and machine.

To lose one's God-given spiritual nature, to be equated instead with an assemblage of molecules, spinning wheels, spurting fountains, linotype machines or electric tram-cars, or today's supercomputers, is to lose part of one's identity, to be shorn of the mystery of divine creation and the potential for immortality, to be reduced to some*thing* which can be analysed, encoded, repeated, managed – which can be enclosed in a box. It is to become something precise, measurable, predictable and useful (or, conversely, totally useless – a person could never do what an electric tram-car does). It is to deprive humanity of the spiritual and symbolic associations that have long given meaning to man's journey between conception, birth and death and have offered him the prospect of a place in a future life.

To reduce Man to a machine is wishful thinking, since people who have abused the metaphor of Man the machine, such as Hobbes, are bound to have been frustrated in their search for machine-like order and rationality in humans. And Hobbes was not alone. After him came the marquis de Sade, who was heavily influenced by d'Holbach's writings on Man the machine. And then, in the nineteenth and twentieth centuries, came reductionist and highly alienating one-dimensional interpretations of humanity: the totalitarian Karl Marx treated man abstractly as a cog in an Automated State, and the technocrat H. G. Wells saw man as an imperfect human machine that ought – ideally – to be organized to function as well as nineteenth- and twentieth-century mechanical devices. Wherever it has applied the machine model of the Automated State, in which humans are reduced to being mere cogs, Marxism created tremendous dysfunctions: it has converted whole societies virtually into labour camps, and has also led directly to the deliberate totalitarian slaughter of tens of millions of human beings, the arbitrary imprisonment of millions more, and an outflow of refugees in search of freedom and dignity. It is ironic that Marx, while claiming through communism to lessen the alienation of the individual, developed a dogmatic ideology that ultimately produced a huge increase in human alienation.

How could this have happened? By the nineteenth and twentieth centuries, much of humanity was losing touch with its other personal and spiritual dimensions. Machines, meanwhile, had so extended the possibilities of man that frustrated intellectuals like Marx and Wells could see them as models for man and in some respects rivals to man. Machines by then could do all the things that man had dreamt of doing on his own, and failed. And if, by then, human society seemed hopelessly, utterly complex, machines seemed at times to offer the utopian promise of restoring order to the planet.

But the prophets of totalitarianism and technocracy, like Marx and Wells, forgot that machines only perform some of the functions that we humans design for them. Machines cannot be expected to satisfy humanity's thirst for meaning in relation to Creation and the universe, for self-completion and for human personality itself.

Indeed, in the words of the French historian Jean Delumeau, "European and world philosophy had been optimistic in the nineteenth century, but then foundered in pessimism – and we have not emerged from this pessimism. In fact, the dominant current of contemporary philosophy is pessimistic, and this pessimism can be attributed to the judgment that science and technique, contrary to what we had previously thought, can provide gratifications here and there, but cannot bring about universal happiness."[43]

What then of machines? A machine is not the same as a person. Artificial intelligence (or some hypothetical "artificial spirituality" of the future) has limits: a computer will never know that it knows, nor will it ever be a free and responsible agent. Leibniz, inventor of an early digital calculator, was right in 1695, when he wrote: "By means of the soul or form, there is in us a true unity which corresponds to what we call 'I'; this can have no place in artificial machines or in a simple mass of matter, however organized it may be."[44]

If it is appropriate to use the metaphor of Man the machine to describe certain mechanical functions of the human body, mind or psyche, then the metaphor of Man the machine should not be transformed into an equation, the way Descartes did, nor should it be treated as a prescription, the way Hobbes, Marx and Wells did – as a boldly rational ordering of the way we ought to be. For that Cartesian equation diminishes us, and that Hobbesian, Marxist or Wellsian prescription, imposed vertically from above, deprives us of our liberty.

This study seeks to recover the Leibnizian value of "the true unity which corresponds to what we call 'I'". We humans are far more complex, marvelous and beautiful, we are more loveable, mysterious and surprising in our intuitions and aspirations than any machine. We are unique in countless indefinable ways, which resist any attempt at coding, mastering or copying, symbolic, digital, algorithmic or otherwise. We, not machines, are capable of dignity, liberty, spiritual growth, intelligence and self-sacrifice. To understand our multi-faceted nature, however, one needs to place humanity back in the holistic, synthetic context of the Renaissance, a context that respects the many dimensions of our existence.

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[1] In the course of this study, our use of the word "man" encompasses humanity, and does not imply any exclusion of woman.

[2] According to John L. Casti, "The overall structure of the brain is composed of many interesting types of neural cells, which are themselves arranged into a variety of regions.... The cortex is a continuously folding layer forming the outside of the brain. In humans, this region is often termed the *neocortex*, and it is the newest part of the brain, evolutionarily speaking. It is the part of the brain where reasoning and thought occur. Although the cortex can be divided into a great many areas, both structurally and functionally... all the parts are built of the same basic components and are linked together in similar ways. The functional differences among areas are probably due to the different sensory signals coming into them, not to a difference of structure. In the highest levels of the central nervous system, the neurons form many thin layers called the *gray matter.* In this region the firing threshold of the neurons tends to be higher than for neurons in the rest of the brain, probably as a way of suppressing spurious 'noise' from other sources, thereby preventing sporadic, unneeded (and unwanted) responses. This, in turn, acts to promote the overall stability of the entire cortical system. The human cortex is a pleated sheet of around 2,000 square centimeters..., which is 2 to 3 millimeters thick. This sheet contains about 100 billion cells and several times as many synapses. Most of the human cortex is made of many layers of densely interconnected neurons, each neuron connected to between 1,000 and 100,000 other neurons. Evidence suggests that the smallest functional unit in the brain is not actually the single neuron but rather a collection of 4,000 or so neurons forming a column. This is a cylinder 300 microns across, which vertically connects six layers of the cortex. These cylinders, or *modules*, are connected to each other so that the brain can act as a single, integrated system. The essence of arguments in support of 'machines who think' is that a computing machine, for example, a Turing machine... can somehow be made to perform the same functions as the brain. This argument is immeasurably strengthened if we can mimic in a machine, not only the functions of the brain, but also its actual logical structure..." John L. Casti, *Would-be Worlds: How Simulation is Changing the Frontiers of Science* (New York, 1997) pp. 153-4.

[3] This is the perspective of Pierre Lévy, an expert on artificial intelligence, author of *La machine univers* and other works, who currently holds the Canada Research Chair in Collective Intelligence at the University of Ottawa. Interview conducted by author, October 2002, University of Ottawa.

[4] The American artificial intelligence expert and entrepreneur Raymond Kurweil expressed this perspective in two breathless and overly optimistic works: *The Age of Intelligent Machines* (Cambridge, Mass., 1982) and *The Age of Spiritual Machines* (New York, 1999).

[5] This has been one of the leading themes of science fiction from H. G. Wells onwards. One of the best and most succinct expressions of the computerized control of individual liberty is to be found in the 1960s television series *The Prisoner.* The relevant passage of the script for episode two – *The Chimes of Big Ben* – starts off as follows:

"The man whom we will call 'The Prisoner' resigns and is gassed exactly as before. He wakes up in the Village [a fantastic technocratic seaside prison, under constant camera and computer surveillance, from which there is no possible escape].

"The following conversation accompanies a miscellany of images.

"Prisoner: 'Where am I?'

"Number 2's spherical chair rises from the floor.

"Number 2: 'In the Village.'

"Prisoner: 'What do you want?'

"Number 2: 'Information.'

"The newly arrived prisoner explores the Village.

"Prisoner: 'Whose side are you on?'

"Number 2: 'That would be telling. We want information.'

"The Prisoner is running frantically along the beach.

"Number 2: 'Information... Information...'

"Prisoner: 'You won't get it.'

"A bubble rises through water. Ahead of the Prisoner there looms a huge white whining ball. Number 2 watches the coloured bubbles on his screen.
"Number 2: 'By hook or by crook...'
"He faces us in his chair, and the reverb drops completely.
"Number 2: '... we will.'
"This Number 2 is a plumpish man with a dark beard.
"His screen shows the Prisoner being chased through the water by the huge white ball. It knocks him down and rolls past him.
"Prisoner: 'Who are you?'
"Number 2: 'The new number 2.'
"Prisoner: 'Who is Number 1?'
"We see the Control Room with its rotating seesaw of observers.
"Number 2: 'You are Number 6.'
"Alone on the beach under a gloomy sky, the Prisoner punches the air in fury.
"Prisoner: 'I am not a number. I am a free man!'
"Number 2's deranged laughter echoes away."

[6] For example, Robert Shapiro writes "The general human plan is stored in a language of four letters. Some modest spelling variations provide for our individual differences. We each carry two copies of the plan: One is taken from our mother and one from our father. When we reproduce, we shuffle the deck and splice out two copies as if we were shuffling a deck of cards, then we donate half the mixture to our child. All of this was missed by our ancestors for millennia. The document was well guarded; few hints escaped that such a plan existed. The greats who speculated on heredity, from Pythagoras to Darwin, never dreamed that it preserved in a row of individual letters of the alphabet, much like the Bible, or the words in which they wrote their theories. And what a text it is! Like a massive encyclopedia, it stretches for forty-six volumes (scientists calls them *chromosomes*), or rather a double set of twenty-three volumes, each set differing one to three percent in spelling from the other. However, each set is immensely larger than the ones we see in the library. Our heredity is not written in words separated by spaces, so a comparison is best made in terms of letters. The *Encyclopedia Britannica* has perhaps 280 million letters; each of our double sets has more than ten times that amount – about 3 billion letters each." Robert Shapiro, *The Human Blueprint* (New York, 1991) pp. 3-4.

[7] Interviews conducted by author, April and October 2002, Sanger Centre, near Cambridge, UK.

[8] Interview conducted by author, July 2002, Centre National de Séquençage, Evry, France.

[9] World Health Organization, *Genomics and World Health* (Geneva, 2002). Some examples culled from this report: "In recent years, there has been a growing emphasis in medical research on the analysis of disease mechanisms at the level of molecules and cells in general, and of genes in particular." (p. 4) "Work in the field of genomics will also offer completely new insights into the mechanisms of human and animal development and ageing; and, because our evolutionary history is written in our DNA, it will start to unravel our genetic roots and help us to understand the relationships between and within different species." (pp. 4-5) "Numerous viral genomes have now been sequenced and much is known about the way in which viruses infect cells, copy their genes and proteins by using the cell's machinery and raw materials, and package fresh copies into new viral particles that are able to infect other cells." (p. 48) "Using microarray technology, it is possible to analyse the expression of batteries of microbial or parasite genes at different phases of infection and hence to define the virulence determinants and to understand how pathogens 'sense' their environments and evade host defence mechanisms." (pp. 37-38)

[10] *Poetics* 21 in Aristotle, *Basic Works of Aristotle* (New York, 1941), p. 1476.

[11] Paul Ricoeur, *The Rule of Metaphor,* translated by Robert Czerny. (Toronto, 1981), pp. 173.

[12] During the English Renaissance, Sir Francis Bacon (1561-1626) articulated a "modern" vision of the role of natural philosophy in the world, sometimes mixing the metaphors of light, the garden and the forest, as in the following example: "The true method of experience," he wrote in *The New Organon*, "first lights the candle, and then by means of the candle shows the way; commencing as it does with experience duly ordered and digested, not bungling or erratic, and from it educing axioms, and from established axioms again new experiments; even as it was not without order and method that the divine word operated on the created mass. Let men therefore cease to wonder that the course of science is not yet wholly run, seeing that they have gone altogether astray, either leaving and abandoning experience entirely, or losing their way in it and wandering round and round as in a

labyrinth. Whereas a method rightly ordered leads by an unbroken route through the woods of experience to the open grounds of axioms." *The New Organon*, Translated by Michael Silverthorne. (New York, 2000). Book One, Axiom LXXII, pp. 79-80. Likewise, in situating the origins of the scientific revolution in Renaissance Italy, Jakob Burckhardt used the metaphor of the veil of ignorance, which needed to be drawn back by Renaissance explorers of knowledge, such as Alberti and Leonardo, in order to reveal the light of truth: "In the Middle Ages both sides of human consciousness – that which was turned within as that which was turned without – lay dreaming or half awake beneath a common veil. The veil was woven of faith, illusion, and childish presupposition, through which the world and history were seen clad in strange hues." Jacob Burckhardt, *Civilization of the Renaissance in Italy* (London, 1938), p. 70. For his part, A. N. Whitehead used the less heroic, but equally intuitive metaphor of colour: "The thesis which these lectures will illustrate is that this quiet growth of science has practically recoloured our mentality so that modes of thought which in former times were exceptional, are now broadly spread through the educated world. This new colouring of ways of thought had been proceeding slowly for many years in the European peoples. At last it issued in the rapid development of science; and has thereby strengthened itself by its most obvious application. The new mentality is more important even than the new science and the new technology. It has altered the metaphysical presuppositions and the imaginative contents of our minds; so that now the old stimuli provoke a new response. Perhaps my metaphor of a new colour is too strong. What I mean is that slightest change of tone which yet makes all the difference." A. N. Whitehead, *Science and the Modern World* (Harmondsworth, 1938), p. 12. Karl Popper acknowledged the role of metaphysical ideas: "It cannot be denied that along with metaphysical ideas which have obstructed the advance of science there have been others – such as speculative atomism – which have aided it. And looking at the matter from the psychological angle, I am inclined to think that scientific discovery is impossible without faith in ideas which are of a purely speculative kind, and sometimes even quite hazy; a faith which is completely unwarranted from the point of view of science, and which, to that extent, is 'metaphysical'." *The Logic of Scientific Discovery* (London, 1992), p. 38. Popper also used the metaphor of particles suspended in a fluid, to explain scientific developments: "To obtain a picture or model of this quasi-inductive evolution of science, the various ideas and hypotheses might be visualized as particles suspended in a fluid. Testable science is the precipitation of these particles at the bottom of the vessel: they settle down in layers (of universality). The thickness of the deposit grows with the number of these layers, every new layer corresponding to a theory more universal than those beneath it. As the result of this process ideas previously floating in higher metaphysical regions may sometimes be reached by the growth of science, and thus make contact with it, and settle." *Ibid.*, pp.277-278. Finally, Thomas S. Kuhn used the metaphor of a playing-card experiment (his long-winded account of the experiment will not be cited here), to explain the emergence of scientific discoveries: "Either as a metaphor or because it reflects the nature of the mind, that psychological experiment provides a wonderfully simple and cogent schema for the process of scientific discovery." *The Structure of Scientific Revolution* (Chicago, 1970), p. 64.

[13] *Encyclopaedia Britannica*, 1999 CD-ROM version, no page number.

[14] A brilliant analysis of the instrumental-naturalist world-view, and its negative impact on spirituality particularly in Western industrialized countries, is contained in Charles Taylor's *Sources of the Self* (Cambridge, Mass., 1989).

[15] Lucretius, *On the Nature of the Universe*, translated by R. E. Latham (Harmondsworth, 1951), p. 91.

[16] *Ibid.*, p. 104.

[17] An interesting discussion of Lucretius is provided in Frederick Albert Lange, *The History of Materialism*. 3rd edition, translated by Ernest Chester Thomas (London, 1925) 1st Book, 1st Section, pp. 126-158.

[18] Plato, *Republic*, Book IX, 587e in *The Dialogues of Plato*, vol. II, p. 462, translated by Benjamin Jowett (Oxford, 1958).

[19] Karl Popper, *The Open Society and its Enemies*, 2 vols. (Princeton, 1966).

[20] Galen, *On the Parts of Animals*, Book I, 639b, 2 vols., translated by Margaret Tallmadge May (Ithaca, 1968).

[21] "For just as human creations are the products of art, so living objects are manifestly the products of an analogous cause or principle, not external but internal, derived like the hot and the cold from the environing universe. And that the heaven, if it had an origin, was evolved and is maintained by such a cause, there is therefore even more reason to believe, than that mortal animals so originated. For

order and definiteness are much more plainly manifest in the celestial bodies than in our own frame; while change and chance are characteristic of the perishable things of the earth." *Ibid.*, Book I, 641b.
[22] Vitruvius, *The Ten Books on Architecture*, translated by M.H. Morgan (Cambridge, Mass., 1914), pp. 72-73.
[23] *Ibid.*, pp. 72-75. In the fifteenth century, Leon Battista Alberti gave a somewhat different interpretation of the role of symmetry and proportion in his highly influential *Ten Books on Architecture*, translated by James Leoni (London, 1995). It is important to note that he was also a leading humanist who upheld man (and himself first of all) as a self-mastering individual. Commenting on the significance during the Renaissance of the Vitruvian passage just cited, Kenneth Clark writes in *The Nude*: "There is ... one short and obscure statement in Vitruvius that, whatever it meant in antiquity, had a decisive influence on the Renaissance. At the beginning of the third book, in which he sets out to give rules for sacred edifices, he suddenly announces that these buildings should have the proportions of a man. He gives some indication of correct human proportions and then throws in a statement that man's body is a model of proportion because with arms and legs extended it fits into those 'perfect' geometrical forms, the square and the circle. It is impossible to exaggerate what this simple-looking proposition meant to the men of the Renaissance. To them it was far more than a convenient rule: it was the foundation of a whole philosophy. Taken together with the musical scale of Pythagoras, it seemed to offer exactly that link between sensation and order, between an organic and a geometric basis of beauty, which was (and perhaps remains) the philosopher's stone of aesthetics." Kenneth Clark, *The Nude* (London, 1956), p. 15.
[24] For example, St. Paul wrote of the instrumentality of and relationship between different organs of the mystical body of Christ (*1 Corinthians 12.12-26*): "For just as the body is one and has many members, and all the members, though many, are one body, so it is with Christ. For by one Spirit we were all baptized into one body – Jews or Greeks, slaves or free – and all were made to drink of one Spirit. For the body does not consist of one member but of many. If the foot should say, 'Because I am not a hand, I do not belong to the body,' that would not make it any less a part of the body. And if the ear should say, 'Because I am not an eye, I do not belong to the body,' that would not make it any less a part of the body. If the whole body were an eye, where would be the hearing? If the whole body were an ear, where would be the sense of smell? But as it is, God arranged the organs in the body, each one of them, as he chose. If all were a single organ, where would the body be? As it is, there are many parts, yet one body. The eye cannot say to the hand, 'I have no need of you,' nor again the head to the feet, 'I have no need of you.' On the contrary, the parts of the body which we think less honorable we invest with the greater honor, and our unpresentable parts are treated with greater modesty, which our more presentable parts do not require. But God has so composed the body, giving the greater honor to the inferior part, that there may be no discord in the body, but that the members may have the same care for one another. If one member suffers, all suffer together; if one member is honored, all rejoice together. Now you are the body of Christ and individually members of it."
St. Paul also wrote of the body as the temple of God (*1 Corinthians 3.16*), invoked the Church as the body of Christ (*1 Corinthians 12.27*), and described the cosmic dimensions of salvation through Christ, often comparing Christ to the world: "From now on, therefore, we regard no one from a human point of view; even though we once regarded Christ from a human point of view, we regard him thus no longer. Therefore, if any one is in Christ, he is a new creation; the old has passed away, behold, the new is come... In Christ God is reconciling the world to himself, not counting their trespasses against them, and entrusting to us the message of reconciliation." (*2 Corinthians 5.16-19*) In Ephesians, St. Paul also wrote: "So then you are no longer strangers and sojourners, but you are fellow citizens with the saints and members of the household of God, built upon the foundation of the apostles and prophets, Christ Jesus himself being the cornerstone, in whom the whole structure is joined together and grows into a holy temple in the Lord; in whom you also are built into it for a dwelling place of God in the Spirit." (2.19-22) However, St. Paul also described Christ as the head of the body representing the faithful, and this metaphor will reappear in a changed form in the writings both of Harvey and Hobbes: "Speaking the truth in love, we are to grow up in every way into him who is the head, into Christ, from whom the whole body, joined and knit together by every joint with which it is supplied, when each part is working properly, makes bodily growth and upbuilds itself in love." (*Ephesians 4.15-16*) Perhaps the most compelling "microcosmic" statement in St. Paul is in the openings words of his *Letter to the Hebrews*: "In many and various ways God spoke of old to our

fathers by the prophets; but in these last days he has spoken to us by a Son, whom he appointed the heir of all things, through whom also he created the world. He reflects the glory of God and bears the very stamp of his nature, upholding the universe by his word of power." (1.1-3) According to these various Pauline statements, the world's salvation is dependent upon Christ, in whom the world has been refashioned by God, after being condemned to sin through the first man; Christ also serves as the head of the mystical body, which is His Church on Earth.

[25] Galen, *On the Usefulness of the Parts*, I, 2, volume I, p. 68.

[26] *Ibid.*, I, 31, volume I, p. 88.

[27] *Ibid.*, I, 37, volume I, p. 93.

[28] *Ibid.*, I, 195, volume I, p. 204.

[29] *Ibid.*, I, 327, volume I, p. 298.

[30] One should not be altogether surprised that human organs are described metaphorically. Many organs bear the names of objects outside of the human body that they resemble. An example is provided by the early Renaissance anatomist Jacopo Berengario da Carpi, in his *Short Introduction to Anatomy*, translated by L.R. Lind (Chicago, 1959): "You will consider first the place of the umbilicus, which is called the root of man. On the outer surface of the body toward the uterus it has two veins and very often one, and it has two arteries covered over with a shell of skin which is tied up in the newborn and is cut near the abdomen and consolidated by itself and closed up. The middle part of it thus consolidated is called the acrophalus, and because it is wrinkled it is called 'little old women' [*vetula*] in Latin and grea in Greek." (p. 41). Again, in describing the uterus, the same author wrote: "Between the cervix and the inner receptacle is a certain substance of pellicular flesh which is quite sensitive, perforated in the middle, capable of dilation and constriction, called the mouth of the uterus and having the form of the head of a mullet, or of a cephalus or trench, or of a newborn kitten... To the receptacle toward the cervix there is a ligamentous addition bound to the back toward the anchae, with the shape of a snail's horn. Therefore these are called the horns of the uterus." (pp.78-80).

[31] Galen, *op. cit.* II, 13, volume I, p. 432.

[32] *Ibid.*, II, 299, volume II, p. 630.

[33] *Ibid.*, II, 360, volume II, p. 670.

[34] Avicenna, *The Treatise on the Canon of Medicine*, 2.45, p. 65, edited by O. Cameron Gruner (London, 1930).

[35] Cf. Robert S. Brumbaugh, *Ancient Greek Gadgets and Machines* (New York, 1966), for a detailed description of Hero's automata.

[36] Charles Webster, *From Paracelsus to Newton: Magic and the Making of Modern Science* (Cambridge, 1982), p. 68.

[37] This list is not intended to be exhaustive. Some may object, for example, that medieval writers on mechanics have been omitted, or that Kepler (1571-1630), Spinoza (1632-1677) and Newton (1642-1727) should have been assigned specific chapters. However, the list is no more than representative, and is designed to serve as a basis for an exploration of varying different interpretations of Man the machine, drawn from different disciplines.

[38] Detailed discussion of some of these other interpretations of humanity have been relegated to this footnote, so that the focus of the text remains on Man the machine:

On the subject of **man in God's image and likeness**, much has been written over the millennia. According to the pre-modern version of the Jewish-Christian world-view, the universe was largely static, perfect, harmonious, closed and geocentric; God had fashioned man in his own likeness; and God had created the Heavens and the Earth the better to share them with man, who would enjoy mastery over earthly Creation. (According to the *Old Testament*, the Earth was flat, but it was in the centre of the universe.) This world-view held that many mysteries of Nature simply could not be penetrated by the inquiring gaze of man, who was better off showing a certain contempt for the ephemeral nature of the material world, in order to fulfill his inner, spiritual nature, and draw near God and immortality through self-purification, prayer and collective ritual. It should be added that once the Jewish-Christian world-view converged with Classical philosophy in the early centuries of our era, man was also likened to God because of his ability to reason.

The Bible begins with the doctrine that man is in God's image and likeness. In *Genesis*, man from the beginning has been godlike, and is thus destined to accomplish great things in God's universe. In *Genesis 1.26*, for example, we read the stirring commandment of God the Creator: "'Let us make man in our image, after our likeness, and let them have dominion over the fish of the sea, and over the birds of the air, and over the cattle, and over all the earth, and over every creeping thing that creeps upon the earth.' So God created man in his own image, in the image of God he created him; male and female he created him." Not only was man in God's image; man was unique in this respect, when compared to every other being or feature of Creation. While it is not clear what this passage would have meant at the time it was finally committed to writing, it may denote the bodily resemblance of man to God, the spiritual resemblance of man to God, or even the resemblance of the image of man, fashioned by God, to spiritual beings or angels previously created by God.

The image of man in God's being and likeness accorded special powers, as can be inferred from *Psalm 8*: "thou hast made him [man] little less than God, and dost crown him with glory and honor, Thou hast given him dominion over the works of thy hands; thou hast put all things under his feet, all sheep and oxen, and also the beasts of the field, the birds of the air, and the fish of the sea, whatever passes along the paths of the sea."

The doctrine that man was created in God's image is reaffirmed and reinterpreted in the *New Testament*, since God was so displeased with the wickedness of humanity that He sent His only Son – the perfect man – Jesus Christ, to suffer crucifixion and rise from the dead, thereby redeeming mankind and restoring man's potential of immortality. According to the *New Testament*, Christ was the new Adam, and this changed the course of divine and human history, and raised a new standard of human perfection, a standard requiring human contempt for the world and love of the future life. This is stated in *II Peter 1:3-4*: "His divine power has granted to us all things that pertain to life and godliness, through the knowledge of him who called us to his own glory and excellence, by which he has granted to us his precious and very great promises, that through these you may escape the corruption that is in the world because of passion, and become partakers of the divine nature." Athanasius (AD 293-373) went a step further, in maintaining that God had become man in order that humans become God.

The Biblical view of man in God's image is in marked contrast to the polytheistic view of the gods in man's image. Since prehistoric times, outside of the monotheistic tradition, man had likened himself to the gods, who were anthropomorphic, capable of good and evil, fallible, but nevertheless immortal, whether by virtue of their spiritual essence or through a succession of ordeals which had raised them from a mortal condition to the immortal stature of the gods in the Heavens. In ancient works such as Hesiod's eighth century BC *Theogony*, the immortal gods were man-like; they were approachable, capable of error, their destiny was reversible; they were affected by experiences, subject to pleasure, pain, sorrow and joy; they interacted readily with man, even to the point of enjoying sexual relations with mortals; they were subject to man-like vices, such as deceit, anger and destructiveness.

But comparisons of man with God or the gods did not appear solely in religious texts. They were also common features in ancient Greek philosophy, particularly since they corresponded to the dualistic view of man as made up of two often conflicting natures: body and soul. And it was in the philosophy of ancient Greece, rather than in its religion, that the metaphor of man in the image of God reached its consummate expression.

Plato maintained that the philosopher could hold converse with the divine order, and thereby become orderly and divine, at least as far as the nature of man allows. In the closing passage of the *Timaeus*, for example, it is stated that "when man is always occupied with the cravings of desire and ambition, and is eagerly striving to satisfy them, all his thoughts must be mortal, and, as far as it is possible altogether to become such, he must be mortal every whit, because he has cherished his mortal part. But he who has been earnest in the love of knowledge and of true wisdom, and has exercised his intellect more than any other part of him, must have thoughts immortal and divine, if he attain truth, and in so far as human nature is capable of sharing in immortality, he must altogether be immortal; and since he is ever cherishing the divine power, and has the divinity within him in perfect order, he will be perfectly happy." Plato, *Timaeus* 90b-c, in *The Dialogues of Plato,* vol. III, p. 778, translated by Benjamin Jowett (Oxford, 1958).

In other words, according to Plato, reason, the love of knowledge and true wisdom, as well as the exercise of the intellect, are means by which man could share in immortality, and partake of the divine power and harmony evident in the universe.

In the same vein, Epictetus (50?-120? AD) in *Discourses I:3* drew a distinction between the animal and divine natures of man: "since these two things are mingled in the generation of man, body in common with the animals, and reason and intelligence in common with the gods, many incline to this kinship, which is miserable and mortal; and some few to that which is divine and happy." *Discourses*, translated by George Long (Chicago, London & Toronto, 1952), p. 108.

It will be noted to what extent use of the metaphor of man in God's image by Plato and Epictetus are set in the context of promoting spiritual and moral aspirations, on the assumption that they draw man away from his base animal nature and closer to God. In this respect, this Greek position seems to have been compatible with the Judean tradition, then in the process of development.

While subscribing to Plato's belief that man was godlike in some respects, Aristotle (384-322 BC) used this metaphor to explain some of man's physical features, thus interpreting physical characteristics in a new light. In *On the Parts of Animals 10:25-30*, in Aristotle, *op. cit.*, for example, he suggested that "Of all animals man alone stands erect, in accordance with his god-like nature and essence. For it is the function of the god-like to think and to be wise; and no easy task were this under the burden of a heavy body, pressing down from above and obstructing by its weight the motions of the intellect and of the general sense." It is possible that Aristotle was torn in his interpretation of man in God's image, since he considered virtue the proper condition of the soul, much as Plato did, while simultaneously urging the study of theoretical science and philosophy, of the practical and experiential. See on this subject, W. K. C. Guthrie, *The Greek Philosophers form Thales to Aristotle* (London, 1970), pp. 157-8.

Galen (130-200 AD), much like Aristotle, maintained in *On the Usefulness of the Parts* that man "is an intelligent animal and, alone of all creatures on earth, godlike." Galen, *On the Usefulness of the Parts*, I.2, volume I, p. 68. As will be seen in later chapters, the views of Aristotle and Galen were to prove of particular importance in the early modern study of anatomy and physiology.

It should come as no surprise that St. Augustine (354-430 AD), while Christianizing Neoplatonism, made widespread use of the doctrine of man in God's image, buttressing *The Bible* with references to Plato. In *On Christian Doctrine I:22*, in St. Augustine, *Works* (Chicago, London and Toronto, 1952), p. 629, for example, he affirmed that "a great thing truly is man, made after the image and similitude of God, not as respects the mortal body in which he is clothed, but as respects the rational soul by which he is exalted in honour above the beasts."

Likewise, the leading Scholastic philosopher of the Christian Middle Ages, St. Thomas Aquinas (1225-1274), devoted an important section (First Part, Q. 93.Art.1) in the *Summa Theologica*, vol. I, p. 492 (Chicago, London and Toronto, 1952) to the question "whether the image of God is in man": "Now it is manifest that in man there is some likeness to God, copied from God as an exemplar. Yet this likeness is not one of equality, for such an exemplar infinitely excels its copy. Therefore there is in man a likeness to God; not, indeed, a perfect likeness, but imperfect." Shortly thereafter, (First Part, Q.93 Art. 4 – vol. I, p. 494) Aquinas asked whether the image of God is found in every man, to which he answered that "since man is said to be in the image of God by reason of his intellectual nature, he is the most perfectly like God according to that in which he can best imitate God in his intellectual nature. Now the intellectual nature imitates God chiefly in this, that God understands and loves Himself. And so we see that the image of God is in man in three ways. First, because man possesses a natural aptitude for understanding and loving God; and this aptitude consists in the very nature of the mind, which is common to all men. Secondly, because man actually or habitually knows and loves God, though imperfectly; and this image consists in the conformity of grace. Thirdly, because man knows and loves God perfectly; and this image consists in the likeness of glory."

An interesting treatment of this subject during the Italian Renaissance has been made by Charles Trinkaus: *In Our Image and Likeness: Humanity and Divinity in Italian Humanist Thought*, 2 vols. (London, 1970), which deals with human existence and divine providence in early humanist moral theology, the human condition in humanist thought – in terms both of Man's dignity and his misery, the impact of the humanist tradition by means of philosophy devoted to the condition of man, and the Christian Renaissance in Italy.

The **microcosm myth**, meanwhile, has a long and colourful history. In the words of W.K.C. Guthrie, *op. cit.*, p. 37, Pythagoras (580?-500? BC) "argued that if we want to identify ourselves with the living cosmos, to which we believe ourselves to be essentially akin, then while not neglecting the old religious rules, we must first and foremost study its ways and find out what it is like.... Just as the Universe is a *kosmos*, or ordered whole, so Pythagoras believed that each one of us is a *kosmos* in miniature. We are organisms which reproduce the structural principles of the macrocosm." Heraclitus (535?-475? BC) and Democritus (460?-370? BC) referred specifically to it. Plato also developed the myth of the microcosmos, for example in the *Timaeus*, where it is stated that the universe is made up of the same elements as the human body, and therefore must have a soul as humans do: "Wherefore also finding the whole visible sphere not at rest, but moving in an irregular and disorderly fashion, out of disorder [God] brought order, considering that this was in every way better than the other. Now the deeds of the best could never be or have been other than the fairest; and the creator, reflecting on the things which are by nature visible, found that no unintelligent creature taken as a whole could ever be fairer than the intelligent taken as a whole; and again that intelligence could not be present in anything which was devoid of soul. For which reason, when he was framing the universe, he put intelligence in soul, and soul in body, that he might be the creator of a work which was by nature fairest and best. On this wise, using the language of probability, we may say that the world came into being – a living creature truly endowed with soul and intelligence by the providence of God." Plato, *Timaeus* 30b, in *The Dialogues of Plato,* vol. III, p. 717, translated by Benjamin Jowett (Oxford, 1958).

It will be noted in the example provided from Plato, that man could tell us as much about the universe as the universe about man. The relationship worked both ways. The analogy between man and his parts served as the foundation of a cosmology, relating to man's place in the universe.

The microcosm myth was taken up again by Neoplatonists, passed through the *New Testament* and Gnostics to Christian scholastics and Jewish kabbalists alike, and is also found in the hugely influential Galen, who applied the microcosm directly to his study of anatomy and physiology: "What is the grandest and most beautiful of created things?" he writes, in *On the Usefulness of the Parts.* "The universe, as everyone admits. But the Ancients, so well-versed in Nature, say that an animal is, so to speak, a little universe, and you will find the same wisdom displayed by the Creator in both his works." (I, 177, volume I, p. 191.) Galen goes on to show the objections of his imagined interlocutor: "Then show me, you say, a sun in the body of an animal. What a thing to ask! Are you willing to have the sun formed from the substance of blood, so prone to putrefy and so filthy? Wretched fellow, you are mad! This, and not failure to make offerings and burn incense, is true sacrilege. I will not, indeed, show you the sun in the body of an animal, but I will show you the eye, a very brilliant instrument, resembling the sun as closely as possible [for a part located] in the body of an animal."

The microcosm myth was popular during the Middle Ages, and was developed further by Renaissance natural philosophers such as Paracelsus (1493-1541). Ernst Cassirer noted the relevance to Renaissance Christian theology of the microcosmos myth, and the influence of Nicolas of Cusa or Nicholaus Cusanus (1401-1464) on the Platonic Academy of Florence, and more specifically on the highly syncretistic Marsilio Ficino (1433-1499): "Cusanus considers man to be the bond that joins the world – not only because man unifies within himself all the elements of the cosmos, but because the religious destiny of the cosmos is, in a sense, decided within man. Because he is the representative of the universe and the essence of all its powers, man cannot be raised to the divine without simultaneously raising the rest of the universe by virtue of and within the process of man's own ascension. The redemption of man, therefore, does not signify his liberation from a world worthy of being left behind because it is the inferior realm of the senses. Rather, redemption now applies to the whole of being." *The Individual and the Cosmos in Renaissance Philosophy*, translated by Mario Domandi (New York, 1964) p. 64.

The role of the microcosmos myth in Renaissance astrology has been studied by Eugenio Garin, in *Astrology in the Renaissance*, translated by Carolyn Jackson and June Allen (London, 1983). According to Garin, there was a complex struggle during the Renaissance between astrology and astronomy: "the stages of so-called scientific progress are anything but straightforward and unambiguous, and for a long time they have in fact been mixed up with all kinds of magical, hermetic and mystical themes." The myth of the microcosm was very powerful during the Renaissance; it implied a correspondence between the stars and man's destiny. Astrology had come to Renaissance Italy, partly by way of Arabic civilization, which had developed a view of the conjunctions of different planets and the influence they brought to bear on human events. Astrology was sometimes attacked during the Renaissance, but more on a moral level than an epistemological one.

In the seventh letter of the first book of *Seniles*, written to Francesco Bruni about death, Petrarch (1304-1374) denied that the stars could be signs because they are not causes, and he distinguished the beginning of all things from the totality of things and from the physical universe in general. The fourteenth century North African philosopher of history Ibn Khaldun (1332-1406) wrote that psychic knowledge does not belong to the world of the elements. This position of radical rationalism anticipated that of Pico della Mirandola (1463-1494) a century and a half later: Pico held that the Magus could achieve much, through the use of rigorous techniques, yet he disbelieved that the stars could influence human events.

As we shall see in the course of this work, the microcosm myth is also to be found throughout Leonardo, Vesalius, Bacon, Shakespeare (1564-1616), Leibniz and many others. In the nineteenth century Rudolph Lotze resurrected the myth, in his work on knowledge and reality. The myth recently resurfaced in Lynn Margulius and Dorion Sagan, *Microcosmos: Four Billion Years of Microbial Evolution* (Berkeley, 1987) and is implicit wherever people talk of the "geography" of the human body.

Man as self-mastering individual has been one of the great themes of Western thought. To a certain extent, Plato set the self-mastering individual up against both public authority and the weight of tradition. "Know yourself," said Socrates (*Philebus* 48d), and the idealistic struggle of self-knowledge, symbolized by the bitter hemlock that Socrates was forced to take, has inspired many schools of thought over the ages. In the *Republic* (430-431), Plato developed the idea of self-mastery, drawing an analogy with the State: "Temperance, I replied, is the ordering or controlling of certain pleasures and desires; this is curiously enough implied in the saying of 'a man being his own master" and other traces of the same notion may be found in language, may they not?... There is something ridiculous in the expression 'master of himself'; for the master must also be the servant and the servant the master, since in all these modes of speaking the same person is denoted... The meaning of this expression is, I believe, that there is within the man's own soul a better and also a worse principle; and when the better has the worse under control, then he is said to be master of himself; and this is a term of praise: but when, owing to evil education or association, the better principle, which is also the smaller, is overwhelmed by the greater mass of the worse – in this case he is blamed and is called the slave of self and dissolute... And now, I said, look at our newly created State, and there you will find one of these two conditions realized; for the State, as you will acknowledge, may be justly called master of itself, if the words 'temperance' and 'self-mastery' truly express the rule of the better part over the worse." Plato, *Republic* 430-431, in *The Dialogues of Plato,* vol. II, pp. 281-284, translated by Benjamin Jowett (Oxford, 1958)

Commenting on Plato and the Stoics in *Sources of the Self,* Charles Taylor wrote: "The mastery of self though reason brings with it these three fruits: unity with oneself, calm, and collected self-possession. Plato helped set the form of the dominant family of moral theories in our civilization. Over the centuries, it has seemed self-evident to many that thought/reason orders our lives for the good, or would if only passion did not prevent it. And the background connections underlying this view have remained much the same: to consider something rationally is to take a dispassionate stance towards it. It is both to see clearly what ought to be done and to be calm and self-collected and hence able to do it. Reason is at one and the same time a power to see things aright and a condition of self-possession. To be rational is truly to be a master of oneself." Taylor noted the partial Christian reaction to this idea, and the much later Romantic rebellion against it: "From some Romantics in one way, from Nietzsche in another, down to the Frankfurt school which borrowed from both, the notion has been developed that rational hegemony, rational control, may stifle, dessicate, repress us; that rational self-mastery may be self-domination or enslavement. There is a 'dialectic of Enlightenment', in which reason, which promises to be a liberating force, turns into its opposite. We stand in need of liberation from reason." (p. 116) Moreover, according to Taylor, "the themes of strength and self-control also figured in the Stoic tradition. The early writers spoke of the good soul's "tension", almost as we might speak of the tonus of a muscle. An eclectic writer like Cicero (significantly, a Roman under a still Republican regime) can also put great emphasis on self-control as a virtue of 'manly' strength." *Ibid.*, p. 153.

St. Augustine took up the same passions/self-control theme in his *Confessions,* when he wrote "and what was it that I delighted in, but to love and be loved? But I kept not the measure of love, of mind to mind, of friendship's bright boundary; but out of the muddy concupiscence of the flesh, and the bubblings of youth, mists fumed up which beclouded and overcast my heart, that I could not discern the clear brightness of love, from the fog of lustfulness. Both did confusedly boil in me, and hurried my unstayed youth over the precipice of unholy desires, and sunk me in a gulf..." *Confessions* in St. Augustine, *Works*, p. 9.

These themes continued to be cherished by Western thinkers right through to the late medieval period, when humanism placed new emphasis on the dignity of human experience, on the importance of knowledge for the individual, and on the role that the newly-recovered wisdom of the ancients could play in self-mastery.

The theme of **man as a psychological being**, with virtually unlimited possibilities, was elaborated by humanists, but also by writers drawing inspiration from occult philosophy, such as Shakespeare and Robert Burton. It served in some respects as an extension of man as a self-mastering individual.

Petrarch (1304-1374) is often recognized as the father of humanism, as the man who had opened the way to show in what manner humans might acquire learning. How did he do this? He had a better grasp of classical Latin literature than his contemporaries, although he did not learn Greek. He urged scrupulous attention to detail in the study of ancient manuscripts. He had a disdain for the "systems" approach of scholastic philosophy, preferring the self-doubt of Socrates, the direct moral teachings of Stoic philosopher-citizens like Cicero (106-43 BC), and the spiritual journey of St. Augustine instead.

Petrarch allied rhetoric and philosophy in an attempt to provide intellectual dignity and moral grounds for *studia humanitatis*. Eloquence was no vain enterprise, for him, but on the contrary served to open the mind to the great masters of antiquity who had understood the greatest products of the mind and thus the full powers of the soul. Petrarch affirmed the value of the active life (patriotism, love of one's country and one's neighbour), while seeing the contemplative life, such as his ascent of Mt. Ventoux, as a passage of solitude and self-questioning which would come to serve the active life.

A very different type of humanist was Marsilio Ficino (1433-1499), who developed the Platonic Academy of Florence under the patronage of Cosimo de' Medici. Ficino made numerous translations of Greek into Latin including some Neoplatonic writings (Plotinus) and early Christian writings. He issued a complete translation of Plato. He put Plato into Renaissance perspective by assigning to the human soul a privileged central place in the hierarchy of being, thus underscoring the universal (and typically Renaissance) importance of man and his dignity. He saw parallels in Platonic and Christian concepts of love – indeed, Ficino's reworking of "Platonic" love came to dominate European poetry.

Ficino wanted to establish the true character of Platonism (based on a careful study of the original texts, as far as possible) and from there, harmonize it with the Christian faith. More than that, Ficino claimed that the "doctrine of the prophets and theologians is confirmed by the Persian wise men and by the Hermetic and the Platonic philosophers." Quoted in Ernst Cassirer, Paul Oskar Kristeller and John Hermann Randall (ed.) *The Renaissance Philosophy of Man* (Chicago, 1948), p. 212 This highly syncretistic approach showed complete disregard for the scholastic "systems" approach to philosophy.

Pico della Mirandola (1463-1494) was a syncretist like Ficino, who incorporated the best bits of classical thinking into a new whole, thus demonstrating his freedom from scholastic strictures. He delved into the Hebrew Cabbala, although some of his theses were judged heretical. Pico's *Oration on the Dignity of Man* (contained in *The Renaissance Philosophy of Man*) is one of the main products of Italian humanism. In it Pico asserted that humanity was free to determine its own level and to create its own future. It is interesting to note that Pico, like Ficino before him, picked and chose between many different sources, to buttress his argument: that all Men were equally creatures of God, but traditional philosophers wanted to keep their knowledge obscure and inaccessible; that the individual discovering and affirming his or her conscience by means of Dialectic and Natural Philosophy deserves to be treated with dignity. Pico upheld the humanist idea that the individual was capable of critical self-knowledge, and had the power to become what he or she willed. This was obviously a break with the power of religious and traditional authority, and an incentive for the individual to realize him/herself.

Leonardo da Vinci's works of art made powerful contributions to the view of man as a psychological being with virtually unlimited possibilities; in our view, Shakespeare's psychology, although often couched in occult terms, has never been surpassed; finally, Robert Burton's *The Anatomy of Melancholy* (Oxford, 1997) served as a work of proto-psychiatry, describing different melancholy afflictions and the colourful although often disturbing therapies of his time, yet laying the ground for later, more scientific works on various psychiatric disorders.

The theme of **man as endowed with reason and engaged in the pursuit of happiness** was a part of Epicurean philosophy as well as early humanism. An interesting early modern figure involved in developing this theme was the French mathematician and philosopher Pierre Gassendi (1592-1655). Seeing Artistotelian philosophy going into decline, Gassendi sought to revive Epicureanism and to harmonize mechanistic atomism with Christian doctrines of immortality, free will and an infinite God. That man could justifiably devote his life to the pursuit of happiness was strengthened by Bishop Joseph Butler of England (1692-1752) who harmonized enlightened self-interest and morality. The pursuit of happiness became one of the predominant values of the Enlightenment in the next century, and had a large impact on the American Revolution and resulting Constitution.

Finally, the theme of **man as a cog in an Automated State** became crucial in the nineteenth and twentieth centuries. The main unit of economic relations in ancient Greece and in subsequent European history has been the household or family, although it varied between the nuclear and extended families, and in some cases the clan. With the advent of Christianity, the human person became, at least ideally, the focus of attention.

But with Marx, in particular, the individual became a cog condemned to playing a predetermined role, inevitably marked by his class origins, acting according to his own particular class interests and thus subject to a form of historical determinism, since the development of history was a rational process finding fulfillment in Marx's system. Marx's vision was absolute, destructive and tyrannical. The fundamental contradiction in Marx's thought was the way he purported to criticize the dehumanized and alienated status of the individual under capitalism (he said the Industrial Revolution had transformed the proletarian into a machine performing meaningless, repetitive machine-like tasks, for the sole benefit of the capitalist). But the remedy Marx offered, through communism, treated every individual of society as a cog, a constituent part of a machine-like Automated State, in a far more dehumanizing and alienating way than capitalism ever could. While Marx idealized the proletariat, he condemned many other aspects of contemporary social life under capitalism, from human rights to religious conscience, from national identity to individual liberty. The list is long of historic institutions that Marx wanted to see abolished through violent revolution. The remedy he proposed – communism – proved in many ways to be worse than the problems he decried. His ideology was a mixed bag combining historical determinism, calls for revolution and the abolition of the most basic social institutions, pseudo-scientific rhetoric and secular prophecy. This combination paradoxically meant that the individual under communism was doomed to be no more than a cog in an Automated although dysfunctional State, controlled by a ruling clique which it was almost impossible to dismiss from power. As the experience of Marxist States everywhere in the world has shown, this had the effect of condemning the individual to a form of perpetual slavery, with all power and legitimacy residing solely in State power, which itself was monopolized by an extremely small, secretive, unaccountable and greedy communist leadership. By a stroke of the pen, Marx claimed that his ideology was the fruit of History, but also outside of History, since it would be subject to no further evolution. This latter was one of the most vicious aspects of communism, since the State derived its strength from naked police and military power, an ongoing psychological war waged by the Party against all of society, and a fierce resistance to any change not manipulated by the Party, as well as to any unauthorized criticism of the dysfunctions of the Automated State. H. G. Wells attacked Marxism, promoting his own "Wellsian" evolutionary collectivism instead. But he favored the creation of a utopian New Republic, in which technocrats would take the place of Plato's guardians, and govern in a supposedly altruistic fashion, while the citizens would be enlightened, productive and peaceful, within the highly-regimented, authoritarian "machinery" of an idealized State. Nevertheless, the idealized Wellsian State was still conceived as a closed, unchanging and tightly regimented society.

39 W. H. Hudson, *Idle Days in Patagonia*, (London, 1984), p. 33.

40 *The Cloud of Unknowing*, a fourteenth-century English mystical work, is the best expression of this view. "Therefore," wrote the anonymous author, "leave all outer knowledge gained through the senses; do not work with the senses at all, either objectively or subjectively. For if those who mean to become contemplatives, spiritual and inward looking, reckon they ought to hear, smell, see, taste, or feel spiritual things in external visions or in the depth of their being, they are seriously misled, and are working against the natural order of things. For the natural order is that by the sense we should gain our knowledge of the outward, material world, but not thereby acquire our knowledge of things spiritual. I mean, of course, by what the senses do.... For even if a man is deeply versed in the understanding and knowledge of all spiritual things ever created, he can never by such understanding come to know an uncreated spiritual thing ... which is none else than God! But by recognizing the reason for the limitation of his understanding, he may. Because the thing that limits his understanding is God, himself alone. That is why St. Dionysius said, 'the most godlike knowledge of God is that which is known by unknowing.'" Anonymous, *The Cloud of Unknowing and Other Works,* translated by Clifton Wolters (Harmondsworth, 1961), p. 145.

41 Quoted from Galileo's *Letter to the Grand Duchess* in Ernan McMullin, "Galileo on science and Scripture" in Peter Machamer (ed.) *The Cambridge Companion to Galileo* (Cambridge, 1998), p. 303.

42 Origen (c. 185-255 AD), established an original framework for understanding the relationship between faith and reason. He did so in order to confront heresy, to discredit Jewish objections to

Christianity and to buttress Christian orthodoxy with rationality as it was then understood. It is interesting to note that Origen, writing well before the doctrine of the Trinity had been established, allowed each individual Christian, as long as he adhered to the faith passed down by the apostles, a good deal of speculative latitude within the bounds of that faith. "It is necessary," Origen wrote in *On First Principles,* translated by G.W. Butterworth (Gloucester, 1973, p. 269), "to discuss the manner in which [the divine scriptures] are to be read and understood, since many mistakes have been made in consequence of the method by which the holy documents ought to be interpreted not having been discovered by the multitude. For the hard-hearted and ignorant members of the circumcision have refused to believe in our Saviour because they think that they are keeping closely to the language of the prophecies that relate to him, and they see that he did not literally 'proclaim release to captives' or build what they consider to be a 'real city of God' or 'cut off the chariots from Ephraim and the horse from Jerusalem' or 'eat butter and honey, and choose the good before he knew or preferred the evil.'" According to Origen, Scripture has a three-part nature (body, soul and spirit) just as men do. At a first level of understanding, the body of Scripture is its literal meaning. At a second level of understanding, the soul of Scripture is its moral meaning. At a third level of understanding, the spirit of Scripture is the spiritual or allegorical meaning.

[43] Interview conducted by author, July 2002, Collège de France, Paris.

[44] G. W. Leibniz, *New System of the Nature of Substances*, in *Philosophical Texts*, translated by R. S. Woodhouse and Richard Franks (Oxford, 1998), p. 148.

LEONARDO DA VINCI (1452-1519)

Leonardo da Vinci's rendering of *Vitruvian man* has become a cultural icon in the Western world: it graces the one Euro coin, and evokes for us today the heightened potential of Man as a result of technology.[1] Looming in the air-conditioned shadows of the Gallerie dell'Accademia in Venice, this extraordinary ink drawing represents a well-proportioned adult male (Leonardo may have drawn it in 1490 as an idealized self-portrait), extending his hands and arms to fit within the perfect geometrical shapes of the circle and square.[2] The drawing bears minute traces of a series of compass marks, and seems to have been painstakingly traced from another original drawing.

This compelling graphic image was important to Leonardo. He drew it to capture his particular fusion of the unique proportions and harmony of man, a creature in God's image and likeness, who was also a microcosm, and indeed was machine-like in his perfections. With exquisite artistry, Leonardo here brought together the Renaissance fascination with divine proportions, the implicit Pythagorean belief that "number is all", the Renaissance view that art is the mirror of nature, and finally the Neoplatonist metaphysical view that the cosmos is rational and can be measured.

Vitruvian man is perhaps our first graphic image of Man the machine, and it is appropriate that this first image should have been the work of an *uomo universale.* Leonardo was recovering a classical value, in taking this stance – and he did so in several distinct ways: as an artist acutely sensitive to the beauty of the body, as an anatomist whose drawings were used in the university setting in his day, and were still recognized in the twentieth century as the finest ever made,[3] and finally as an engineer[4] and builder of machines and automata,[5] who was keenly aware of the classical and medieval science of mechanics.[6]

Unlike drawings contained in Leonardo's many notebooks, the *Vitruvian man* is on a single leaf of paper. He may have drawn it to illustrate an uncompleted work on painting, proportion or perspective.

Leonardo da Vinci is a difficult figure to study, given the sheer volume of original sources which he left behind, many of them incomplete and in haphazard order: paintings, statues, handwritten texts scrawled from right to left in his many notebooks, anatomical drawings, schematics, studies, plans, maps, caricatures, allegories, astronomical observations, word and conjugation lists in Latin and Italian, as well as musical notation.

He devoted some attention to philosophical speculation, albeit in a "self-taught", highly personalized style, writing apparently for himself. He came out of the Neoplatonist workshop tradition, but he learned to feel comfortable in the largely Aristotelian university. He was fascinated by divine proportions, by perspective and by the hidden role of number throughout the universe, and he was pragmatic in his inventions. Like Leon Battista Alberti, before him, and Albrecht Dürer after, he came to study the perfections of man, by way of mathematics.

Leonardo devoted considerable energy to the precepts of painting, architecture, mechanics, the design of machines, the science of structure, optics, as well as hydraulic, nautical and military engineering. In the fifteenth century, mechanical innovations were being developed not only to raise the cupola above Brunelleschi's cathedral in Florence (as a young man Leonardo played a minor role in completing it), but also in order to address many challenges of military and hydraulic science. In offering his services to Ludovico Sforza (1452-1508) around 1482, for example, Leonardo proposed to construct portable bridges, mantlets, scaling ladders, methods for destroying fortresses built in solid rock, mortars for hurling stones, ships which could withstand smoke and fire, covered armoured cars (the Renaissance equivalent of tanks) and light ordnance. It is well known that he carefully studied the flight of birds, and proposed a helicopter and a flying machine with ribbed wings. He also proposed the manufacture of special magnifying lenses, which would enable an observer to increase the perceivable universe. He invented a breathing apparatus for use under water, a method for walking on water, and possibly even air bags to soften impact during a vehicle collision.

Leonardo's life is best known today through the colourful and somewhat unreliable work of Giorgio Vasari (1511-1574), the art historian.[7] Vasari's almost contemporary account in *Lives of the Painters, Sculptors and Architects* presented Leonardo as supernaturally beautiful in body and infinitely gracious in his actions, royal in spirit and magnanimous in courage, but also variable and unstable in his interests, so that he sometimes abandoned things shortly after beginning them. "It is clear," Vasari wrote, "that Leonardo, through his comprehension of art, began many things and never finished one of them, since it seemed to him that the hand was not able to attain to the perfection of art in carrying out the things which he imagined; for the reason that he conceived in idea difficulties so subtle and so marvelous, that they could never be expressed by the hands, be they ever so excellent. And so many were his caprices, that, philosophizing of natural things, he set himself to seek out the properties of herbs, going on even to observe the motions of the heavens, the path of the moon, and the courses of the sun."[8]

According to Vasari, Leonardo did an apprenticeship in the workshop of Andrea del Verrocchio (1465-1466), and quickly surpassed his master, by adding an angel of compelling beauty to his master's panel-picture of St. John baptizing Christ. The young artist quickly gained the attention of Pope Clement VII (1478-1534) as well as Giovan Galeazzo (1469-1494), Duke of Milan, with the exquisite beauty of his paintings, fashioning of musical instruments and verse improvisations, so that Leonardo's work was soon presented even to the Emperor himself.

Vasari recounted that the Prior of the Friars of St. Dominic kept pressing Leonardo to finish *The Last Supper* in a most importunate manner. To justify the delays, Leonardo ended up reasoning with the Duke of Milan "about art, and made him understand that men of lofty genius sometimes accomplish the most when they work the least, seeking out inventions with the mind, and forming those perfect ideas which the hands afterwards express and reproduce from the images already conceived in the brain."[9]

Vasari's account of Leonardo's more scientific works leaves a somewhat ambivalent contemporary impression. He worked under Duke Giuliano de' Medici's patronage in a Roman workshop, and showed some of his weird experiments in alchemy and natural philosophy to Giuliano's brother, Pope Leo. Vasari's description of the latter encounter is worth quoting: Leonardo "went to Rome with Duke Giuliano de' Medici, at the election of Pope Leo, who spent much of his time on philosophical studies, and particularly on alchemy; where, forming a paste of a certain kind of wax, as he walked he shaped animals very thin and full of wind, and, by blowing into them, made them fly through the air, but when the wind ceased they fell to the ground. On the back of a most bizarre lizard, found by the vine-dresser of the Belvedere, he fixed, with a mixture of quicksilver, wings composed of scales stripped from other lizards, which, as it walked, quivered with the motion; and having given it eyes, horns, and beard, taming it, and keeping it in a box, he made all his friends, to whom he showed it, fly for fear.... He made an infinite number of such follies, and gave his attention to mirrors, and he tried the strangest methods in seeking out oils for painting, and varnish for preserving works when painted."[10]

Vasari's account offers a coherent view of Leonardo, from a nearly contemporary artist's and art historian's perspective: of a man fully conscious of his genius, who could discourse on an equal footing with Europe's leading statesmen, and keep them waiting, and yet whose changeable nature and bold inventions held some terrors for his contemporaries. Vasari does not seem to have understood Leonardo's pursuit of knowledge, contenting himself instead with vague statements of how original that knowledge must have been.

The admiring ambivalence betrayed by Vasari may, to some extent, account for the difficulty many historians have in assessing Leonardo's significance. He has proven an elusive and controversial figure for historians.[11] Was he a Faust, a prophet, a tantalizing Renaissance magus, an *uomo universale* – at once cosmopolitan, highly developed as an individual, with a practiced eye and a mastery of all the elements of the culture of his age? Was he the finisher and master where Alberti had been the beginner and dilettante? Was Leonardo a precursor of the modern scientific revolution, the first Renaissance man in whose work converged the three pillars of modern scientific method – empiricism, mechanistic science and mathematics? Was he at the origin of a tremendously important movement in world history, a representative figure straddling the transition period from medieval to modern, a sort of intellectual fluke coming out of the azure sky of Tuscany, or perhaps, instead, an isolated figure, one totally absorbed in experimentation and discovery, who could not be shown to have had much influence at all on the future course of science and technology? Was he a person of such remarkable powers of observation that he ended up being swamped by all that he had come to know?[12]

Despite these many questions,[13] Leonardo's influence on philosophers and artists of his own day can be clearly demonstrated. The argument can be defended that Vesalius, Harvey and even Hobbes knew of Leonardo's work (particularly through the latter's admirer and imitator, Albrecht Dürer and subsequently through Netherlandish Renaissance graphic artists), where the gradual development of mechanical and ultimately mechanistic anatomy is concerned.

The recovery of the classical value of Vitruviuan man was nothing short of an artistic revolution – a revolution in which Leonardo was a dominant actor. It had enormous implications for Renaissance art, anatomy as a science, mathematics, architecture, and indeed the moral baggage of Christian asceticism. It meant, in essence, that the perfectly proportioned body was in the image of God's world, and that the body could be represented, abstracted and idealized mathematically. Operating at the metaphysical level, this artistic revolution advanced the image of the microcosm, at the same time providing a new basis for investigations in natural philosophy, which was to prove of paramount importance to the emergence of early modern science.

Several years after drawing the *Vitruvian man*, for example, Leonardo collaborated with a Franciscan mathematician at the University of Pavia, Luca Pacioli, in a 1498 publication, in Milan, *On Divine Proportion*. The book was subsequently republished in 1509 in Venice. Leonardo prepared for publication the profile of a head, as well as elaborate lettering, and illustrations depicting columns and geometric shapes.

Pacioli wrote of Leonardo in this work as follows: "Shortly afterwards, as hopes nourished my courage, I dedicated to Ludovic Sforza, Duke of Milan, the treatise entitled *On Divine Proportion*, with such ardour that I included shapes and volumes by the hand of Leonardo da Vinci, so that the reader could picture them more easily."[14]

Pacioli, it should be noted, was a Tuscan at the leading edge of mathematical thinking during the Italian Renaissance. He was a key personality providing the intellectual underpinnings of a significant cultural change. The humanist rediscovery of the classical Greek familiar tenet of "divine" mathematical proportions (from Pythagoras by way of Plato and Neoplatonists), meant the body and the world alike could be interpreted in terms of number, quantity, shape and space; they could be abstracted, measured and idealized in art; and the body itself, as a reflection of divine perfection, was worthy of study in and of itself.[15] Much as Vitruvius had established that the proportions of the "well shaped man" could be reduced to number, and that they underlay the principles of architecture, the "well shaped man" providing an ideal model for the design of a temple, so, throughout much Renaissance writing, one finds that the perfectly-proportioned human figure is a world in itself reflecting the image of the divinely-proportioned world or universe (microcosm).

Pacioli recognized that the strength of Leonardo's images and fame would give a great boost to his literary work. "In the company of the most skilled architects, engineers and inventors of novelties," he wrote in *On Divine Proportion*, "was Leonardo da Vinci, our Florentine compatriot, whose work as a sculptor and painter has made his name known to one and all. The admirable and marvelous equestrian statue (its total height is 12 braccia, that is to say 37 times 4/5 the length of the line 'ab' here shown, and whose casting required about 200,000 pounds (the common ounce being the twelfth part of a pound), this statue, dedicated to the sacred and glorious memory of [the] father [of Duke Sforza], is every bit the equal of the equestrian statues of Phidias and Praxiteles on Monte Cavallo.... As if that were not enough, and after already finishing with great care his remarkable treatise on painting and human motion, [Leonardo] has applied himself to writing a tremendous work on local movement, on impact, weights and every type of force..."[16]

Pacioli's astute selection of Leonardo to provide illustrations for his work guaranteed its acceptance at the ducal court of Milan and its wider influence beyond. Leonardo's artistry could draw readers to Pacioli's work, as well as intellectual and possibly even financial support. The glowing terms in which Pacioli described a man by turns artist, anatomist, engineer and inventor, shows how closely Leonardo was identified with the artistic revolution. The *Vitruvian man* symbolizes that revolution.

Those historians who downplay the likelihood of any tangible influence of Leonardo on the subsequent development of early modern science have gone astray. In 1495, Albrecht Dürer likely met Galeazzo di Sanseverino, Pacioli's patron, at the wedding of his friend, the Dutch humanist Willibald Pirckheimer; the Hungarian-born Dürer may have met Leonardo in 1506, and may well have studied under

Pacioli in Venice or Bologna the same year; Dürer was a great admirer of Vitruvius, and is known to have been influenced by Leonardo in matters of proportion as much as of technique. Vasari considered Dürer to be "a most marvellous German painter, and an engraver of beautiful copperplates", noting that he had expounded on the secrets of the arts, much as had done the great Alberti himself. Dürer's theoretical work on human proportions, first published in 1532, resembles the work of Leonardo and Pacioli in many respects, and accounts for part of Dürer's huge influence on Netherlandish painting, engraving and woodcuts.[17]

Another example of Leonardo's collaborative work in the university setting is provided by Giorgio Vasari, who described his early role in medical illustration as an aid to teaching. Leonardo "applied himself, but with greater care, to the anatomy of man, assisted by and in turn assisting, in this research, Messer Marc' Antonio della Torre, an excellent philosopher, who was then lecturing at Pavia, and who wrote of this matter; and he was one of the first (as I have heard tell) that began to illustrate the problems of medicine with the doctrine of Galen, and to throw true light on anatomy, which up to that time had been wrapped in the thick and gross darkness of ignorance. And in this he found marvelous aid in the brain, work, and hand of Leonardo, who made a book done in red chalk, and annotated with his pen, of the bodies that he dissected with his own hand, and drew with the greatest diligence; wherein he showed all the frame of the bones; and then added to them, in order, all the nerves, and covered them with muscles; the first attached to the bone, the second that hold the body firm, and the third that move it; and beside them, part by part, he wrote in letters of an ill-shaped character, which he made with the left hand, backwards; and whoever is not practised in reading them cannot understand them, since they are not to be read save with a mirror."[18] This account may have been exaggerated, however.[19]

Leonardo's system was also used to teach painting throughout the sixteenth century. Long after his death, Gian Paolo Lomazzo wrote that "Leonardo is worth remembering as he taught the anatomy of the human body … which I have seen at Francesco Melzi's, drawn divinely by Leonardo's hand … but of all these works none was printed, existing only in his manuscripts which in great part have come into the hands of Pompeo Leoni and some also came into the hands of Signor Guido Mazenta, distinguished scholar who treasures them highly."[20] Melzi organized and published Leonardo's treatise on painting about 1550,[21] while Lomazzo brought out another derivative work, the *Treatise of the Art of Painting, Sculpture and Architecture*, in 1585.[22] These works ensured that Leonardo's system continued to influence future generations of artists.

These examples of collaboration with leading philosophers at Pavia, then one of Europe's greatest centres of learning, and a rival to Padua, show that Leonardo was no marginal, enigmatic or self-defeating personality. His medical illustrations and artworks therefore placed him at the forefront of the new learning, in two settings: the university and the artist's workshop. And those works were grounded in a definable value system.

The Neoplatonic idea that beauty and pleasure were in God's mind (and that the artist was called upon to mirror what was in that mind) had wide appeal during the Renaissance. "Beauty," wrote Marsilio Ficino in his *Commentary on Plato's Symposium*, "is a kind of force or light, shining from Him through everything, first through the Angelic Mind, second through the World-Soul and the rest of the souls, third through Nature, and fourth through corporeal Matter. It fits the Mind with a system of ideas; it fills the Soul with a series of Concepts; it sows Nature with seeds; and it provides Matter with Forms."[23] This statement may seem disembodied, but it actually served to focus attention on beautiful forms (among them, the human body), which acquired new dignity, since they were directly derived from the light of God. Ficino praised pleasure, since it was derived from "the noble disposition of the soul, the comely appearance of a beautiful body, and the harmony of sounds."[24] Bodily perfection was thus implicitly associated with the mind of God, the harmony of his creation and human pleasure. This was light-years away from the self-abnegation and other-worldliness of medieval piety, and goes far to explain the particular blend of idealism, sensuality and close attention to mathematics, which characterize the Renaissance.

Similar statements on the link between "the comely appearance of a beautiful body" can be found in many Italian Renaissance authors. Indeed, the beautiful (i.e. perfectly-proportioned) body mirrors the divine proportions of the universe.

One of Leonardo's contemporaries, Francesco Zorzi, a Neoplatonic friar, wrote why man in the figure of the circle is an image of the world: the Vitruvian figure "discloses through the visible, corporeal world ('homo-mundus') the invisible, intellectual relation between the soul and God; for God is the 'intelligibus sphaera.'"[25]

Leonardo took a multidisciplinary approach to Man the machine, drawing on many of the classical sources identified so far. From Plato and Vitruvius, Leonardo derived the ideal of divine proportions throughout the world, proportions finding an echo in the perfections of Man; he integrated Aristotle's teleology, according to which the structure of an organism can best be explained by the final cause, the purpose for which it exists; he studied and corrected Galen's anatomy, but retained the Galenic value of the instrumentality of the body's parts; and he was fascinated by automata, much like Hero of Alexandria. His main encounter with Epicurus seems to have been on the subject of the size of the Sun.[26]

Leonardo saw man as a machine, made up of elaborate mechanisms, which it was the task of art and anatomy to observe and render, and the task of engineering to copy.[27] Man was also in God's image and likeness. Man was a microcosm, which implied correspondences with the macrocosm of the world. Leonardo saw himself as a self-mastering individual, and a psychological being with virtually unlimited dimensions.[28] These values and some of their probable sources are summarized below:

Leonardo's interpretation	Sources	Key features
Man the machine	Plato, Aristotle, Vitruvius, Galen & fifteenth century Sienese and Florentine engineering, classical & medieval view of God's Creation having order and rationality and thus being measurable	This metaphor flows from the microcosm, since the world itself was considered a "machina mundi" or machine in its own right, of God's invention
Man in God's image and likeness	Judaism, Christianity, Greek & Roman mythology, hermetic philosophy, Neoplatonists like Pacioli	Man is like God: he has a soul, powers of observation, an ability to serve as a mirror of nature; ideal proportions of man are divine
Man as a microcosm	Pythagoras, Plato, Gnostics, Neoplatonists like Pacioli, medieval thinkers on mechanics, hermetic philosophy	Parallel between God's orderly and rational universe and man and his destiny; ideal proportions of man are divine
Man as self-mastering individual	Platonic, Stoical, Christian, Neoplatonic ideals and growing awareness of self among humanists like Alberti	Leonardo's individualism and awareness of his own genius
Man as a psychological being	Humanism and Leonardo's insights into humanity	*Notebooks*, depiction of human emotions in his art
Man as a being endowed with reason and devoted to the pursuit of happiness	Absent	
Man as a cog within an Automated State	Absent	

Leonardo represented in graphic art the ideal "divinely-proportioned" man. But the meaning during the Renaissance of "divine proportions" is not quite as evident as it may seem. It should be seen as a metaphysical and moral value; but it was at the same time, an esthetic value, which could be expressed in theoretical terms by means of mathematics, and which required a technique – perspective – to be translated into works of art. The combination of Leonardo's metaphysical and moral views, with the mathematical approach to proportion and the technique of perspective helps to explain why his works are emotionally still so satisfying to this day. They have something wonderfully complete about them, since they combine the ideal with the sensual, the mathematical with the spiritual, captured in an improbably perfect moment of time.

At the metaphysical and moral level, "divine proportions" meant several things: God was Creator of a rational Cosmos; the Cosmos has rational structure which could be compared to the structure of man, whose perfect design reflected the final cause; and man himself was in God's image and likeness in his ability to represent and mirror and measure the structure of God's Creation. This linkage of values provides a backdrop for Leonardo's own interest in divine proportions. While some of his scientific interests stemmed from Aristotelianism, Galenism and medieval mechanics, many of his underlying values were Neoplatonic.[29]

Leonardo's vision of man begins with God, whose mind embraces the whole universe.[30] God's works are great.[31] Together with the planets, God influences the movements of visible bodies.[32] God's works in nature are not always just.[33] Yet Nature must obey the laws of God.[34] The Creator deserves praise, since nothing He makes is superfluous or defective.[35] While we have in the main drawn the link between Leonardo and Plato, this last value is clearly Aristotelian.

Man is in God's image and likeness in several different ways. First, man has a soul, which likens him to God. But Leonardo's soul is less ethereal than it is tangible, located in an identifiable part of the body, and related to observable functions of that body. The soul "apparently resides in the seat of the judgment, and the judgment apparently resides in the places where all the senses meet, which is called the common sense; and it is not all of it in the whole body as many have believed, but it is all in this part..."[36] The nerves convey sensation, but more than that they are "the team of drivers of the soul, for they have their origin from its seat and command the muscles so that they move the members at the consent of the will of this soul."[37]

Man is like God in that he is specially constituted, through powers of observation and reason, to apprehend the infinite works of nature. Leonardo's God-like man is more Neoplatonic than Aristotelian. The eye is the window of the soul.[38] The eye is "the chief means whereby the understanding may most fully and abundantly appreciate the infinite works of nature."[39] In other words, the visible universe, the works of nature, can be observed by man, and this act of observation has something spiritual about it, since it draws man closer to God. And what is the ultimate structure of the visible reality which man can observe, with the window of his soul? The defining element of that structure is proportion, which is found throughout nature, in numbers and measurements, just as much as in sounds, weights, times, positions and other powers.[40]

If divine proportion is found in the idealized human body, then it is also found in the world itself. Sometimes Leonardo stated this explicitly: "therefore there shall be revealed to you here in fifteen entire figures the cosmography of the 'minor mondo' (the microcosmos or lesser world) in the same order as was used by Ptolemy before me in his Cosmography."[41] Moreover, Leonardo wrote that "the body of the earth like the bodies of animals is interwoven with a network of veins which are all joined together, and are formed for the nutrition and vivifying of this earth and of its creatures..."[42] At other times, he alluded to the Pythagorean and Neoplatonic microcosm implicitly: "Here shall be represented the tree of the vessels generally, as Ptolemy did with the universe in his Cosmography; then shall be represented the vessels of each member separately from different aspects." [43] Such a linking of man and world is important, considering Leonardo's pioneering work in anatomy, in cartography, and also in speculation about the heavens.

Man is in God's image and likeness in the sense that his ability to make a true representation of nature can be likened to God's Creation. "In Art we may be said to be grandsons unto God.... Therefore we may justly speak of [painting] as the grandchild of nature and as related to God himself."[44] Indeed, for Leonardo, the artist's ability to represent nature, which likens him to God, is God-given: "the Lord who is the Light of all things shall vouchsafe to reveal to me, who seek to interpret this light..."[45] The mind of the artist should be like a mirror, taking the colour of what it reflects, and serving to accurately reflect nature.[46]

These excerpts from Leonardo's *Notebooks* provide some idea of his vision of divine proportion, an idea completed by the graphic illustration of *Vitruvian man.* Even so, Leonardo did not offer a particularly coherent statement of his beliefs, such as may be found in the writings of Italian humanist poets and philosophers such as Petrarch, Coluccio Salutati, Lorenzo Valla, Marsilio Ficino or Giovanni Pico della

Mirandola.[47] On the contrary, Leonardo was cryptic and in a hurry, where the others had been discursive and synthetic, and he based his views on an idiosyncratic combination of Christianity, Neoplatonism and hermeticism, reading, feats of art, architecture and engineering, and his own painstaking observations of nature.

A compelling literary statement of the meaning of divine proportions is contained in the book for which Leonardo drew the illustrations – the masterful work *On Divine Proportion*, cited above, by Luca Pacioli. It is clear that Leonardo fully shared Pacioli's passion for Vitruvius, given the glowing terms in which Pacioli praised Leonardo in his preface, and the huge body of evidence to be found in Leonardo's *Notebooks* and works of art themselves. This passion for Vitruvius combined the belief that the human body's proportions were divinely ordained and should be observed and rendered, with the belief that these human proportions should serve as the basis for works of architecture.

According to Pacioli, "Our present discourse shall be divided into three succinct parts, following the three examples proposed at the beginning of this work entitled *On Divine Proportion*. We shall speak first of all of the proportions of man, his body and members, because all measures and denominations are derived from the human body, in which all sorts of proportions and proportionalities are to be found, created by the finger of the Most High, according to His mysterious laws of Nature. This is why all measures, and the means employed to determine the dimensions of the public and private buildings of which we have spoken, are named after the human body, one called arm, the other step, foot, palm, joint, finger, head, etc. As our Vitruvius has well said, we must observe, in every building, the proportions that resemble those of the well-proportioned human body and its members. That is why we shall speak first of all of the measure of the human body and of its members, a measure which should dictate your choices in the matter of the construction of pediments and façades, cornices and architraves, just as our Vitruvius has so completely exposed the matter."[48]

On Divine Proportion may be seen as a work of philosophy and mathematics destined for Renaissance architects, but it was also a book that clearly identified Plato's place in the Vitruvian outlook:

"We should consider what Plato says in the *Timaeus,*" Pacioli continued, "about the nature of the universe. God, in creating man, placed his head at the summit of the body, much as we build fortified castles and fortresses above cities, doing so in order that the head may protect the corporal edifice, that is, all the other members. And God reinforced and provided this head with everything appropriate and necessary, as is demonstrated by the seven orifices or seven fundamental means by which the intellect apprehends external objects: the two ears, the two eyes, the two nostrils, and the seventh which is the mouth; this moreover is the case, as the philosophical maxim tells us, because nothing reaches the intellect before first being apprehended by the senses, of which there are five, which enable us to see, to hear, to feel, to touch and to taste.... Nature, the minister of divinity, when she shaped man, gave the head all its desired proportions, corresponding to all the other parts of the body. Which is why the ancients, in view of the just disposition of the human body, erected all their buildings, and principally their holy temples, according to these proportions. Indeed, they found in the body of man the two most important figures, without which it would be impossible to execute any work of whatever sort: the first of these figures is the circle, which is the most perfect and capable to enclose all the other figures within its perimeter, as Dionysodorus [of Amisus c.200 BC] wrote in his treatise on spheres; the other is the equilateral square."[49]

Pacioli even went so far as to say that holy offices had little value unless they were celebrated in churches having the right proportions. What is interesting in Pacioli's writing is the assertion that the idealized or geometrical human body should be a standard by which to arrange the design of harmonies and proportions in sacred architecture. The body was no longer a miserable, transitory shell in which the soul was imprisoned, as it had been throughout much of the Middle Ages: the body expressed spiritual values and realities.

The emotional effect of these proportions is better conveyed in artistic and architectural works, than in Pacioli's Neoplatonic prose, however. Leonardo's metaphysical beliefs in divine proportions and in the microcosm explain the beauty of so many of his artistic creations. Indeed, the concentration on divine proportions changed the way many Renaissance artists looked at and depicted the human body. No more were the gangly, two-dimensional, oval nudes of Gothic art the canon. No more did artists seek to cloak the human body, to shield it from view as if it were a shameful hindrance to the soul's longing to fly to heaven. No more did the spirit and the flesh seem to dwell in two antagonistic, mutually exclusive worlds – the one contemptible and destined for perdition, the other noble and destined for redemption. On the contrary, the human body, male and female alike, often portrayed defiantly in the nude, re-emerged as an ideal of earthly perfection, as a long-limbed, muscular, dignified and self-possessed creature, reducible to geometric forms, and associated with the beauty of the soul and indeed the celestial harmony of the whole world. As Kenneth Clark wrote, "the formalized body of the 'perfect man' became the supreme symbol of European belief. Before the *Crucifixion* of Michelangelo, we remember that the nude is, after all, the most serious of all subjects in art; and that it was not an advocate of paganism who wrote, 'The Word was made flesh, and dwelt among us … full of grace and truth.'"[50] In the vault of the Sistine Chapel, Michelangelo represented God as a perfectly formed male nude, although a flowing cloth discreetly covered his waist. And so were joined, in the image of ideal human beauty, this world and the next – something that Christianity had long sought to keep separate.

The microcosm myth, as filtered through Vitruvius and Renaissance Neoplatonists like Pacioli, was also important to Leonardo the engineer and builder of machines. In the words of Paolo Galluzzi, "Leonardo saw a unity between the animate and inanimate worlds, and so believed in the validity of a strictly mechanical investigation of man. This led him to conduct a series of systematic dissections… In so doing, he constantly underlined the relationship between man and the Earth (respiration, circulation of humors, and so on), largely based on analogies whose central element was water. During these same years, he stepped up his theoretical studies of optics and mechanics. A powerful motive was his calling as an artist intent on achieving a perfect imitation of Nature – a task that required a thorough knowledge of Nature's laws."[51] Indeed, Leonardo considered that his role was to perform a dissection of machines, as much as of human cadavers, in order to uncover the secrets of Nature. According to Galluzzi, "Leonardo's anatomical investigations present the human body as a remarkable ensemble of mechanical devices: 'It does not seem to me that coarse men with lewd habits and little reasoning power deserve so beautiful an instrument or so many varieties of mechanism.' He continually stresses the need to look beneath the 'armatures' of the human body, exactly as he had suggested doing with machines..." At the same time, "There remains the extreme coherence with which, taking the anatomy of machines as his starting-point, Leonardo – for more than a decade – conducted an analysis of the human body based on direct observations and yet strongly conditioned by a strict interpretative framework. At a certain point, he was even tempted to extend this approach (as indeed Descartes was to do) to the analysis of human passions." However, Galluzzi concluded, "here and there in the tight fabric of Leonardo's mechanism cracks appear through which the awareness of an irreducible distinction between machines and human beings tries to break forth..."[52]

There was another sense in which proportion was important. It could be expressed at the theoretical level by means of mathematics, and could then be translated into works of art by means of the technique of perspective.

Since proportion was to be found throughout nature, it could be mathematically measured in a way that leads to truth and certainty.

"Proportion," Leonardo wrote, "is not only found in numbers and measurements but also in sounds, weights, times, positions, and in whatsoever power there may be."[53] He discoursed at length in rather technical language about the proportions and movements of the human figure, going so far as to give mathematical values to a perfectly-proportioned face: "The space between the line of the mouth and the beginning of the nose *a b* is the seventh part of the face. The space from the mouth to the bottom of the chin *c d*, is the fourth part of the face and equal to the width of the mouth…"[54]

Proportion is to be found in the human figure, and the weight and movements of man,[55] in force and movement,[56] in the relations between geometrical figures,[57] in the trajectories of stones thrown,[58] and in many other instances besides. In fact, underlying Leonardo's canon of human proportions and his keen interest in the proportions to be found in nature, was the recovery of the ancient Pythagorean belief that "number is all": geometrical order, harmony and proportion pervade the universe, the fundamental values of nature are to be associated with mathematical representation, and numbers provide a key interpretative framework. This belief is found throughout Leonardo's writings: "arithmetic is a mental science and forms its calculations with true and perfect denomination…"; "there is no certainty where one can neither apply any of the mathematical sciences nor any of those which are based upon the mathematical sciences."[59]

Proportion could be expressed in mathematical terms, but converting these mathematical terms into art required something additional: the science of perspective to be applied to art.

If mathematical perspective is one of the enduring achievements of Italian Renaissance art, then it is also true that this achievement did not come easily or quickly.[60] On the contrary, it was the culmination of work by humanists seeking to restore the lost heritage of antiquity, by Giotto and other late medieval-early Renaissance artists, and by engineer-architects such as Brunelleschi.[61] In the fifteenth century, engineer-architects such as Brunelleschi and Alberti revolutionized approaches to perspective, by going into ever more complex mathematical calculations in order to create the illusion, on two-dimensional surfaces, of three-dimensional space. Brunelleschi's discoveries in applied mathematics led to his being considered a "second Archimedes" by humanist contemporaries, so that the characteristic link with antiquity was made once again.[62] Indeed, he knew Vitruvius well, and integrated mathematical proportions into such buildings as the churches of San Lorenzo and Santo Spirito in Florence.

Brunelleschi's innovation was to apply the rules of optical science, following Roger Bacon, to the development of linear perspective in his picture of the Florentine Baptistery. This picture showed the relative dimensions and spatial relationships between different elements of the picture under a silvery sky.[63] Brunelleschi followed this picture up with another, showing an oblique view of the Palazzo della Signoria. Demonstrations of "artificial perspective" made by Brunelleschi not only challenged his contemporaries: they showed that mathematics was increasingly being developed on the applied side outside of the schools, and that new mathematical rules could change the way people perceived space itself. But what was the value of artificial perspective? The end result was that it gave tremendous prestige to mathematics, to the methodical analysis and reduction of what the eye could see to its constituent (geometric) elements, and to the naturalistic school of painting, which sought to depict in painting and drawing an idealized vision of what the eye actually took in. It also popularized mathematics, making it somewhat more accessible to an increasingly educated urban public.

Alberti picked up where Brunelleschi left off, publishing a treatise on painting and perspective construction called *Della pittura (On Painting).* The opening page of *On Painting* gives a clear indication of the relationship of art and mathematics:

"In writing about painting in these short books, we will, to make our discourse clearer, first take from mathematics those things which seem relevant to our subject.... Mathematicians measure the shapes and forms of things in the mind alone and are divorced entirely from matter. We, on the other hand, who wish to talk of things that are visible, will express ourselves in cruder terms."[64]

In this work, Alberti described how to draw a checkerboard floor retreating into the distance. This illusion was obtained by determining a "centric point" of the perspective – "the point in the picture directly opposite the viewer's eye, that is the foot of the perpendicular from the eye to the picture plane." The appropriate number of tiles are drawn along the bottom of the picture. Then lines are drawn from the left and right sides of each tile at the bottom, all of these lines converging on a diagonal point actually outside of the picture. The resulting series of triangles provides the illusion of perspective, of triangles slanting to the right. Alberti's explanation of perspective construction proved useful in Renaissance art, since it helped offer a spatial setting to portraits, and provided an illusion of three-dimensional space. There were other perspective constructions in the Renaissance, however: another leading Renaissance figure in terms of perspective was Masaccio, whose enormous *Trinity* fresco in Santa Maria Novella in Florence contains many significant mathematical ideas.[65]

Leonardo absorbed the work of Giotto, Brunelleschi, Alberti and Masaccio, where perspective was concerned, and he took it further. Perspective for Leonardo had a basis in the five mathematical terms of the point, line, angle, surface and body.[66] Indeed, "perspective is a rational demonstration whereby experience confirms how all things transmit their images to the eye by pyramidal lines."[67] He divided the subject of perspective as it concerns painting into three chief parts: the diminution in the size of bodies at different distances; the diminution in the colour of these bodies; and the gradual loss of distinctness of the forms and outlines of these bodies at various distances.[68] Leonardo returned several times to the idea that perspective helped to capture images, and create an impression of the disappearance and diminution of opaque bodies, that it was a way of interpreting light and of geometrizing space in order to provide a representation of that light: "Perspective is nothing else than the seeing of an object behind a sheet of glass, smooth and quite transparent, on the surface of which all the things may be marked that are behind the glass; these things approach the point of the eye in pyramids, and these pyramids are cut by the said glass."[69] After considering the methods and advantages of perspective, Leonardo wrote that it is "to be preferred to all the formularies and systems of the schoolmen, for in its province the complex beam of light is made to show the stages of its development, wherein is found the glory not only of mathematical but also of physical science, adorned as it is with the flowers of both."[70]

At the same time, perspective was something that had been developed by artist-engineers, outside of the university setting. Luca Pacioli wrote admiringly of the way painters had mastered the technique of perspective. He must have been writing with his illustrator, Leonardo, in mind: "We could continue as long as we wished, dividing the parts [of the object we were looking at] into still smaller precise parts: indeed, the more numerous the precise parts become, the easier things become for the painter, because his eye can better seize the dimensions he wishes to trace, whether it be a head or any other thing, such as animals, trees, buildings, etc. This is the reason why painters build a square or rectangular frame, on which they hang many very fine wires made of metal or silk, or even nerves, a frame the size of which depends on what is needed to execute the work, whether on canvas, wood or on a wall. And then having placed the frame carefully, between himself and what he plans to reproduce, so that it won't fall, and will remain stable in the place where he wishes it to be, the painter positions himself in the place he considers most favourable: sitting, standing or on his knees; then, carefully examining one point of his model and than another, he considers how the intervals of the wires correspond in length and in width to his model. As a result, observing the proportions existing between the checkered pattern of the frame and the model, he notes them down on paper or elsewhere, writing a number whether larger or smaller, and he sketches his figure, to which he will then give a gracious appearance, so that it is agreeable to see. This instrument is what painters called 'graticule.'"[71]

Perspective was thus a valuable complement to proportion, in the sense that it was developed and used by artists such as Leonardo to provide a sense of the harmonic ratios to be found in nature. At the same time, it was based on abstractions about three-dimensional space, and the geometrical representation of that space. Alberti wrote a brilliant treatise on painting, explaining in layman's terms the meaning of perspective. Leonardo wrote about perspective in his private notebooks, and collaborated with a leading philosopher and mathematician – Luca Pacioli – on a book, which also explained perspective. This book, by two native Tuscans, was published in Milan and again in Venice.

Leonardo's life and works have so far been considered, and the way he shared with Renaissance contemporaries a fascination with divine proportions and mathematical perspective, both of which were early modern articulations of an originally Pythagorean belief that "number is all." In addition, Leonardo's view has been traced, according to which man is in God's Image and likeness, a microcosm, a self-mastering individual, and a psychological being with virtually unlimited dimensions. Leonardo takes his place at the beginning of this study, since through his anatomical drawings and mechanical studies, he interpreted man as a machine. And in so doing, he laid the groundwork for a truly modern idea, and one that has proven very influential.

Leonardo interpreted the metaphor of Man the machine in five different ways. Man is an organic machine, in the sense that a living creature could be interpreted in terms of mechanical structure (springs, joints, cables, pulleys etc.) as well as mechanical processes (clutching, raising, swimming, seeing, smelling, feeling etc.) Man can be represented on the model of an automaton – a relatively self-operating mechanical object, such as cable- or water-powered robotic animals. Man can serve as a model for machines, resulting in mathematical predictability, harmony and rationality. Man can be seen as the mechanical work of God – the Creator of a mathematically ordered world. And Man can be seen as a sort of universal machine, a perfectible being capable of all of these operations simultaneously. Throughout his writings, he constantly compared the mechanical workings of the human body to specific technologies available to him.

In developing his original synthesis of Man the machine, it is clear Leonardo's anatomy owed something to the medical tradition of Hippocrates, Galen and Avicenna, and something to own work in mechanical science. He wavered between the two traditions. From Galen, Leonardo learned of the instrumentality of the body. He took this instrumentality further, seeing the structure of the body as a complex series of mechanisms. Sometimes he approvingly quoted Galen in this respect, while at other times he used medieval mechanics to refute Galen.[72] But Leonardo transformed classical and medieval values, by merging them together in a bold new synthesis, which was explicitly mechanical.

In the *Notebooks*, Leonardo made it clear he saw the human body as a machine or instrument, fashioned by the Creator: "O speculator concerning this [anatomical] machine of ours let it not distress you that you impart knowledge of it through another's death [i.e. through dissection], but rejoice that our Creator has ordained the intellect to such excellence of perception."[73] He described man as a mechanism (in the Italian original, the term he used was "figura strumentale"): "We shall describe this mechanical structure of man by means of diagrams of which the three first will treat of the ramification of the bones; that is one from the front which shows the positions and shapes of the bones latitudinally; the second as seen in profile and shows the depth of the whole and of the parts and their position; the third diagram will show the bones from behind..."[74] To be fair, not just man but animals as well have been created as machines: "nature cannot give the power of movement to animals without mechanical instruments..."[75]

Even Leonardo's interpretation of the spirit is mechanical: "We have just now stated the definition of a spirit is a power united to a body, because of itself it can neither offer resistance nor take any kind of local movement."[76]

In his anatomical drawings and mechanical studies, Leonardo developed Renaissance techniques of proportion and perspective that relied on mathematical calculations and idealized forms. In so doing, he showed himself capable of making new and truly revolutionary abstractions, ones moreover that nobody in any previous age seems to have been able to make. The very fact that he was able to make these abstractions, to rethink the human body in ideal terms, and to conceive of three dimensional space in the abstract and then to represent it in two-dimensional terms, helped to transform the outlook of Western Europe at least through his works of art.

According to Eugenio Garin, "Leonardo's anatomy, which is developed step by step through optics, general mechanics and a physical interpretation of that universe, finally reveals an interplay of canals, flow and counter-flow, cords, levers, weights, primary and secondary motors, and is full of forces which are being transferred and modified."[77] Drawing after drawing is devoted to the static measurement of muscular force, arm and leg joints, the hand, heel and foot joints, back and spinal-column muscles and the mechanism of breathing. These drawings are accompanied by minimal and sometimes rather cryptic annotations. At the same time, it should be noted that through the ambient culture of Renaissance Italy, Leonardo imbibed Aristotelian and Galenic values such as a belief in the final cause – in the perfect design of the human body based on its purposes. Yet unlike Galen, Leonardo based his understanding of anatomy on rigorous observation, obtained through the dissection of human cadavers.

The anatomical drawings were works of art in their own right: they reflected the canon of human proportion and Leonardo's engrossing interest in experience as well as the mathematical and mechanistic expression of reality. During Leonardo's lifetime, they attracted the attention of Dürer and other great artists. The study of anatomy they reveal is also implicit in his naturalistic approach to painting.

During Leonardo's last years in France, for example, Antonio de Beatis, secretary of Cardinal Louis d'Aragon, noted in his *Journal* in 1517 that "this gentleman has compiled a particular treatise of anatomy with the demonstrations in draft not only of the members, but also of the muscles, nerves, veins, joints, intestines, and of whatever can be reasoned about in the bodies both of men and women, in a way that has never yet been done by any other person. All, which we have seen with our eyes; and he said that he had already dissected more than thirty bodies, both men and women of all ages. He has, also, written concerning the nature of water, and of divers machines, and other things, which he has set down in an endless number of volumes, and all in the vulgar tongue."[78] This passage shows that contemporary observers drew a link between Leonardo, human anatomy and machines.

Leonardo saw a close analogy between the human body and the machine. As Paolo Galluzzi wrote, "He saw both as the wonderful achievements of Nature, whose iron laws govern not only mechanical instruments but also the motions of animals.... Not surprisingly, therefore, his anatomical investigations concentrate on the basic organs of the human body of which his drawings repeatedly underscore the direct analogy with mechanical devices – to the point of suggesting the possibility of building fully operational artificial limbs and models."[79] He may have sought to demonstrate this analogy, as Galluzzi said, but he wished to demonstrate it mainly for himself.[80]

Leonardo's metaphor of man the machine worked both ways. His study of anatomy also had implications for his study of machines, in that those machines could replicate the mechanical functions of animals. In developing plans for a flying machine, he wrote that a bird "is an instrument working according to mathematical law, which instrument it is within the capacity of man to reproduce with all its movements..."[81] In this respect, he took precisely the same approach to architecture and machine design (or industrial design) as he did to human anatomy. The links between architecture and anatomy in Leonardo are noted by Paolo Galluzzi, in the companion volume to the Montreal Museum of Fine Arts' groundbreaking exhibition on Leonardo's technological inventions: "Leonardo's studies of flying machines were a dream, but a dream nurtured by the hope of opening up vast horizons through a new approach. His dream was rooted in the intuition of the substantial unity of the entire realm of Nature, which used the same, simple, necessary laws to produce man, the earth, and the animals."[82]

Leonardo was an enigma to many of his contemporaries. If we seek the reason why, it may be that he manufactured his own self-image – the Vitruvian man drawing in Venice may be an idealized self-portrait. Leonardo so dazzled men of his time that they either accepted or rejected this manufactured self-image. Eugenio Garin, for one, believed that Vasari had faithfully reproduced Leonardo's polemical and ironic vision of himself. "If we want, today, to understand Leonardo," Garin wrote, "we must above all understand the meaning of his irony and his polemical attitudes without becoming captive to either. Leonardo displayed contempt of as well as humility towards the learned world, replete with the most over-refined forms of culture. This we must take as our beginning."[83]

Leonardo developed a powerfully appealing vision of himself as an *uomo universale*, capable of mastering any art and technique, any branch of divine, human or natural knowledge. He upheld the *authority of phenomena* in mechanical analyses of the functions, processes and interactions of bodily organs and the system of the body as a whole.

Garin, who characterized Leonardo's original view as follows, supports this view: "the artist is a craftsman. He is not a man of pure culture, but a mechanic. He confronts the learned men of the schools as well as the civilised courtiers who teach the sciences in the universities and cultivate literature in the liberal circles, which had formed around both the old and the new princes. In the course of the fifteenth and sixteenth centuries the impact of the arts tended to undermine the traditional scheme of things. Technology, both in architecture and engineering, became more refined and thus tended to destroy the old barriers between mathematics and the practical, mechanical sciences."[84] Leonardo, according to Garin, was rebel, critic and outsider; he defied the existing intellectual order and through his investigations of phenomena, he identified hidden connections between ideas and phenomena from many different disciplines – which may be the hallmark of native genius.

Leonardo's artistic works made him famous throughout Europe – the envy of popes, emperors and kings. The greatest of Renaissance artists – the rival of Michelangelo and Raphael, the model for Dürer – was known in his own day for having launched an artistic revolution. His scientific and technological works may not have been *widely* known and understood during his day, but there is documentary evidence that they were known by *influential* contemporaries, although sometimes in private; influence at the Court was all-important at a time when no artist-engineer could work without a powerful patron. Moreover, his artwork was extremely well known, and implicit in this artwork was a naturalist conception, based on painstaking analysis of the structure and workings of Nature, which was in its own way revolutionary.

It is striking that many historians today dismiss any possible influence Leonardo may have exercised on subsequent work in anatomy and other areas of natural philosophy.[85]

Any assertion that Leonardo influenced anatomy and natural philosophy requires solid evidence. In the context of the metaphor of Man the machine, Leonardo's works and values exerted influence along several pathways: collaboration in the university setting with Pacioli and Marc' Antonio della Torre; personal meetings with artists such as Dürer; the compelling view of Nature contained in Leonardo's works of art, which were widely known and imitated; publication of treatises on proportion (such as Dürer's) that were clearly inspired by Leonardo; and further dissemination of works and values through noble patrons, who served as vectors of ideas.

Kenneth Keele divided Leonardo's anatomical career into three distinct periods: "early artistic exploration of the muscles, bones and joints, and their movements; topographical exploration and discovery; and that of physiological inquiry." According to Keele, "it was as an artist that Leonardo attempted the fusion of anatomy with medical science through della Torre… Leonardo was known throughout northern Italy as the artist-anatomist who had created the new science; he was the spearhead of the new creative anatomy."[86] It should be noted that it was in Leonardo's "early artistic exploration of muscles, bones and joints, and their movements" that he seized on the mechanical metaphor.

How did Leonardo influence those anatomists who followed him? It is likely, at the very least, that Vesalius would have read the 1509 Venice edition of *On Divine Proportion* at the University of Padua – which was Venice's university. As an ardent student of anatomy, Vesalius would have known that forty years before he wrote *On the Fabric of the Human Body*, Marc' Antonio della Torre's had delivered lectures at Pavia, which were greatly enhanced by Leonardo's illustrations. Jan Stephan van Calcar, the Flemish artist from Titian's studio who supervised the woodcut illustrations for the Vesalian masterpiece, would also have been familiar with Leonardo, and as a competent artist would have studied Leonardo's paintings and sculpture.[87] Moreover, Jan Stephan van Calcar came out of the Netherlandish Renaissance artistic tradition, on which Dürer (as vector and translator of Leonardo's ideas on proportion and perspective) had exerted enormous influence. William Harvey may have studied *On Divine Proportion* during his two years at Padua. Harvey certainly examined Leonardo's anatomical notebooks, since he accompanied his friend the Earl of Arundel in 1636 on a long journey to Italy, during which Arundel acquired the "Codex Arundel", consisting largely of anatomical notes and drawings. This codex, acquired in 1690 by Constantijn Huygens *fils* (1628-1697), is now partly housed in the Windsor Collection, and partly in the Pierpont Morgan Library in New York. Harvey was invited on this aristocratic expedition precisely in order to advise Arundel on the purchase of anatomical and other works.[88] However, the date at which Harvey is certain to have examined the Codex Arundel – 1636 – came several years *after* publication in 1628 of his masterpiece *De Motu Cordis*. Harvey may in turn have shared or discussed the treasure-trove to be found in these notebooks with his close friend Thomas Hobbes, whose mechanistic philosophy was partly derived, as we shall see, from a study of Harvey's works.[89]

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1 *Vitruvian man* is used as a corporate symbol by the American artificial intelligence expert and entrepreneur Raymond Kurzweil. It also features prominently in the Warner Brothers science fiction film *Contact* (1997).

2 In the accompanying text, Leonardo wrote: "The architect Vitruvius states in his work on architecture that the measurements of a man are arranged by Nature thus:– that is that four fingers make one palm, and four palms make one foot, six palms make one cubit, four cubits make once a man's height, and four cubits make a pace, and twenty palms make a man's height, and these measurements are in his buildings. If you set your legs so far apart as to take a fourteenth part from your height, and you open and raise your arms until you touch the line of the crown of the head with your middle fingers, you must know that the center of the head formed by the extremities of the out-stretched limbs will be the navel, and the space between the legs will form an equilateral triangle. The span of a man's outstretched arms is equal to his height. From the beginning of the hair to the end of the bottom of the chin is the tenth part of a man's height; from the bottom of the chin to the crown of the head is the eight of the man's height; from the top of the breast to the crown of the head is the sixth of the man; from the top of the breast to where the hair commences is the seventh part of the whole man; from the nipples to the crown of the head is a fourth part of the man. The maximum width of the shoulders is in itself the fourth part of a man; from the elbow to the tip of the middle finger is the fifth part; from this elbow to the end of the shoulder is the eighth part. The complete hand will be the tenth part. The penis begins at the center of the man. The foot is the seventh part of the part of the man. From the sole of the foot to just below the knee is the fourth part of the man. From below the knee to where the penis begins is the fourth part of the man. The parts that find themselves between the chin and the nose and between the places where the hair and the eyebrows start each of itself compares with that of the ear, and is a third of the face." Leonardo da Vinci, *The Notebooks of Leonardo da Vinci*, edited by E. MacCurdy (London, 1938), pp. 213-214.

3 This was the twentieth-century view both of Charles D. O'Malley and J. B. de C. M. Saunders, translators and editors of *Leonardo on the Human Body* (New York, 1983) and of H. G. Wells, whose three-volume *The Science of Life* (written in collaboration with Julian Huxley and G. P. Wells) featured several of Leonardo's anatomical drawings (London, 1931).

4 Leonardo derived one of his ideas on the mechanics of the ventricles of the heart from *De Ponderibus*, a thirteenth-century work on mechanics by Jordanus Nemorarius: "'But you would not be balancing it [the heart] properly inasmuch as the heart has two supports descending from the root of the neck and, according to the fourth [proposition] of the *De Ponderibus*, the heart cannot be balanced except upon a single support." (O'Malley and Saunders, *op. cit.*, p. 242.)

5 Leonardo designed a humanoid robot, which has since been reconstructed. According to Mark E. Robinson, "In approximately 1495, before he began work on the *Last Supper*, Leonardo designed and possibly built the first humanoid robot in Western civilization. The robot, an outgrowth of his earliest anatomy and kinesiology studies recorded in the Codex Huygens, was designed according to the Vitruvian canon. This armored robot knight was designed to sit up, wave its arms, and move its head via a flexible neck while opening and closing its anatomically correct jaw. It may have made sounds to the accompaniment of automated drums. On the outside, the robot is dressed in a typical German-Italian suit of armor of the late fifteenth century. On the inside, it was made of wood with parts of leather and metal and operated by a system of cables." In Paolo Galluzzi, *Renaissance Engineers from Brunelleschi to Leonardo da Vinci* (Florence, 1996), p. 234.

6 The drawing itself, and several detailed references in the *Notebooks* to Vitruvius suggest that Leonardo had made a careful study of the Roman architect/engineer's writings.

7 Giorgio Vasari, *Lives of the Painters, Sculptors and Architects*, translated by Gaston du C. de Vere (New York, 1996). Commenting on Vasari, Wallace Ferguson noted, "Vasari's conception of the history of Renaissance art has remained such a vital force in modern thought that he is often criticized as though he were a contemporary historian.... The defects of his work from the modern point of view are

clear. His method was 'unscientific.' He was frequently credulous and prejudiced, though seldom consciously untruthful. He shared the pragmatic, individualistic tendency of the humanist historians, laying great stress on the practical and ethical lessons taught by history, and ascribing each step in the progress of art to individual skill and invention... And he assumed, without question, that the art of antiquity, together with the classical Italian art of his own day, represented the ultimate degree of perfection possible to man." *The Renaissance in Historical Thought*, (Boston, 1948) pp. 64-65.

[8] *Lives of the Painters, Sculptors and Architects*, vol. I, pp. 627-628.

[9] *Ibid.*, p. 632.

[10] *Ibid.*, p. 638.

[11] One reason that Leonardo is difficult to study is the sheer imaginative power of interpretations made of him. In the judgment of most nineteenth and twentieth century historians, Leonardo was an artist-engineer of prodigious imaginative powers, ability and widespread interests, who *anticipated* a phenomenal range of discoveries in anatomy, applied engineering and mathematics, geology and mechanics. But to say that Leonardo *anticipated* later discoveries does not really tell us much. A fallacy may be at work here, however. David Hackett Fischer warned in *Historians' Fallacies* (New York, 1966, p. 166) of the "fallacy of *post hoc, propter hoc* ... the mistaken idea that if event B happened after event A, it happened because of event A." In fact, where Leonardo resembled his contemporaries or those immediately following him, it is possible that the main thing he had in common with them was that he came out of the same traditions, and responded in a similar way to the same environment, conditions and challenges.

Jacob Burckhardt saw Leonardo as a universal man, superior even to Leon Battista Alberti, although "the colossal outlines of Leonardo's nature can never be more than dimly and distantly conceived." (*The Civilization of the Renaissance in Italy*, p. 75) In Alexandre Koyré's view, the prevalent nineteenth-century view of Leonardo was a Faust, "a lonely giant, *proles sine matre*, creator or at the very least precursor of all the basic conceptions of modern science". A. Koyré (ed.), *Léonard de Vinci et l'expérience scientifique au seizième siècle* (Paris, 1953), p. 237. One of the most interesting historians of science to have examined Leonardo (although one whose insights were flawed) was Pierre Duhem. In the three-volume *Études sur Léonard de Vinci* (Paris, 1906-1913), Duhem developed the view that Leonardo was a sort of unsung hero of early modern science, a precursor, a man whose manuscripts published only in the nineteenth century bore witness to tremendous creativity and originality. The problem with this view is that it is a challenge to demonstrate Leonardo's influence. Duhem, a French nationalist, overly intellectualized or rationalized Leonardo's work: he read into Leonardo's statements both positions and supposed influence that may not have been there. Duhem's view is surprising, considering that Leonardo described himself as self-taught and ever reliant on personal observation, his notebooks being unencumbered by the profusion of classical quotations that make reading most scholastic and humanist texts such a chore.

One of the leading twentieth-century experts on Leonardo, Edward MacCurdy, considered the notebooks alone to be "the records of the mightiest machine perhaps that has ever been a human brain: fragments of a larger purpose, charted, defined, explored, but never fulfilled, of which the treatises containing the sum of his researches in anatomy, physiology and geology form components parts, fragments of a vast encyclopaedia of human knowledge. What thinker has ever possessed the cosmic vision so insistently? He sought to establish the essential unity of structure of all living things, the earth as organism with veins and arteries, the body of a man a type of that of the world." Edward MacCurdy, Preface to *The Notebooks of Leonardo da Vinci*, p. 14. It is interesting to note that MacCurdy himself subscribed both to the view of Leonardo as machine and to the universe as macrocosm!

According to Giorgio Nicodemi, whose essay "The Life and Works of Leonardo" appears in the Istituto Geografico De Agostini's magnificent volume *Leonardo da Vinci* (reissued in New York in 1997), "Leonardo's contribution to humanity appears even today so profound and real that it is as though this extraordinary artist mind must have foreseen the spiritual needs, the aspirations, and the technical achievements of modern times. His greatness was recognized even while he lived, and without him the Renaissance as a whole would have fallen short of those spiritual conquests that brought light to all of European civilization. To the thoughts and emotions stirred by Christianity he added his discovery of the affinities between human processes and those of nature, and through scientific studies he came to realize that the knowledge and application of nature's laws could carry human endeavor to greater and nobler heights." (p. 19)

In reaction to the views of Leonardo as Faust, as the supremely individualistic Renaissance man, and as the creator or precursor of the early modern scientific revolution, several twentieth-century historians of science have suggested that the evolution of modern science would not have been greatly affected, had Leonardo never seen the light of day! For instance, according to George Sarton, "the development of mechanics would have been exactly the same, even if Leonardo had never existed." In *Léonard de Vinci et l'expérience scientifique au seizième siècle*, p. 114. In the same manner, some historians have suggested we can only speculate about how Leonardo might have changed the course of the history of science. According to Charles Singer, "in endless matters [Leonardo] was centuries ahead of his contemporaries. Had he produced the anatomical textbook which he had planned in collaboration with the Pavian professor, Marcantonio della Torre, the progress of Anatomy and Physiology would have been advanced by centuries." Charles Singer, *A Short History of Anatomy and Physiology from the Greeks to Harvey* (New York, 1957), pp. 90-1.

Other historians of science have simply scoffed at the scientific achievements of Leonardo. This is overly pessimistic. E.A. Burtt mentioned only in passing that Leonardo was an early supporter of mathematics in scientific inquiry. After alluding to a number of Leonardo's scientific mistakes, Herbert Butterfield wrote sarcastically that "even Leonardo da Vinci had tended to cast around here and there, like a schoolboy interested in everything, and when he drew up a plan of experiments in advance – as in the case of his projected scheme of study on the subject of flying – we can hardly fail to realise that here are experiments, but not the modern experimental method." Herbert Butterfield, *The Origins of Modern Science*, (New York, 1952), p. 108.

Raymond Klibansky has cautioned that "some studies on Leonardo da Vinci, in seeking to underline the novelty of his thought, detach him from the world to which he belongs; while others, underlining the importance of the sources which he may have tapped, deprive him in our eyes of the originality of his creative genius; and these practices are all the more absurd in that they make Leonardo seem to have been two distinct personalities. In *Léonard de Vinci et l'expérience scientifique au seizième siècle*, p. 225. Our translation.

In the same vein, Paolo Galluzzi wrote in the companion volume to a series of exhibits on Leonardo the engineer, "we need to reassess the traditional image of Leonardo as the pioneer of an approach to mechanical engineering guided by new methods and bold objectives. Instead, Leonardo now emerges as the culmination, as the most mature and original product of a collective development lasting several decades, to which many highly talented figures made sizable contributions. From such a vantage point, Leonardo ceases to be a visionary prophet in the desert. Rather, he appears as the man who most eloquently expressed – both in words and, above all, images – the utopian visions about the practical potential of technology that were enthusiastically shared by many 'artist-engineers' of the fifteenth century." *Renaissance Engineers: from Brunelleschi to Leonardo da Vinci*, p. 11.

Certainly, the few paintings he is known to have executed are works of incomparable grace and harmony. They contain an enduring human message. The extraordinary gift of representation in works such as the *Virgin and Child with St. Anne*, the *Mona Lisa* and *The Last Supper*, the power of expression of his sensuous nudes, are partly attributable to Leonardo's close study of the mathematics of perspective and ideal form.

[12] According to Kenneth Clark, "From the first he is obsessed by vital force and finds it expressed in plants and creatures; then, as his scientific researches develop he learns the vast power of natural forces and he pursues science as the means by which these forces can be harnessed for human advantage. The further he penetrates the more he becomes aware of man's impotence..." Kenneth Clark, *Leonardo da Vinci*, (Harmondsworth, 1967), p. 160.

[13] A. Richard Turner devoted an entire work to these conflicting interpretations: *Inventing Leonardo* (New York, 1993).

[14] Luca Pacioli, *Divine proportione*, (Paris, 1980), p. 29. Our translation into English from the French translation of the 1509 Venice edition has been compared to the Latin original.

[15] Through the Pythagorean School, mathematics became an abstract discipline in the sixth century B.C., was pervaded by a mystical character, and yet opened up a huge range of practical applications While it may be intellectually satisfying to distinguish between the mystical character of numbers and their practical applications (from the modern perspective, these are distinct categories), it seems clear the Pythagorean School, much like Florentine Neoplatonism, was interested in both. Indeed, these mystical and practical aspects of number grew in parallel and were intimately bound together. No writings can be attributed to Pythagoras with any degree of certainty, but his influence can be detected

along the two pathways just mentioned: along the philosophical pathway, all the way from Plato's *Timaeus* to Pico della Mirandola's *Oration on the Dignity of Man*, Leonardo's *Notebooks*, Kepler's *Harmonies of the World* and Galileo's *Dialogues Concerning the Two Chief World Systems*; and along the artistic pathway, from Polykleitos and Vitruvius to Renaissance painting and sculpture.

A long series of Italian humanists put great stock in mathematics, thanks to the flowering of Neoplatonist thought (and thereby, ultimately, to Pythagoras). Pico della Mirandola believed that the investigation and understanding of all that is knowable is to be had through numbers, although he held that mathematics does not give a true picture of God. P.L. Rose, *The Italian Renaissance of Mathematics* (Geneva, 1975), p. 9. Ficino considered that mathematics could lead the soul to the highest contemplation of metaphysics. In Poliziano's classification of knowledge, arithmetic, astronomy and geometry figured prominently. And this focus of humanists on mathematics could at least partly be attributed to educators such as Salutati, for whom "the mathematical sciences, far from harming religion, are indispensable for the understanding of theology. Arithmetic and geometry lead to appreciation of the religious symbolism of the monad and triad – *infinita mystici numeri sacramenta* – while contemplation of the size, movements and beauty of the universe direct man to its Creator." (*Ibid.* p. 12.)

[16] *Ibid.*, p. 47.

[17] The relevant passages in Vasari are to be found in *Lives of the Painters, Sculptors and Architects*, vol. I, p. 731 & vol. II, pp. 865-866. The encounters of Dürer with Sanseverino, and the influence of Leonardo and Pacioli, are described in a variety of works: William Martin Conway (ed.), *The Writings of Albrecht Dürer* (London, 1958), pp. 208-209; Jane Campbell Hutchison, *Albrecht Dürer* (Princeton, 1990), p. 53; and Erwin Panofksy, *The Life and Art of Albrecht Dürer* (Princeton, 1955), pp. 251-261.

[18] Vasari, *Ibid.*, vol. I, pp. 633-4.

[19] O'Malley and Saunders warned that Vasari's account may contain misleading statements. *Op. cit.*, p. 21.

[20] Quoted in *Leonardo on the Human Body*, p. 34.

[21] Francesco Melzi, *Leonardo da Vinci Treatise on Painting*, translated by A. Philip McMahon (Princeton, 1956).

[22] Lomazzo, *Trattato Dell'Arte Della Pittura, Scolture et Archiiettura* (Milan, 1585)

[23] Quoted in Albert Hofstadter and Richard Kuhns (ed.), *Philosophies of Art and Beauty* (New York, 1964), p. 213.

[24] *Ibid.*, p. 219.

[25] Wittkower, *Architectural Principles in the Age of Humanism* (London, 1973), p. 16.

[26] Leonardo sought to correct the erroneous Epicurean notion that the Sun was only as big as it appears to us: "Think, then, what this star of ours would seem like at so great a distance, and then consider how many stars might be set longitudinally and latitudinally amid these stars which are scattered throughout this dark expanse. I can never do other than blame those many ancients who said that the sun was no larger than it appears, - among these being Epicurus; and I believe that such a theory is borrowed from the idea of a light set in our atmosphere equidistant from the centre [of the the earth]; whoever sees it never sees it lessened in size at any distance..." Edward MacCurdy (ed.) *The Notebooks of Leonardo da Vinci*, pp. 277-278.

[27] According to Mara Miniati, vice-director of the Museum of the History of Science in Florence, Leonardo applied the laws of mechanics in order to account for the functions of the human body, but his use of this mechanical model in no way diminished or contradicted the value of the human soul. Interview conducted by author, February 2002, Museum of the History of Science, Florence, Italy.

[28] Leonardo did not see Man as naturally destined for reason, justice and happiness, or Man as a cog in an Automated State. These ideas developed several centuries later.

[29] Renaissance art was closely associated with this philosophical system. Florentine Neoplatonism is not known for its originality; indeed, leading thinkers such as Ficino and Pico della Mirandola give the impression of having been experimental, open-minded, syncretistic, and not especially good at abstract thought. Florentine Neoplatonists may be notable mainly because they were syncretists, so closely linked to Renaissance art. They expressed philosophical views on the ideal of human perfection, an ideal both highly spiritual – it emanated from God – and sensual – it could be conveyed in pleasurable art.

[30] *The Notebooks of Leonardo da Vinci*, p. 83.

[31] *Ibid.*, p. 87.

[32] *Ibid.*, p. 509.
[33] *Ibid.*, p. 1100.
[34] *Ibid.*, p. 1128.
[35] *Ibid.*, p. 167.
[36] *Ibid.*, p. 110.
[37] *Ibid.*, p. 170.
[38] *Ibid.*, p. 232.
[39] *Ibid.*, p. 852.
[40] *Ibid.*, p. 622.
[41] *Ibid.*, p. 161.
[42] *Ibid.*, pp. 350-351.
[43] *Ibid.*, p. 182.
[44] *Ibid.*, pp. 853-854.
[45] *Ibid.*, p. 989.
[46] *Ibid.*, p. 857.
[47] Charles Trinkaus made an exhaustive study of the subject in his two-volume *In Our Image and Likeness: Humanity and Divinity in Italian Humanist Thought*, (London, 1970).
[48] Pacioli, *op. cit.*, p. 143.
[49] *Ibid.*, pp. 143-144.
[50] *The Nude*, p. 29.
[51] Paolo Galluzzi, *Renaissance Engineers: from Brunelleschi to Leonardo da Vinci*, p. 63.
[52] *Ibid.*, p. 79-80.
[53] *The Notebooks of Leonardo da Vinci*, p. 622.
[54] *Ibid.*, p. 207.
[55] *Ibid.*, pp. 206-207.
[56] *Ibid.*, p. 511.
[57] *Ibid.*, p. 617.
[58] *Ibid.*, p. 793.
[59] *Ibid.*, p. 613 & p. 619.
[60] According to Samuel Edgerton, Renaissance Italian art was "the first artistic method anywhere which had the capacity to map point by point and to scale the edges, surfaces, and relative distances apart of physical objects just as they are optically perceived from a fixed viewpoint." Indeed, he considered that Western Renaissance picture making relied on "the unique capacity ... to reproduce on a plane surface the basic shapes of fixed three-dimensional objects as formed by light and recorded point by point in the human optical apparatus when focused from a fixed point of view." Samuel Edgerton, *The Heritage of Giotto's Geometry* (Ithaca, 1991), pp. 5 & 7.)
[61] Samuel Edgerton noted that medieval attempts at perspective were not very successful, in such areas as scientific illustration and the depiction of spheres on maps, for example. In medieval times, people may have been conscious that they had lost the classical ability, particularly in astronomical treatises, to construct geometrically accurate perspective pictures, but if they were, they also seemed unable to make the intellectual leap from their own flat pictures, whether in illuminated gospels or squashed Byzantine icons, to the illusion of three dimensional representation. Even such an early Renaissance artist as Uccello seemed to stack up figures on top of each other, rather than represent them with perspective.
The unknown Master of the Second Modillion Border at the Basilica of San Francesco in Assisi was one of the first artists to create the illusion of perspective, by introducing a series of enormous polygonal frames around the figures in his frescoes. One of the first known artists to have introduced perspective was Giotto. In the frescoed cycle of the *Lives of the Virgin and Jesus* in the Arena Chapel at Padua, for instance, Giotto "clearly wanted his viewers to think of themselves as standing more or less in the center of the chapel and looking through occluded wall openings at a series of fictive stagelike spaces on the other side.... What endows the fresco with such extraordinary illusionistic vitality, however, is that the overhanging *sporti* beside the figures, along with their jutting flag-poles, appear to project dramatically in front of the wall and almost to soar above the viewer's head." *The Heritage of Giotto's Geometry.*, p. 24.
In *The Invention of Infinity: Mathematics and Art in the Renaissance*, J.V. Field discussed Giotto's mathematics. Fresco cycles had to be planned ahead, since the wall was first covered with coarse

plaster, the storyboard had to be mapped out in advance to show the relationships between scenes, and assistants had to be set to work providing framing elements, and great care had to be taken to maintain the uniformity of colours. As a result, mathematics came into play as the lead artist managed the texture and hardening of underlying plaster, the development of the story line, the framing of incidents depicted which included the design of imaginary architectures, and the varying properties of chemical elements in pigments. "Viewed simply as mathematics," Field concluded, "the surveyor's geometry and craftsman's arithmetic to which we have referred are not particularly interesting. What is interesting about them is that at least from the late thirteenth century onwards such mathematical skills were recognised as useful in wider contexts and were increasingly taught in abacus schools specially set up for the purpose." J.V. Field, *The Invention of Infinity* (Oxford, 1997), p. 15.

[62] P.L. Rose, *The Renaissance of Italian Mathematics*, p. 29.

[63] "Moreover," Samuel Edgerton noted, "he cut a little hole in the back of the picture to convince his viewers, as they looked through it in order to see a mirror reflection of the painting in front, that the manner in which they were seeing the painting was just the same as if they were looking through the pupil in the uvea and beholding what the inner eye displays upon the surface of the glacial membrane." *The Heritage of Giotto's Geometry*, p. 105.

[64] Leon Battista Alberti, *On Painting*, translated by Martin Kemp (Harmondsworth, 1991), p. 37.

[65] J.V. Field made a detailed study of these ideas, and traced orthogonals in order to determine "the position used in designing the perspective scheme." *The Invention of Infinity*, p. 45. The fresco depicts a crucified Christ drooping limply on the Cross, with haloed God behind and above him; at the Lord's feet are Mary and a few other saints, while the backdrop is a vault with squares in its domed ceiling. The general effect of the fresco is to transport the viewer into the scene of the crucifixion, if not a little beyond it. Field divided the painting into squares, in order to produce a trapezium representing the perspective image of the square. But "investigating the squares had added another element to the problem, and had provided a hint towards a solution only in the very limited sense of suggesting that Masaccio had not regarded the square as primary elements in producing a perspective illusion. As Vasari had noted, the vault was what took the eye through the wall. No doubt Masaccio had reckoned on this being so.... There simply is no visible *pavimiento* in the Trinity fresco." *Ibid.*, pp. 47-48. Indeed, Field concluded he may not have been able to find the mathematical basis of Masaccio's trompe-l'oeil because there wasn't any: the viewer has to imaginatively construct a space around the sculptural solidity of the figures. In other words, Massacio was playing with the effect of his painting on the viewer's mind; he was teasing out of the viewer's mind a series of responses to complete, or balance, elements of the picture. "That a picture so impressively visually correct as the Trinity can turn out to be mathematically faulty is a warning against confusing artist and mathematician," Field concluded somewhat sheepishly. *Ibid.*, p. 61. But then the purpose of the Renaissance artist was to use mathematics to create visual effects, rather than to provide painstakingly accurate mathematical sketches.

Perspective was thus a valuable complement to proportion, in the sense that it was developed and used by artists to provide a sense of the harmonic ratios to be found in nature. At the same time, it was based on abstractions about three-dimensional space, and the geometrical representation of that space. As Rudolf Wittkower noted, "Nobody expressed his belief in the efficacy of harmonic ratios behind all visual phenomena with more conviction than Leonardo. We may recall in particular his well-known saying that music is the sister of painting.... Musical intervals and linear perspective are subject to the same numerical ratios, for objects of equal size placed so as to recede at regular intervals diminish in 'harmonic' progression."*Architectural Principles in the Age of Humanism*, pp. 117-118.

[66] Leonardo, *Notebooks*, p. 986.

[67] *Ibid.*, p. 993.

[68] *Ibid.*, p. 1000.

[69] *Ibid.*, p. 992.

[70] *Ibid.*, p. 989.

[71] Pacioli, *op. cit.*, p. 148.

[72] Charles D. O'Malley and J. B. de C. M. Saunders noted the influence of Galen on Leonardo, and the latter's implicit understanding of the Galenic instrumentality of bodily structure as a complex series of bodily mechanisms, in at least one case deriving his mechanical theory of the body from medieval mechanics, in other cases opposing his original mechanical theory to Galenic traditions. Their commentary in *Leonardo on the Human Body* is rife with Leonardo's references to the mechanical

structure and functions of the human body. Concerning the osteological system, for example, they noted that "the lateral view of the articulated [vertebral] column correctly represents the spinal curvatures and reflects Leonardo's appreciation of their importance in bodily mechanics." (*op. cit.*, p. 42.) "Leonardo presents us with a highly original discussion on the occlusion of the teeth and the mechanical principles which determine their power in mastication, as well as the relationship between their form and function." (*op. cit.*, p. 44.) "The primary purpose of the illustration [of the bones of the upper extremity] is to show the mechanism of pronation and supination… The illustrations [showing relative shortening of the radius on pronation] emphasize his acute interest in body mechanics." (*op. cit.*, p. 54.) Leonardo "clearly sets forth" the "mechanical principles of the effects" of the sesamoid bones at the metatarso-phalangeal joint of the great toe. (*op. cit.*, p. 64.) Concerning the mycological system, the authors likewise noted Leonardo's system provides a mechanical justification of the dissection of cadavers: "'O speculator on this machine of ours, let it not distress you that you give knowledge of it through another's death, but rejoice that our Creator has placed the intellect on such a superb instrument.'" (*op. cit.*, p. 76.) The authors also noted Leonardo's drawings and explanations of the superficial muscles of the shoulder, trunk and leg: "Suddenly as though overwhelmed by the complexity of the body and the wonder of its construction, Leonardo interjects in the middle of his discussion the remark: He who finds it too much, let him shorten it; he who finds it too little, add to it; he for whom it is sufficient, let him praise the first builder of such a machine.'" (*op. cit.*, p. 80.) They note, that "the penetration of the tendon of flexor digitorum sublimes by flexor digitorum profundus greatly interested Leonardo because of the mechanical principles involved. Therefore, around and about the sketch he writes the reminder to include in his projected work [on anatomy] a section on mechanics with examples before taking up the action of the muscles: 'Arrange it so that the book on the elements of mechanics, with its practice, comes prior to the demonstration of the movement and force and man and of all other animals, and by means of these [examples] you will be able to prove all your propositions.'" (*op. cit.*, p. 154.) Concerning the functioning of the cardio-vascular system, it is interesting to note the two authors showed how Leonardo tried to reconcile his mechanical interpretation of the ventricles of the heart with Galenic speculation: "He attempts a mechanical explanation of how the pneuma and vapors pass to and from the heart and lungs. At a later period he came to realize that there is no free passage of air to the heart and that the respiratory movements of the heart which in diastole create a vacuum which by drawing out the air from the lung causes its collapse." (*op. cit.*, p. 222) The authors noted in writing of the aortic pulmonary valves, Leonardo "presents an interesting theory on the function of the walls of the aortic vestibule as a sphincteric mechanism to assist the aortic valves in preventing regurgitation of the blood into the left ventricle during diastole." (*op. cit.*, p. 264.) Finally, the authors noted in writing of the respiratory system, Leonardo "continues in greater detail the argument presented [previously], on the influence of the respiratory movements of the diaphragm in the emptying of the stomach, and he offers a mechanical explanation in opposition to the Galenical theory." (*op. cit.*, p. 404)

[73]Leonardo, *Notebooks*, p. 168.

[74] *Ibid.*, p. 131.

[75]*Ibid*, p. 159.

[76] *Ibid.*, p. 146.

[77] Eugenio Garin, *Science and Civic Life* (Gloucester, Mass., 1978), p. 68.

[78] quoted in Kenneth Clark, *Leonardo da Vinci*, pp. 157-8.

[79] *Renaissance Engineers: from Brunelleschi to Leonardo da Vinci*, p. 226.

[80] Our view is shared by Serge Bramly, according to whom, "His idea of the human machine spilled over into his engineering projects, and vice versa. He discussed botany with the vocabulary of an embryologist or gynecologist, while he tackled anatomy with the spirit of the geographer." Serge Bramly, *Leonardo: Discovering the Life of Leonardo da Vinci*, translated by S. Reynolds (New York, 1991), p. 208.

[81] Leonardo, *Notebooks*, p. 493.

[82] Paolo Galluzzi, "The Career of a Technologist", in *Leonardo da Vinci: Engineer and Architect*, p. 82.

[83] Garin, *Science and Civic Life*, p. 60.

[84] *Ibid.*, p. 60.

[85] Michael White discounted the possibility of Leonardo influencing Vesalius, and did not know that Harvey studied Leonardo's anatomical notebooks. *Leonardo: The First Scientist* (New York, 2000).

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[86] Kenneth D. Keele, "Leonardo da Vinci's Influence on Renaissance Anatomy" in *Medical History* 8 (1964), p. 369.

[87] Vasari wrote that an artist from Titian's studio supervised the woodcuts for Vesalius. *Lives of the Painters, Sculptors and Architects,* vol. 2, p. 798. This supervising artist was identified by Vasari as Jan Stephan van Calcar. On this subject, see Tom Jones, "The Artists of Vesalius's Fabrica" in *Bulletin of the Medical Library Association* 31 (1943) pp. 222-227.

[88] Details of the journey made by Arundel and Harvey are contained in Sir Geoffrey Keynes' biography.

[89] A rigorous and colourful account of the Arundel hoard of Italian Renaissance manuscripts, paintings and drawings is given by David Howarth in *Lord Arundel and His Circle* (New Haven, 1985).

ANDREAS VESALIUS (1514-1564)

Andreas Vesalius was the leading anatomist of the High Renaissance as well as personal physician to Emperor Charles V (1500-1558).[1] A good deal more is known about his life and work than is known about Leonardo. Vesalius, unlike Leonardo, was of the university world. He made his contribution not as a rather enigmatic universal man taking up one thing after another, the way Leonardo did, but as a scholar in a competitive world, focusing on a single discipline with great intensity. He was a humanist, and as such, devoted himself to preparing standard texts of some classical authors, in a more accurate and annotated translation than had previously been available. He was an original anatomist, struggling loose not just from Aristotle and Galen (although he readily acknowledged their intellectual heritage), but also from the enslavement of European anatomy in his day, which was largely based on the unquestioning acceptance of the tradition and authority with which Aristotle and Galen in particular had come to be invested through late classical times and the Middle Ages.

Vesalius also made an enormous contribution to early modern science, by laying down the experimental foundations of anatomy, in exhaustive detail, and by shifting the focus of scientific work in this domain, from the interpretation of classical texts to the systematic observation of natural phenomena in the "book of life" itself, as well as "reason".[2]

On the Fabric of the Human Body (often referred to simply as the *Fabrica*, the shortened form of its original Latin title, *De humani corporis fabrica libri septem*) was the single masterpiece, which marked the life of Vesalius.[3] The work, first published in 1543, consists of seven books: the nature of all the bones and cartilages; the ligaments and muscles; the intricate series of veins; the distribution of the nerves that go to the muscles and also the off-shoots belonging to all the other parts; the construction of the organs that serve nutrition; the heart and the parts that serve it; the harmony of the brain and the organs of sense, without repeating the arrangement of the nerves that take their origin from the brain.

In addition, a shorter work by Vesalius is extant: the *Epitome*, a brief digest of the far longer *Fabrica*, also published in 1543.[4] Also important is *Andreas Vesalius' First Public Anatomy at Bologna, 1540: an Eyewitness Report*, by Baldasar Heseler, which consists of lecture notes taken by one of the great anatomist's early students. The interest of this latter publication is that Heseler elaborated on the public and very controversial context in which Vesalius made his anatomical demonstrations. This work was only published for the first time in Sweden, in 1959.

One possible interpretation of the word "fabrica" in the title of the Vesalian masterpiece is that the body is a "fabrica", (in medieval Latin a "workshop") – God's workshop – in which bodily processes and mechanisms could be analysed, accurately measured, drawn and described. Charles Singer wrote that "It must not be translated 'fabric', nor does 'mechanism' quite render it. In classical usage it means 'an artisan's workshop' where something is going on and, by transference, the art of trade itself. This is reflected in modern German, *Fabrik* (factory), and rather better in French, *fabrique*, which means both the process of making and the place where things are made. In Renaissance Latin the word has kinetic associations. A good – if unliterary

– rendering would be "works" or "workings." *De Humani Corporis Fabrica*, "*On Man's Bodily Works*." It was always "works" in action, living anatomy, that Vesalius was trying to describe and, as a corollary, he had always in mind the body as a whole – the living body."[5] In support of the translation "workshop", however, is L.R. Lind's translation of the *Epitome*, according to which "the veins suck out from the intestines (especially the small ones) whatever is suitable for the making of the blood, together with the aqueous and thin refuse of the stomach's concoction, and carry it to the workshop of the liver, where the blood is made."[6]

One cannot help seeing a parallel between the *Fabrica*, on the one hand, and the contemporary sixteenth-century writings by Nicholaus Copernicus (1473-1543) on the machinery of the world or universe: "Accordingly," the Polish astronomer wrote in *De Revolutionibus Orbium Celestium* (*On the Revolutions of Heavenly Spheres)*, also published in 1543, [7] "when I had meditated upon this lack of certitude in the traditional mathematics concerning the composition of movements of the spheres of the world, I began to be annoyed that the philosophers, who in other respects had made a very careful scrutiny of the least details of the world, had discovered no sure scheme for the movements of the machinery of the world, which has been built for us by the Best and Most Orderly Workman of all."[8]

Indeed, Vesalius developed in the *Fabrica* a "system of the human body", much as Copernicus developed a "system of the world". In the early seventeenth century, William Harvey's work on the motions of the heart and the circulation of the blood, was by comparison more specialized – and characterized the heart as a sort of individual mechanical device, rather than an entire "system of the world".

The *Fabrica* set the experimental study of human anatomy as well as the practice of medicine on a new footing, establishing the breadth of an entire scientific discipline, much as Aristotle had done with biology. The *Fabrica* broke with Galen's habit of making inferences about human anatomy from dissections of Barbary apes, pigs, goats and other animals. Much like Aristotle in ancient Greece, and Galen in the Hellenistic world, Vesalius synthesized leading knowledge about human anatomy during the Renaissance, developing a rigorous and more empirical method to test that knowledge, based on critical observation and personal experiment.

Given that Vesalius could work free from the Hellenistic taboos affecting Galen concerning the human body, he was in a position to perform human dissections himself, and make detailed critical evaluations of the results. Dissection for Vesalius was a public enterprise, conducted in the presence of faculty members and several hundred students, in Bologna, Padua and other places. An anatomical theatre in Padua still exists, although in its current form it may have been built several decades after the time of Vesalius. The theatre consists of a large windowless room, with rows of seats steeply overlooking a central confined space, consisting of a table where dissections were performed and, according to local lore today, a secret trapdoor in the floor which enabled the cadaver to be quickly dumped into a hidden canal beneath the theatre, in the event of a raid by the Inquisition.

Dissection had quite different religious associations for Vesalius. It helped him to uncover and scrutinize the hidden designs of God. "Marvelous indeed," he wrote in Book II of the *Fabrica*, "is the ingenuity of the Creator, who wills that from linked bones should grow forth a bodily substance by means of which the bones should at once be bound securely and accurately together and their joints contained so that they should not easily be pulled apart by violent motion, and that this substance should by its hardness be able to survive constant and untiring movement without suffering damage. Again, so that the bones and cartilage should follow quickly when pulled by the muscles, it was necessary that the substance of ligament also be soft and in this sense weak. But strength and hardness are incompatible with weakness, infirmity and softness. Dissection of the human frame will show you how great, then, was the skill of the Creator, who fashioned a material that combines both these natures and performs both of these tasks and is in addition resistant to injury."[9]

The *Fabrica* underlines the importance of printing and publication, in the broad dissemination of new scientific ideas.[10] The *Fabrica*'s rich woodcuts, developed according to Vasari by Jan Stephan van Calcar in Titian's studio, established a high standard in medical illustration, and help to explain why Vesalius' work was quickly plagiarized in many editions.[11]

Compared to Leonardo's notebooks, examined in the previous chapter, the *Fabrica* is noteworthy for several reasons. It was a public document designed for widespread dissemination – restoring to anatomy the prestigious role it had once enjoyed in Greek Antiquity, and directing anatomy to support the practice of medicine. In praising (and soliciting) the contribution of Charles V as patron and emperor, Vesalius expressed this latter position in no uncertain terms: "In our present age, however, which by the will of the gods is subject to your Majesty's wise rule, things have taken a turn for the better, and medicine, along with all other studies, has begun so to come to life again and to raise its head from the profound darkness which enveloped it that in several universities it has beyond all argument come close to recovering its former glory. Nothing was more urgently required than knowledge of the parts of the human body, a knowledge that had become almost extinct."[12]

The *Fabrica* is a practical guide to dissection, a "how-to book". This is particularly evident in Book II, for example, where Vesalius described the Renaissance tools of dissection – razors, small knives for cutting pens, ordinary knives, boxwood knives, hooks, styli, siphons, needles, thread, saws, shears, mallets and tubes – providing a macabre illustration of these tools arrayed on a wooden table, to prove his point.[13] A picture is worth a thousand words!

Vesalius was one of the leading Renaissance scholars to publish the view that man had machine-like functions, and that human anatomy could be more easily understood according to the machine model. In this respect, Vesalius owed an intellectual debt to some classical and medieval views, according to which God's Creation had order and rationality and was thus measurable. Drawing evident parallels with Renaissance technology, Vesalius also saw the body as a complex series of intricate mechanisms, which should be observed and experimented upon in the dissection of human cadavers, to bolster the science of anatomy and serve as a foundation for the practice of medicine.

The decisive Vesalian contribution to modern science was deeply marked by the value-system – the teleology and metaphysics and religious beliefs and some hermetic thinking – of the Renaissance. Indeed dissection, according to Vesalius, ultimately served to bolster the metaphysical view that the human body, this perfect production of divine ingenuity, was a microcosm, in the image and likeness of the world itself. As he wrote in the preface to the *Fabrica*, devoted to Emperor Charles V: "because you are so uniquely fascinated by the study of the world, I am quite sure that you will be delighted also to study the construction of the most perfect of all creatures and will take pleasure in examining the lodging-house and instrument of the immortal soul, a domicile that, because in so many respects it corresponds exactly to the universe, was aptly known to the ancients as the microcosm."[14]

Vesalian interpretation	Sources	Key features
Man the machine	Aristotle, Galen, Islamic medicine, anatomists such as Mundinus & Bergengario, classical & medieval views of God's Creation having order and rationality and thus being measurable	The body is a complex series of intricate mechanisms which should be observed and experimented upon in the dissection of human cadavers, to bolster the science of anatomy and serve as a foundation for the practice of medicine
Man in God's image and likeness	Judaism, Christianity, Greek & Roman mythology, Aristotle, Islamic medicine, Neoplatonism…	Man is like God: he has a soul, powers of observation, an ability to serve as a mirror of nature; ideal proportions of man are divine
Man as a microcosm	Pythagoras & Plato through Neoplatonism, Persian and Islamic medicine, Christian medieval thinkers as well as the hermetic tradition	Parallel between God's orderly and rational universe and man and his destiny; ideal proportions of man are divine; Vesalian anatomical drawings can be compared to geographic charts, which implies a relation of sorts between man and world…
Man as self-mastering individual	No explicit statement in Vesalius	Showed up in his combative attitude to life and work, if nothing else…
Man as a psychological being	No statement in Vesalius	Absent
Man as a being endowed with reason and devoted to the pursuit of happiness	Absent	
Man as a cog within an Automated State	Absent	

Charles Webster, commenting on the role of magic in the making of modern science, noted that seventeenth century thinkers may have been exposed to the new mechanical philosophy, but they continued to uphold "the idea of harmony in nature, parallelism between the macrocosm and the microcosm, the pervasiveness of forces akin to sympathy and antipathy, the application of animistic explanations and hierarchies that bridged the gulf between the material and non-material world." He called these views "the rambling edifice of Neoplatonic and hermetic metaphysics," and observed that they "remained viable explanatory options which were actively drawn upon by forward-thinking thinkers through the seventeenth century."[15] This can also be said of Vesalius, who was never very "mechanistic" in his evocation of man the machine.

The late nineteenth century biographer Moritz Roth may have overstated the importance of Vesalius, [16] but then his work came out at a time when it was quite common for historians to highlight the unique achievements of heroic Renaissance individuals. The tone for this type of exaggeration was after all set in the mid-nineteenth century by Jacob Burckhardt, who wrote about individual genius and about the "national" genius of Italy itself. Sir William Osler considered the *Fabrica* to be the greatest medical treatise of all time. In *The Evolution of Modern Medicine*, for example, he wrote that "Two things favored [Vesalius] – an insatiate desire to see and handle for himself the parts of the human frame, and an opportunity, such as had never before been offered to the teacher, to obtain material for the study of human anatomy. Learned with all the learning of the Grecians and of the Arabians, Vesalius grasped, as no modern before him had done, the cardinal fact that to know the human machine and its working, it is necessary first to know its parts--its fabric."[17]

This viewpoint was reaffirmed by the leading Vesalian biographer of the twentieth century, C.D. O'Malley, who did not consider it particularly important to decide who had been the founder of modern anatomy: "Whoever may be designated the founder, it was Vesalius who made the foundation secure by his factual contributions and, more important, by his method of presentation and by the scientific principle he enunciated as fundamental to research..."[18] For his part, the historian of science Charles Singer wrote that the *Fabrica* "is not only the foundation of modern Medicine as a Science, but the first great positive achievement of Science itself in modern times."[19]

After the research phase of his life was over, Vesalius settled into the monotony of being Count Palatine and personal physician to the gluttonous, gouty Emperor, Charles V, whom he had so highly praised in the opening lines of his masterpiece. This frustrating new life, far from the pleasures of the university, serves as a reminder of the way that political power has sometimes sought to appropriate, control and smother original thinkers. Vesalius died in mysterious circumstances on the Greek isle of Xanthos, while returning from a pilgrimage to Jerusalem.

The question of whether Leonardo could have influenced Vesalius is an interesting one. In the early part of the twentieth century, scholars finally digested the original anatomical work of Leonardo. There was some speculation as to the influence Leonardo may have had on Vesalius,[20] although the general consensus was that direct influence on Vesalius could not be conclusively proven.

Leonardo was the greatest artist and anatomical illustrator of his day. Vesalius, a keen student of the history of anatomy, must have been familiar with the anatomical teachings of Marc' Antonio della Torre, director of the department of anatomy at Pavia who (according to Vasari) had used Leonardo as an illustrator in the classroom. Vesalius must have known of Luca Pacioli, the mathematician whose book *On Divine Proportion*, containing Leonardo's illustrations, was published in

Venice in 1509. Albrecht Dürer may have met Leonardo and have studied under Pacioli; Dürer certainly was a "Vitruvian" and imitator of Leonardo, as much in matters of proportion as of technique, who introduced Renaissance values to the Netherlands, from 1520 onwards – at a time when both Vesalius and the woodcut artist of the *Fabrica*, Jan Stephan van Calcar, would have been very receptive to new learning.

Leonardo's anatomical drawings were known in the refined company of the King of France and Cardinal Louis d'Aragon, and therefore of all the competent, competitive artists who might seek their patronage. King Francis I considered Leonardo the greatest man who ever lived, and therefore richly provided Leonardo with every amenity in a residence near Amboise, during the artist's declining years. This seems to have been a dream fulfilled for several Renaissance artists in search of a wealthy patron in a stable kingdom. Titian painted a portrait of Francis in 1539, from a medal by Benvenuto Cellini, and must have known that Francis had richly supported Leonardo. Cellini himself wrote an engaging and widely read autobiography, largely devoted to demonstrating that he alone was worthy to fill Leonardo's shoes at the Court of Francis.

There was another reason why Titian and Jan Stephan van Calcar, the Flemish artist in his workshop delegated to surpervise the woodcut illustrations for the *Fabrica*, may have been familiar with Leonardo's paintings and anatomical drawings. Titian's patron, Cardinal Ippolito de' Medici, the natural son of Leonardo's patron Giuliano de' Medici, the Duke of Nemours, had been painted by Raphael (in a group including Francis and Pope Leo X)[21] and was a great admirer of Leonardo and Michelangelo. Moreover, Ippolito de' Medici was the patron of Giorgio Vasari, who did a painting of the Cardinal concelebrating with Pope Clement VII (Ippolito's uncle) the wedding mass in 1533 of the king's son Henri d'Orléans to Catherine de' Medici, Ippolito's first cousin. Becoming the favoured artist of Ippolito de' Medici meant being a courtier familiar with all the environment, artists, subjects and ideas likely to interest the patron. The cardinal was well known for keeping a "strange court" including an exotic human menagerie.[22] Through Ippolito de' Medici, Titian got a lucrative commission in 1530 – to execute the portrait of Emperor Charles V.[23] In 1532, Titian painted the portrait of Ippolito de' Medici himself.[24] The subject of Leonardo's anatomical drawings may well have been raised during these exchanges. It is interesting to note that Vasari wrote in *Lives of the Artists* of his patron Cardinal Ippolito de' Medici, and of Jan Stephan van Calcar in the sentence immediately following – although this juxtaposition may have been coincidental.[25]

It has sometimes been assumed that humanism did not affect "natural philosophy" and medicine and how they were taught in sixteenth century Italy. But it is now more apparent than before that the humanist task of translating, editing and restoring classical texts was an enormously important one that gave a fresh impetus to the New Science – especially when combined with a critical approach to those texts themselves, in the light of experimentation and systematic observation.[26] In this respect, Vesalius was very much a part of the humanist tradition.

The first body of medical works from Antiquity to be taken up by humanists was the body of writings called the Hippocratic canon, attributed to Hippocrates of Cos, an elusive figure of the fifth century BC. Renaissance humanists sought to reconstruct the Hippocratic corpus, and to publish it. Shorter works began to appear in the 1470s, which led to the appearance of supposedly "complete" editions of Hippocrates in the 1520s. Several philologists studied Hippocrates, although somewhat uncritically. Anuce Foes of Metz, for example, devoted his life "to his practice and to Hippocrates. He was sustained by his belief that the best way to advance medical knowledge was to re-establish the Hippocratic text in its purity, to obtain as much of the Hippocratic wisdom as possible, and to apply it faithfully to the medical problems of the day."[27] He established a Greek-Latin edition of the Hippocratic corpus, but George Sarton found that the scholarly work of a practising physician such as Geronimo Mercuriali was more penetrating, although the encyclopaedic range of Foes' work has stood the test of time. The influence of Celsus was perhaps more direct, since his work was already encyclopedic, and written in Latin, which meant that no translation was required to print his work *De medicina* for a wider Renaissance audience. Galen, however, was far more influential in the Renaissance: he was well-known in Latin translation by way of Arabic, from the original Greek; the task of "decanting" Galen from medieval Arabic began in the thirteenth century; and in the late fifteenth and early sixteenth centuries there was a huge amount of activity in editing, retranslating and publishing Galen. In fact, there was something of a Galenic revival during this time, due to the work which philology and medicine played in establishing standard editions of Galen. One may mention in this respect such Renaissance author-editors as François Rabelais, and the Englishman John Caius, who, according to Sarton was "a good Hellenist, a man of great learning, presumably a good doctor and certainly a faithful defender of his profession and of his college... He had enough medical experience to make good observations (e.g., of the sweating sickness) and to recognize good observations in ancient writings. His editions of many Galenic treatises and his English translations of a few were carefully made and obtained a well-deserved popularity not only in England, but also on the continent." [28]

To Hippocrates, Celsus and Galen should be added the towering figure of the eleventh century physician Avicenna, who was translated into Latin in the twelfth century, and constituted the foundation of Greek-Arabic medicine for several centuries. Avicenna's *Canon* was printed a dozen times before 1511. [29]

An important part of the work of the physician in the Renaissance was to understand the classical texts of medical knowledge; to know Greek and particularly Latin well; and thus to bring together both a respect for learning and practical knowledge of the medical arts.[30]

The work of humanists in recovering classical medical knowledge was all-important. These humanists were sometimes practising physicians themselves. By pulling together, re-translating, editing and publishing the corpus of these works, they helped to standardize medical education and to give medical innovators, such as William Harvey, something to react to and overthrow. Moreover, completely new works, such as Vesalius' *Fabrica*, derived their character as well as their influence from that humanist attention to classical authors, from their attention to observation, from the fact they were printed, and from their rich medical illustrations.

Vesalius came from a medical family and some of his forebears had served the imperial and various noble courts as physicians. He grew up in Brussels as well as Louvain, in the years 1514-1533. He undertook medical studies in Paris from 1533 to 1536. Then he moved to Padua, a great center of medical learning in northern Italy, where he served as professor at the University from 1537 to 1542, undertaking many dissections at Bologna, and profiting from these years to prepare the *Fabrica*, and the abbreviated version abstracted from it, the *Epitome*. Vesalius then became personal physician to Emperor Charles V, in whose service he remained from 1543 to 1555.

The medical education of Vesalius provided him with the grounding in classical authors, which his anatomical observations would later call into question. Writing of his medical studies in Paris in the years 1533-1536, O'Malley noted of the University of Paris that "generally, but not always, the first year's courses dealt with those subjects we would call materia medica, pharmacy, and physiology; the second, with pharmacy, pathology, and surgery; the third, with physiology, materia medica, and pathology; and the fourth, with physiology, surgery, and pathology… The regent doctor, discoursing from his high chair, leaned heavily on exposition of ancient and medieval writers such as Hippocrates, Galen, Theophilus – *On urines* and *On the pulse* – Isaac – *De viatico* – Avicenna, Averroes, Avenzoar, Rhazes, and the precepts of the Salernitan school. Although these medical texts remained in use during the period that Vesalius was in Paris, gradually greater emphasis was placed upon the recovered

Greek classics of medicine."[31] The operative word here may be the word "recovered", since a big contribution of humanist medicine during the Renaissance was that it began to bypass Latin translations from Arabic translations of lost Greek original manuscripts, in order to establish ("recover") the original text and develop critical, accurate translations into Latin. Vesalius was very much a part of this movement. During his Louvain years (1536-1537), he sought to restore the *Paraphrasis* of Rhazes to its original state, purifying it of what he termed "barbarisms".[32]

Vesalius was well grounded in ancient and Arabic texts, but he was also conscious of having learned very little about human anatomy at the University of Paris. This tension between classical theory and anatomical practice is to be found throughout his life and works. As he wrote in 1546, three years after the *Fabrica* had been published, "Sylvius [his Paris professor], whom I shall respect as long as I live, always started the course by reading the books *On the use of parts* [by Galen], but when he reached the middle of the first book, the anatomical part, he announced that this was too difficult for us, just beginning our studies, to follow, and that it would be troublesome for him and for us. Therefore he omitted the subsequent books as far as the fourteenth and then read the following. As a result he completed a book in five or six days without ever calling our attention to the fact that Galen contradicts himself elsewhere, as he frequently does, and without indicating that Galen said things which are false. He brought nothing to the school except occasionally bits of dogs."[33]

One is left very much with the impression that Vesalius was frustrated by the uncritical gaze cast by Sylvius at the orthodoxy of Galen, for example, as well as the lack of opportunity for students like himself, to challenge that orthodoxy through anatomical demonstrations on human material. As we shall see, this conflict with Sylvius was to prove long lasting. It was particularly in Padua, that Vesalius had the opportunity to combine theory with practice. Here, anatomy was taught, standing over human cadavers. Here in the heartland of the Renaissance was a tradition of medical illustration that sought to reproduce accurately what the viewer actually saw. Here Vesalius first began to distance himself from the authority of Galen.

Padua was one of Europe's greatest centres of medical learning during the Renaissance. "At Padua and Bologna," Nancy G. Siraisi has noted, "universities that had been centers of medical instruction since the thirteenth century, a standard and highly traditional curriculum of lectures on set books was in the course of the sixteenth century supplemented and consequently reduced in importance by the expansion and development of private medical teaching and of public anatomical and botanical instruction. And anatomy at Padua in particular early produced very striking and widely celebrated scientific results in the shape of the achievement of Vesalius." At the same time, Padua was "still a notable center of Aristotelian natural philosophy," a tradition that embraced Avicenna, but tended to discredit Galen.[34]

Andrew Cunningham wrote of the 'Aristotle project' at Padua. By this he meant that method of investigation and explanation which Aristotle employed in his biological writings, where he considered a creature's life, its activities, its habits and its (other) parts.[35] Cunningham stated this as follows:

"This then is what I have in mind when I talk of the 'Aristotle project': an open-ended research programme on animals, devoted to the acquisition of true causal knowledge (*scientia*) on certain kinds of topics (not research 'problems'), such as parts, organs and processes, and employing a thought-through and consistent methodology and epistemology, a suitable technical vocabulary, and the like. And when I talk of such an 'Aristotle project' being practised in the late sixteenth century, I am referring to a deliberate and self-conscious attempt to model new anatomical research on this kind of view of Aristotle's own practice."[36] This view is a far cry from the devastating criticism made by Galileo of Aristotle's physics! But we are dealing with a different science.

Cunningham showed that Fabricius considered anatomy to be a branch of philosophy; consciously imitated Aristotle; studied many of the same research topics; and openly acknowledged the use of a similar method. Fabricius is not very well-known today. But his greatest Paduan pupil was Harvey, who stands as a compelling testament to the influence of Aristotelianism (and Renaissance humanism) on modern science.

The significance of Padua in the fifteenth and sixteenth centuries goes well beyond striking and celebrated scientific results, or a hypothetical Aristotle project. The University of Padua was the centre of Italian learning most directly implicated in the birth of the modern scientific revolution, which was fundamentally an Italian invention. Copernicus, Vesalius, Harvey, Gilbert, Descartes, Hobbes – all were obliged to sojourn in Padua in order to gain a grasp of the revolutionary teachings of Fabricius, Galileo and others. The example of Leonardo demonstrates that Padua did not *invent* the metaphor of Man the machine – Leonardo, if anything, was associated with Pavia. But Padua capitalized on the invention, incorporating it in a whole approach to study the "mechanisms" underlying the structure and functions of living organisms as well as the heavens.[37] By this means, Paduan scholars like Vesalius were able to use classical authorities as a written platform from which to inquire closely, by dissection, into the Book of Life, which was then interpreted using mechanical metaphors.

Vesalius had his own distinctive view of classical and Islamic authors. He referred repeatedly to Hippocrates, Aristotle, Galen and Avicenna, although never once mentioning Leonardo. According to Vesalius, Hippocrates was a "divine" figure in the history of medicine, to be distinguished from some of the medical quacks of the sixteenth century. Hippocrates "wrote most fully concerning the task of the physician and concerning broken bones, dislocated joints, and injuries of that sort."[38]

Vesalius did not find much to question or challenge in the Hippocratic corpus available to him. He sought to enhance the professional status of anatomy by referring back to one of the leading medical traditions of Antiquity. For example, in Heseler's lecture notes from Bologna in 1540, Curtius, the professor of medicine before whom Vesalius was to perform his dissections, is quoted as saying that "anatomy is also useful to the physician because Nature has great care of the parts of the body… Physicians ought to understand that Nature makes many things, even the smallest in us, and that Nature created no organ without purpose; for even if we do not perform all the operations, yet they support them. Therefore, we must not disregard any of these matters. Regarding anatomy, I shall propound to you a principle stated by Galen in *De usu partium*, I:c.18, which he has taken from Hippocrates' treatise *De alimentis*. According to the construction of the whole body, all the parts of the body are given to maintain, to perform and to fill the functions necessary for preserving the whole."[39]

Vesalius shared this popular Renaissance view. Unfortunately however, he noted, anatomy had fallen since classical times into disrepute, and knowledge of anatomy was no longer considered as important to the practice of medicine as it had been in Hippocrates' own day. In taking this position, Vesalius was very much a part of the humanist tradition, which promoted the revival of Hippocrates and Galen as a way of improving the knowledge of medicine in the early sixteenth century. Vesalius admired Hippocrates for his insight into the importance of anatomy, which explains with what passion he deplored the division, which had grown up since classical times, between medicine and anatomy. Indeed, Vesalius set up a stark contrast between ancients and moderns: "competent practitioners of the Hippocratic art, as contrasted with the impostors who do nothing but prescribe syrups, used to take great pains over the preparation of bones, whether single or linked together, for teaching purposes."[40]

Vesalius respectfully questioned the terminology used by Hippocrates – this was another feature of medical humanism, which consisted in questioning the assumptions of Greek, Latin and Arabic anatomical terms, and bringing some semblance of order to often contradictory and confusing terminology. In the book on bones, Vesalius translated "the ancient name acromion into Latin as *summus* *humerus*; but it is not always easy to work out what each author meant by this name. For the sake of the divine Hippocrates the word cannot be ignored, nor can a decision concerning its meaning be made in a flash; we must turn our attention away from syrups and juleps for a while and recognize that the divine pronouncements of Hippocrates on the subject of fractures and dislocations and similar disasters apply to us as well."[41] Moreover, Vesalius consistently backed up Hippocrates in points of detail, as when he approvingly quoted the passage "of the divine Hippocrates, that blows to the temples are most likely to produce unconsciousness…"[42]

Hippocrates had a dominant and unchallenged place in the Vesalian system. But the place of Aristotle was a far more ambivalent one. Was it Aristotle himself, or late medieval Aristotelianism? The question is not so easy to answer. Petrarch, it should be remembered, wrote that Aristotle was better than his translators and commentators.[43] This statement by such an influential early humanist had the effect of separating Aristotle from his late medieval disciples, and of pushing contemporary readers back to a closer study of Aristotle himself. In fact, Vesalius frequently acknowledged the significance of Aristotle, while attacking those among his contemporaries who, in his view, falsely interpreted or unquestioningly accepted him.

It has occasionally been assumed that Aristotelian philosophy was in decline from the fifteenth century. However, this view has now been discredited. In the sixteenth century, thanks to humanism and printing, Aristotle actually was far more widely known and in more accurate editions and original classical commentaries than he had been in, say, the fourteenth century. Finally, while it may be tempting to conclude, with Galileo, that the "New Science" owed nothing to scholastic traditions and indeed developed in opposition to them, there does not now appear to have been such a clear break between scholasticism and Renaissance science. Andreas Vesalius and William Harvey openly acknowledged their debt to Aristotle, whether to the *Movement of Animals*, *Parts of Animals*, *Progression of Animals*, *Study of Animals* or to the very centrality given to the human heart;[44] even in seeking to reject or replace Aristotle, Francis Bacon (through the *Novum Organon*) and Thomas Hobbes showed that they were coming out of the medieval strain of Aristotelianism. All of these scholars were humanists in their own way. Hobbes was also a nominalist, in direct continuity with scholasticism, which itself grew out of Aristotelianism.

The relationship of Vesalius with Aristotle is a complex one, since he owed a debt to Aristotle's encyclopaedic range of interests in natural philosophy and something of his methods, while forcefully rejecting the details of many Aristotelian theories.

Aristotelianism was not foreign to and outside of the early modern scientific revolution. On the contrary, Aristotle's works covered physics, chemistry, biology, zoology, botany, psychology, political theory, ethics, logic, metaphysics, history, literary theory and rhetoric. He practically founded biology and zoology as distinct sciences, and as such may be considered to influence these fields of study even to this day. And in this respect, at least, Vesalius owed a debt to Aristotle, whose programme of describing the phenomena of nature was truly exhaustive.

It would be misleading to claim that Aristotle dominated science for two thousand years, until being dethroned in the seventeenth century. Various traditions kept Aristotelianism current from the fourth century BC onwards. In the early

Christian era, the Neoplatonist Porphyry sought to harmonize Plato and Aristotle – and indeed up till the sudden explosion of Aristotle on Latin Europe in the thirteenth century, Aristotle was known largely by means of Neoplatonism; interest in Aristotle was revived during the Byzantine scholarly renaissance of the ninth century, following which an Aristotelian Academy was set up in Constantinople in the eleventh and twelfth centuries; the new encyclopedic approach developed at this academy eventually carried over into Renaissance Italy in the fifteenth century, with the migration of leading Greek scholars there at the fall of Byzantium. Meanwhile, leading Islamic scholars such as Avicenna in the eleventh century and Averroes in the twelfth erected Aristotelian systems, which enabled them to develop philosophical doctrines quite at variance with Aristotle, such as the mortality of the individual soul, the eternity of the world and the existence of a single Mind for the whole human race. It was only in the thirteenth century that the corpus of Aristotle's works became widely available to Latin readers, many in flawed translations from older Arabic versions of the Greek original. By means of these translations, Aristotle's physics, cosmology and metaphysics began to attract notice. In the thirteenth century, St. Thomas Aquinas set out to reconcile aspects of Aristotle with Christianity in his *Summa Theologica.*

By the Renaissance, when Vesalius was flourishing, Aristotelianism had become anchored as a philosophical orthodoxy in the universities, and this was something with which Vesalius definitely had to contend. According to Paul Oskar Kristeller, beginning in the thirteenth century, "Aristotle was not studied as a 'great book', but as a textbook that was the starting point for commentaries and questions and supplied a frame of reference for all trained philosophical thinkers even when they ventured to reinterpret him, or to depart from his doctrines, according to their own opinions. The Aristotelianism of the later Middle Ages was characterized not so much by a common system of ideas as by a common source material, a common terminology, a common set of definitions and problems, and a common method of discussing these problems."[45]

This approach to exploring and discussing philosophical problems was widely adopted in Latin Europe, yet there were many medieval philosophical positions. Kristeller noted that fourteenth century advances in logic and natural philosophy (science) were partly attributable "to the Aristotelian, and more specifically, to the Occamist school of Paris and Oxford."[46] In Renaissance Italy, humanism greatly encouraged the study of classical texts, including Aristotle, so that "as far as Italy is concerned, Aristotelian scholasticism, just like classical humanism, is fundamentally a phenomenon of the Renaissance period whose ultimate roots can be traced in a continuous development to the very latest phase of the Middle Ages."[47] In addition, the Paduan school of Aristotelianism made a strict distinction between philosophy or reason, and faith or religious authority, stressing meanwhile the importance of rational argument and sense perception or experience. "At the same time, the related problem of immortality became the center of discussion through a famous and controversial treatise of Pomponazzi, who rejected the unity of the intellect but notes that humanism did a great service to Aristotelianism, by throwing its philological resources into the purification and renewal of the Aristotelian corpus of works. The improved understanding that resulted from the new editions in turn made sixteenth century readers more critical about the Stagirite. On the other hand, Aristotelianism made a solid, though largely unsung contribution to the Scientific Revolution, by establishing a methodology.[48]

A study of philosophy – and generally Aristotelian philosophy – was an indispensable part of the medical curriculum in late medieval and Renaissance universities. The key passage of Aristotle was in *De Sensu et Sensato*, where he wrote that "It is further the duty of the natural philosopher to study the first principles of disease and health; for neither health nor disease can be properties of things deprived of life. Hence one may say that most natural philosophers, and those physicians who take a scientific interest in their art, have this in common: the former end by studying medicine, and the latter base their medical theories on the principles of natural science."[49] Such a pedagogical unity between philosophy and medical studies, which themselves were based on a combination of tradition, classical texts, observation and experiment, gave to Aristotelianism an important role in the development at least of biomedical science.

The main features of Aristotle's scientific thought of interest today were his first-hand observations on living things. He recorded the life and breeding habits of some five hundred forty species; embryological investigations of the developing chick; accounts of the development of octopuses and squids; anatomical investigations of mammals; attention to the heart and vascular system; and the use of scientific diagrams to accompany his texts. He was surely more "scientific" than Plato, in the sense that he made actual observations, even though he threw them hodgepodge into a "common-sense" system that was highly speculative.

From Aristotle, Vesalius gained teleological beliefs on the rationality of man and the functionality of his body. According to Heseler's lecture notes, for example, Curtius lectured in Vesalius' presence on the Aristotelian view that "man is participant of divinity, the noblest entity such as God (for God created man in his own image). It is because man by his intelligence belongs to God, that man has upright stature and not according to the higher seat of the elements of heaven, as if man's parts should be arranged proportionally according to the seat of the elements, just as the fire, which is light, is above the other elements, and man therefore should have his head elevated upwards. The earth, on which we live, is in the centre and in the middle of the universe, and the revolving heaven surrounds the earth with the elements; and opposite our arctic pole is our Antarctic pole… And man is called 'Microcosmos', because as the world is arranged, so is man, etc."[50] This was the value system of the time, and everything indicates that Vesalius accepted this value system, as we have mentioned in other parts of this chapter.

Aristotle likely undertook no human dissection, but dissected and described in remarkable detail the lower animal forms, which he then unfortunately sought to project onto the human body. Aristotle also underestimated the significance of the brain, while ascribing to the heart huge allegorical importance as the sovereign of the human body. In points of detail, Vesalius was determined to hold up the age-old anatomical theories of Aristotle to the test of experiment, and to debunk them wherever necessary.

The main problem Vesalius found with Aristotle was his tendency to develop theories on human anatomy by analogy with animals. As a result, Aristotle strayed away from experimentation and observation, which characterized his work on lower animals, to the realm of speculation about humans. For example, Vesalius objected that "the femur, in birds as in horses and pigs and other quadrupeds, deceived Aristotle (and Galen in Book III of *On the Function of the Parts*) because in these the femur is not visible as it is in man; but I must keep for the appropriate place the inaccurate information which Aristotle handed down to posterity in his book *On the Common Movement of Animals* because of his ignorance of the femur and humerus in quadrupeds and birds."[51]

There are occasional references in the *Fabrica* to errors committed by Aristotle. For instance, "of twenty skulls found in cemeteries, you would be unlikely to find one whose frontal bone is divided. Nor does there seem to be any difference between men and women in this respect, even though Aristotle says otherwise and thus produces a clear error in his account of the sutures."[52] Moreover, Vesalius pointed out, Aristotle had assumed that men and women had a different number of teeth – a view apparently based on speculation rather than observation.[53] Perhaps the most significant error that Vesalius found in Aristotle concerned the humerus: "My assertion that there is so little difference between humans and quadrupeds in respect of this part of the humerus and the elbow joint will, I am sure, surprise the followers of Aristotle and all those who, in their writings on the movement of animals, have relied on his authority and particularly on what he said in his treatise *On the Common Movement of Animals*; among their number are Galen (in Book III of *On the Function of the Parts*), Pliny, and among many others, our own Erasmus of Rotterdam in his dialogue on the game of dice (not an anatomical treatise). I choose a single point for comment. Aristotle and those who follow him say that flexion takes place in one direction in man and the opposite direction in quadrupeds; our flexion, they say, is forward, and theirs is backward. This is not so. In fact, Aristotle deprives quadrupeds of one bone, the humerus; what he thinks is the joint between their arm and forearm bends just as ours does. But Aristotle failed to notice the humerus, and also the femur, in these animals and in birds, perhaps because it is concealed within their body whereas ours is not."[54]

But Vesalius did not dismiss the observations of Aristotle out of hand: he insisted on their value as part as comparative anatomy, rather than of human anatomy itself: "It is as a result of our efforts, which were so successful from the outset, that skeletons are to be seen today in various universities. In addition to these, we have not set down for the benefit of others the method of articulation, not to mention the illustrations, which follow. What more, then, does the student of medicine and natural philosophy need? In fact, such a student should have to hand, not merely the human bones but also those of apes and dogs (for Galen's sake) and those of birds, fish and reptiles (for Aristotle's) – I mean either complete skeletons or disarticulated collections. That is, of course, unless we imagine that this branch of philosophy has no relevance whatever to us and are content to ignore anatomy and fill our purses by deluding mankind with our syrups."[55]

The relationship of Vesalius with Aristotle was ambivalent. He had much the same relationship with Galen, whom he simultaneously admired and deprecated. In the introduction to this work, we showed how Galen's work on the usefulness of the parts played a key role in setting the stage for the early modern view of man the machine. Vesalius shared with Galen the fundamental teleological view that the surprising functionality of organs of the human body could be explained by their being a part of the Creator's design. Many passages in the *Fabrica* on the design and craftsmanship of bodily organs could have been taken literally out of *On the functions of the parts*. Time and again, passages of Galen's celebrated work were scrutinized in the *Fabrica*. Vesalius considered Galen to be "that rare miracle of Nature and most painstaking interpreter of her works [who] in expounding the construction of the parts of the body, nowhere demands as erudite, ingenious, and industrious a hearer as when he describes the movements of the head and how it is joined to the two top vertebrae."[56]

Yet where Vesalius found no fault with Hippocrates, and expressed mitigated admiration for Aristotle, he found serious problems in Galen. In writing the *Fabrica*, Vesalius was well aware that his criticism of Galen, on certain points, would get him into trouble. For example, Vesalius objected to Galen's theories on the upper and lower jaw in humans; he attacked Galen's view that lateral flexion and rotation occurred through the lifting and subsequent separation of the surface of the atlanto-occipital joint on one side or the other; he noted Galen's error in assuming that the sternum of apes and humans was similarly constituted; he attacked Galen's view that the *vena cava* originates in the liver rather than in the heart; he also challenged the Galenic view that the liver and lung each consisted of five lobes; and finally he denied outright that the *rete mirabile*, a minute network of vessels, existed at all.

Underpinning these individual arguments was the fact that Vesalius realized Galen had written abundantly about human anatomy without ever having dissected a human cadaver: "I am quite certain," he wrote in the *Fabrica*, "on the basis of the art of dissection as now reborn combined with a careful reading of Galen's works and many textual restorations thereof for which I make no apology, that he himself had never cut open a human body and furthermore that, deceived by his apes (although he did chance upon two human skeletons) he frequently and quite wrongfully finds fault with the ancient physicians who actually did their training by dissecting human material."[57]

Vesalius was occasionally brutal in his attacks on Galen. In Book II of the *Fabrica*, for example, he wrote that Galen had been misled by a "figment of his imagination" in writing of the flexion of the human thumb, given that he was "deluded by his apes" and in this respect was accompanied in his errors "by a full chorus of professors of anatomy."[58]

Vesalius was still more passionate when it came to criticizing Galen's successors who had, in his view, perverted, oversimplified or merely misunderstood Galen's teachings. For example, Vesalius wrote, "the carelessness and almost unbelievable ignorance of Galen's successors in their dissections have been noted many times in previous chapters and will have to be noted again hereafter in this and following books; and this is no less the case in respect of their description of the sacrum and the coccyx. It seems to me that the words *inadequate* and *superficial* could with justice be applied to the anatomical knowledge of those who merely handed on to posterity the descriptions of Galen...."[59] The clear implication of such a position is that the science of anatomy was a self-correcting enterprise, one that should not be grounded in immutable, dogmatic beliefs as reflected in ancient texts, but one that should be based on a critical reading of those texts – in the light of the tireless, methodical observation of nature – "the book of life" – itself. Only part of the weakness of the Galenic position could be attributed to erroneous or inadequate translation from Greek into Latin.[60]

As O'Malley noted: "Galen's word was subject to doubt in respect to osteology. Such doubt, however, was not a consistent policy and there would be no further dissection before Vesalius would develop the principle of refusing to accept past authority until his own researches had proved it true. But the beginnings were found here. Although Galen admitted in his writings that he was restricted to non-human materials – a fact frequently overlooked in the sixteenth century – the important thing was to free anatomy from its dependence upon the idea of authority or, to put it another way, to make the study of human anatomy dependent solely upon dissection and observation on human specimens."[61]

As a result, when Vesalius used the Galenic system as a platform from which to test Galen on countless points of detail, he placed himself in conflict with many of the leading anatomists of his age. The best place to gain a sense of the conflictual position of Vesalius on the subject of Galen is not in the *Fabrica* – it is in Heseler's lecture notes. An extraordinary passage in the lecture notes shows how Curtius and Vesalius quarrelled over Galenic orthodoxy. The passage is worth quoting at length, since it shows the conflict between medicine and anatomy in his day, as well as the controversy Vesalius provoked by defying conventional wisdom through the demonstration of verifiable facts during a dissection of two cadavers.

Curtius and Vesalius were arguing about veins running alongside the ribs: "Curtius replied: I am no anatomista, but there can be also other veins nourishing the ribs and the muscles besides these. Where, please, Vesalius said, show them to me. Curtius said: Do you want to deny the ducts of Nature? Oh!, Vesalius said, do you want to talk about things not visible and concealed. I, again, talk about what is visible. Curtius answered: Indeed, I always deal with what is most obvious. Domine, you do not well understand Hippocrates and Galen concerning this. Thus, with much quarrel and scoffing they attacked each other, and in the meantime they accomplished nothing. Vesalius, said: D. Doctor, I beg your Excellency not to think me so unskilled that I do not know and understand this. Smiling Curtius said: Domine, I did not say so, for I have said that you are excellent, but I have rejected the wrong explanation of Hippocrates implying that Galen should have erred in this. Vesalius replied: I acknowledge that I have said that Galen erred in this, and this is evident here in these bodies, as also many other mistakes of his..."[62]

This passage is particularly interesting in that it contrasts theoretical medicine, appealing to the traditions of Hippocrates and Galen as then understood, with the revolutionary practical anatomy of Vesalius, appealing to sense experience. It encapsulates the whole dilemma that the new scientific method posed for older knowledge.

Vesalius devoted considerable attention in the *Fabrica* to the perfection of God's creations, to the proportions of the human body, as well as to the functionality of every organ and limb of that body, which underscored the mastery and wisdom of God the workman. He drew the perfectly-proportioned picture of an admirable, marvellous, functional and brilliantly-designed creation of God's, a living workshop, a being containing processes, moving parts, ropes and pulleys, and a protective shell, which contains "the lodging-house and instrument of the immortal soul." In this respect, Vesalius was heir to a rich heritage going back at least to Aristotle and Galen, for whom the body had been well designed by the Creator or Demiurge and consisted of parts marvelous for their functionality. As we shall see, however, he modified this view from classical Antiquity, adapting it to the *Zeitgeist* of his age.

Vesalius expressed his vision of man the machine in rhetorical and political terms, implying in the preface to the *Epitome*, dedicated to the son of Charles V, the future Philip II, that a wise Emperor may see an interest in elevating knowledge of God's instrument – the human body: "And when your spacious spirit shall one day rule the whole world, you may perhaps at times consider it pleasant to be acquainted with my work and to regard it as a situation wretched and unworthy of the greatest Emperors, Kings, and Consuls, that in the pursuit of studies so varied, the harmony of the human body which we shall publish to the world should lie constantly concealed; that man be completely unknown to himself; and that the structure of instruments so divinely created by the Great Artificer of all things should remain unexamined: since it is by the function of these instruments that those things we look upon as most, and almost solely, important are brought to pass."[63]

Vesalius admired the provident wisdom of the Creator and the brilliant skill of Nature, which he likened to a manufacturer.[64] He alluded to the Biblical account of Creation, without either accepting or rejecting it, in his explanation of the manufacture of the human body: "In the beginning, the Author of the human fabric fashioned two human beings for the conservation of the species in such a way that the male should furnish the primary principle of the infant, the female indeed should fitly conceive it and should nourish the little child arising from this principle as she would nourish some member of her own body until the child should become stronger and could be given forth into the air which surrounds us. Both male and female received instruments suitable for these functions and peculiar to them alone."[65]

Vesalius suggested that the human body is perfectly coherent – in other words, well planned. It is regulated by three principles, "the first is surrounded by immovable bone with no muscular interstices, the third by muscle, and the second by something between these, consisting partly of bone and partly of muscle."[66] If the human body has these particular characteristics, it is by divine design, a design that on close analysis proves to have been correct,[67] for example in the fact that "the thumb is beautifully positioned."[68] In discussing cartilage, he wrote that "the wise Creator of the world, realizing how important the function of cartilage in joints would be, not only provided bones in mutual contact with smooth and slippery cartilage like a sort of crust in the manner described above, but in some joints in addition to these cartilages provided a third."[69] Later on, he wrote of the arthrodia that "it is as if Nature constructed this type of articulation in a simple joint where she had decided that the bone would move scarcely at all."[70] In fact, the *Fabrica* is full of references to the intentions of God and the purposes of Nature. We read of the head having been so formed for the sake of the eyes;[71] it is the proper "domicile provided by Nature for the Brain … so the provident Creator of everything did not entrust its protection solely to skin and areas of flesh (as in the abdomen) or to bones spaced well apart."[72] We read "the infinite Creator of the world is greatly to be praised for having endowed the teeth alone of all the other bones with any faculty of sensation worth mentioning."[73] Moreover, "if the Creator of the world had paid such attention to resistance to injury and had subordinated the value and importance of all other aims in the fabric of parts of the body to this one, he would certainly have made a single backbone with no joints, as someone constructing an animal of wood or stone…"[74] Then again, "Nature did not make the head move around and bend sideways on the first vertebra."[75] In the case of the joint between the bodies of cervical vertebrae, Vesalius was positively lyrical in his praise of God: "let us unreservedly admire the constructive artistry of God, who made simultaneous provision with such incredible skill for both security and multiple mobility."[76] The joints in the fibula and tibia "show how cleverly Nature designed all this for the movements which we make with our legs; no one can contemplate them without being lost in admiration for our Creator, and without immediately realizing how the alteration of just one of the features we have described would ruin the whole structure."[77] Finally, "the reason why the Creator of the world supplied the fingers and toes with nails was in order to strengthen them."[78] Similar sentiments are expressed in the *Epitome*, for example where Vesalius said "the great Creator of all things has carefully devised that man should live as long as possible and that his species, never failing, should continue to exist forever."[79]

Vesalius led the reader on, not only by means of medical illustration, but also by means of mechanical metaphors – mechanical, we should note, in the sense of Renaissance technology, as he returned each time to the wonders of God's artifice and manufacture. For example, "when the human bones and cartilage are stripped of their flesh and then assembled together there is no better analogy to describe them than that of the framework of a hut which has been raised but not yet finished off with branches or earth."[80] Cartilage functions as "glue".[81] The human body's structure of bones "could not have been formed from one continuous bone like a marble statue."[82] Ossicles in the ear resemble an anvil and a hammer.[83] The skull is a fortification, a protecting rampart defending the brain;[84] it is a helmet, an immovable wall.[85] The breastbone is like a sword.[86] The middle of the lower end of the humerus, "where can be seen a depression with swellings on either side, the whole resembling the sheave of a pulley around which the ropes turn."[87]

According to Vesalius, the body was a marvel wrought by God.[88] The body is an "instrument of the immortal soul, a domicile that, because in so many respects it corresponds exactly to the universe, was aptly known to the ancients as the microcosm."[89] In the *Epitome*'s canons of proportion, we also see clearly that Vesalius believed there was a standard or ideal form in the human body, which it was the work of anatomists to appreciate.

But this did not mean taking *The Bible* at face value: he challenged the idea in *Genesis* that Eve was created from Adam's rib: "the popular impression that men lack one rib on the left side, and hence that women have one more rib than men, is nonsense, despite the story recorded by Moses in *Genesis 2*…"[90] Likewise, Vesalius mocked the miraculous occult powers attributed by black magicians and philosophers to "a bone, similar in shape to the chickpea, which resists all decay, which remains hidden like a seed in the ground after death, and which will reproduce the person at the last day of judgment."[91]

Yet Vesalius attributed traditional allegorical values to organs of the body. In the *Epitome*, for example, the liver is called "the tinder of the natural or nutritive faculty or, as Plato said, of the part of the soul which desires the pleasures of love, food and drink." The brain meanwhile is "the seat of the animal and the principal faculty" and lies in the skull, which is of perfect spherical shape. Finally, "the principal seat of the soul is assigned to the head; this third cavity of the body is the seat of the brain and the storehouse of the animal spirit."[92]

Was Vesalius merely combining Aristotelian teleology and the Galenic instrumentality of the body, with some colourful appreciations of contemporary Renaissance technology? Or was he doing something more than that? Was he influenced by Leonardo (via Dürer)? Could he have developed an original vision of the human body, which would fundamentally discredit the notion of a created organism and elevate the new idea of a structure containing thousands of intricate mechanical functions and processes?

In recent years, several new interpretations have been made of the Vesalian legacy. David F. Channell, for instance, wrote that the interest Vesalius showed in the body as machine grew out of a fascination with automata: "The Italian [*sic*] physiologist, Andrea Vesalius, discovered through dissection that much of Galen's physiology was wrong, and published his findings in 1543 in the work *On the Fabric of* *the Human Body*. Like other areas of thought, medicine and physiology became caught up in the emerging mechanical worldview. After Vesalius's work, it was clear that the old model of physiology was wrong and, for many scientists and philosophers, automata provided a new model for organic life."[93] As interesting as this view may seem, Descartes would later directly refer to automata, but there is no real indication that Vesalius drew a link between automata and the human body, unless one includes as "automata" the wood or stone carvings of animals Vesalius alluded to. Channell here betrayed confusion over geography, and also attributed to Vesalius some responsibility for what some of his readers following a century later may or may not have believed for other reasons.

Another very different view is that of Jonathan Sawday, for whom "the period between (roughly) 1540 and 1640 is … the period of the *discovery* of the Vesalian body as opposed to the later *invention* of the Harveian or Cartesian body. Guiding the followers of Vesalius was the belief that the human body expressed in miniature the divine workmanship of God, and that its form corresponded to the greater form of the macrocosm… The interior of the body began to take on most of its modern features: Eustachius mapped the ear, Fallopius the female reproductive organs, Realdus Columbus and Fabricius of Aquapendente the venous system, and Michael Servetus the pulmonary transit of the blood. Like the Columbian explorers, these early discoverers dotted their names, like place-names on a map, over the terrain which they encountered."[94] This somewhat heroic view of medical history is at least plausible, if one considers that the anatomical diagrams of Vesalius are sometimes called "topographical" – in an unconscious allusion to the microcosm of the human body!

In the view of Lewis Mumford, Vesalius was a brilliant investigator of anatomy by means of dissection of human cadavers, who inadvertently set in motion the transformation of the God of Life into the Egyptian God of Death. "As the practices of the megamachine became more embedded in Egyptian society..." Mumford wrote, preparing to make a huge multi-thousand-year leap in logic, "the cult of Osiris transferred attention from life to an after-life, fastening on the drama of death and bending its efforts toward the preservation of the body in mummified form... This turned the God of life, which includes death, into a God of death, preparing for a mock life..." In the next paragraph, Mumford suddenly took flight: "The great step in putting biology on a scientific basis, comparable to that made by Copernicus, was taken by Andreas Vesalius in his systematic description of the human body, as disclosed by post-mortem dissection. Many vital truths were learned by this about the structure, the composition, and even the functional relations of the living organs; and in time this was further buttressed by microscopic and chemical examination of equally dead tissues.... The fact is that organic models yielded to mechanical models in interpreting living phenomena mainly for two reasons: organisms could not be connected to the power complex until they were reduced, in thought even more than in practice, to purely mechanical units..."[95] As is sometimes the case with Mumford's prophetic flights of rhetoric, there may be some inspired intuition in this passage, but unjustified assumptions are made. Vesalius was a spiritual person of the sixteenth century, who would have been astonished that his public dissections in Padua should be associated by a twentieth century New Yorker with an Egyptian god from the time of the Pharaohs!

According to Charles Singer, Vesalius, as a child of the Renaissance, was simultaneously an artist with a vision not only of particular bodily organs, but of the entire fabric of the body itself – a humanist starting from the platform of the medical books of Antiquity, who explored the book of life itself – and a naturalist determined to systematically investigate the workings of such a marvellous creation of Nature as the human body.[96]

It is important that any conclusion be rigorously supported.[97] As an artist, humanist and naturalist, Vesalius and Jan Stephan van Calcar, Titian's supervising illustrator, must have known some part of Leoardo's work, at the very least through Albrecht Dürer. Vesalius urged that medical theory and anatomical practice be joined together. He insisted that medical science be based on experience rather than exclusively on traditions, which themselves had often been based on speculative reasoning. And he established that human not animal dissections should form the basis of knowledge of surgery and medicine. As such, he was one of the leading figures providing the impetus to the early modern scientific revolution. In debunking the one thousand four hundred year authority of Galen's system of physiology and medicine, Vesalius became a sort of new Galen. Although not widely read today, his authority remains undiminished.

Vesalius did not seek to "reduce" the body by making metaphorical allusions to a wide variety of machines or mechanisms; he sought rather, in using such metaphors, to uncover the hidden intentions or reason in the mind of the Creator or

Supreme Artificer, in so devising the body that its highly instrumental organs were perfectly adapted. In other words, there was a profoundly spiritual basis to his vision of man the machine. It is important to note that not just Renaissance views of technology but also Presocratic, Aristotelian, Neoplatonic and Vitruvian metaphysical and aesthetic traditions came together in the work of Vesalius. He opened the "book of life", described what he saw in words, and had drawn – from sight – elaborate exploratory charts or maps as it were of the microcosm of the human body, based on close observation, during public dissections. The only way his public could understand this utterly new inner world was by means of cadavers and allusions to technology, both supported by medical illustration as well as metaphors drawn from Renaissance Neoplatonism. In this respect, at least, Vesalius resembled Leonardo.

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[1] A good critical source on the life of Vesalius is C.D. O'Malley, *Andreas Vesalius of Brussels: 1514-1564* (Berkeley, 1964).

[2] For example, in Chapter XVI of Book VI of the *Fabrica*, as translated by C.D. O'Malley as an appendix to the above-mentioned biography, Vesalius notes: "Also, press the lobes of the lung with hands so that their number, site, and shape may be investigated, and finally you may know that no part of the lung in man supports the vena cava which exists between the diaphragm and the heart... These things which will wholly contradict the conclusions of Galen have been taken from the completely trustworthy book of man..." *Ibid.*, p. 363. In a passage of Book II of *On the Fabric of the Human Body,* Vesalius noted that a particular observation of his was "quite different from the account given by Hippocrates, Galen and the other experts in anatomy. Yet my opinion is supported not merely by cutting but by reason itself..." O'Malley, *op. cit.*, p. 293.

[3] We are here using the magnificent translation of Books I and II of *On the Fabric of the Human Body*, recently published in San Francisco. When completed a few years from now, this will be the first-ever complete English translation of the work. Andreas Vesalius, *On the Fabric of the Human Body*, 2 vols., translated by (San Francisco, 1997-1999). Hereafter referred to as *Fabrica.*

[4] Andreas Vesalius, *The Epitome of Andreas Vesalius*, translated by L.R. Lind (Cambridge, Mass., 1969). Hereafter referred to as *Epitome.*

[5] From an article by Charles Singer in the *Times Literary Supplement*, quoted by Sherwin B. Nuland in *Doctors: the Biography of Medicine* (New York, 1988), pp. 63-4.

[6] *Epitome*, p. 41.

[7] Charles Webster, *From Paracelus to Newton: Magic and the Making of Modern Science* (Cambridge, 1982), p. 15.

[8] Copernicus, *On the Revolutions of Heavenly Spheres*, p. 508 (Chicago, London and Toronto, 1952).

[9] *Fabrica*, Book II, p. 102.

[10] An important work on printing during the Italian Renaissance, has been Elizabeth Eisenstein's *The Printing Press as an Agent of Change* (volume II, Cambridge, 1979). This work is an interesting corrective to the Burckhardtian view that individual geniuses, through the exertion of sheer willpower, transformed the world-view of early modern Europe. Eisenstein showed that a key factor in the development of early modern science was the emergence of the printing press.
[11] In the words of Giorgio Vasari, "Now, although many have been with Tiziano in order to learn, yet the number of those who can truly be called his disciples is not great, for the reason that he has not taught much, and each pupil has gained more or less knowledge according as he has been able to acquire it from the works executed by Tiziano. There has been, among others, one Giovanni [Jan Stephan van Calcar], a Fleming, who has been a much-extolled master in figures both small and large, and in portrait marvelous, as may be seen in Naples, where he lived some time, and finally died. By his hand – and this must do him honour for all time – were the designs of the anatomical studies that the most excellent Andrea Vessalio caused to be engraved and published with his work." *Lives of the Painters, Sculptors and Architects*, vol. 2, p. 798. Kenneth Clark noted in *The Nude: A Study in Ideal Form* that it has been speculated that Titian made a satirical woodcut of a monkey, in connection with "the famous controversy on the nature of human anatomy in which Vesalius had accused Galen of describing the structure of an ape, not a man." *Op. cit.*, p. 405, n. 260.
[12] *Fabrica*, Book I, pp. li-lii.
[13] *Ibid.*, Book II, p. 148.
[14] *Ibid.*, vol. I, p. lvii.
[15] *From Parcelsus to Newton: Magic and the Making of Modern Science*, pp. 68-9.
[16] Moritz Roth, *Andreas Vesalius Bruxellensis* (Berlin, 1892).
[17] Sir William Osler, *The Evolution of Modern Medicine* (New Haven, 1921), p. 146.
[18] O'Malley, *op. cit.*, p. 1.
[19] Charles Singer, *A Short History of Anatomy & Physiology from the Greeks to Harvey*, p. 121. Hereafter referred to as *A Short History*.
[20] Singer noted "it has been mooted whether Leonardo's figures may not have affected Vesalius. So far as direct influence goes, the answer is in the negative. But the atmosphere created by Leonardo was not wholly lost, and there are even instances in which the actual mode of representation adopted by Vesalius bears some resemblance to that of Leonardo." *A Short History*, pp. 92-3. Similarly, Elmer Belt wrote: "It is highly unlikely that Vesalius ever saw the anatomical works of Leonardo. What tremendous benefit would have been produced had this immense genius been able to stand on the shoulders of Leonardo instead of at the same level as the giant who had preceded him!" A. Koyré (ed.) *Léonard de Vinci et l'expérience scientifique au seizème siècle*, p. 224, our translation. Finally, we may mention in this respect that the physician Girolamo Cardano saw Leonardo's unpublished treatise on anatomy: "In his *De subtilitate*, after remarking that a painter is at once a philosopher, architect and dissector, he continued, 'for proof there is that remarkable imitation of the whole human body which [I saw] many years ago, by Leonardo da Vinci and of Florence, which was almost complete; but the task required a great master and investigator of nature such as Vesalius'. Apparently Cardano the physician immediately recognized the non-systematic nature of the work." Charles D. O'Malley and J.B. de C.M. Saunders, introduction to *Leonardo on the Human Body*, p. 33. The most asontishing feature of these scholarly comments is that they ignored the huge, direct influence of Leonardo on Dürer, who in turn greatly influenced Netherlandish and other Renaissance artists, through his masterworks and publications.
[21] Vasari, *Lives of the Painters, Sculptors and Architects*, vol. I, p. 735.
[22] Burckhardt wrote: "Even human menageries were not wanting. The famous Cardinal Ippolito Medici, bastard of Giuliano, Duke of Nemours, kept at his strange court a troop of barbarians who talked no less than twenty different languages, and who were all of them perfect specimens of their races. Among them were incomparable *voltigeurs* of the best blood of the North African Moors, Tartar bowmen, Negro wrestlers, Indian divers, and Turks, who generally accompanied the Cardinal on his hunting expeditions." *The Civilization of the Renaissance in Italy*, pp. 151-152.
[23] Arthur Stanley Riggs, *Titian the Magnificent* (New York, 1946), p. 174.
[24] A delightful description of this painting, executed in 1532, was made by Ludwig Pastor: "The Cardinal, who had always lived in the most secular manner, now assumed the Hungarian dress; he has thus been painted in a masterpiece of Titian's, now one of the ornaments of the Pitti Gallery. A robust figure clad in a reddish-brown garment with gold buttons; on the head a red biretta with

peacocks' feathers; the left hand grasps a scimitar, with the right he rests a Hungarian mace upon his knee." *The History of the Popes* (London, 1891), vol. 10, p. 200.
[25] Vasari, *op. cit.*, vol.II, p. 863.
[26] George Sarton demonstrated to what extent Renaissance humanists recovered classical texts on medicine. But he also pointed out that the humanists interested in medicine were not merely philologists. Moreover, because of two new features, namely, "the production of standard texts and of standard illustrations … the twin inventions of typography and engraving may be said to have changed the intellectual face of the world. These inventions open the Renaissance, and their systematic use during the period 1450-1600 differentiate that period from the Middle Ages essentially." *The Appreciation of Ancient and Medieval Science During the Renaissance* (Philadelphia, 1955), p. 167.
[27] *Ibid.*, p. 11.
[28] *Ibid*, p. 31.
[29] In the view of Sarton, "What astonishes one with regard to the Latin incunabula [of Avicenna] is not only their number but also the number of printers who were in competition. At the present time a work of such size could hardly be printed at all; it certainly could not be printed on a commercial basis. In the fifteenth century, however, there were presumably so many potential buyers of that medical bible that many printers were trying to satisfy them."*Ibid.*, p. 42.
[30] Yet, for Sarton, "the fact that the learned doctors attached more importance to ancient and to medieval medicine than to the more modern ones reveals a strange feeling of insecurity. How could they trust so much the ancients and so little the physicians who were their own contemporaries? They suffered from what we would call an inferiority complex. What caused it? Our first guess is that their feeling of inferiority was the result of insufficient experimentation, and yet many physicians, most physicians, were practising medicine, and is not medical practice an endless series of experiments?" *Ibid.*, p. 49.
[31] O'Malley, *op. cit.*, p. 40.
[32] *Ibid.*, pp. 69-72.
[33] Quoted in O'Malley, p. 51.
[34] Nancy G. Siraisi, *Avicenna in Renaissance Italy: The Canon and Medical Teaching in Italian Universities after 1500*, (Princeton, 1987) p .9.
[35] "Fabricius and the 'Aristotle project' at Padua," in A. Wear, R. K French and I. M. Ionie (eds.) *The Medical Renaissance of the Sixteenth Century* (Cambridge, 1985), p. 198. Hereafter referred to as *The Medical Renaissance.*
[36] *Ibid.*, p. 198.
[37] On this point, we disagree with Giulio Peruzzi, who holds the Galileo Chair of the History of Science at the University of Padua. For Prof. Peruzzi, the machine metaphor, while evidently developed in Renaissance Padua, was known at the time throughout Italy and indeed, more generally, throughout Western Europe. Interview conducted by author, February 2002, University of Padua, Italy.
[38] *Fabrica*, Book I, p. xliii.
[39] Baldasar Heseler, *Andreas Vesalius' First Public Anatomy at Bologna*, translated by Ruben Eriksson (Stockholm, 1959) p. 49. Hereafter referred to as *Vesalius' First Public Anatomy.*
[40] *Fabrica*, Book I, p. 370.
[41] *Ibid.*, Book I, p. 231.
[42] *Ibid*, Book I, p. 81.
[43] This point is discussed in Oskar Kristeller, *Renaissance Thought: the Classic, Scholastic and Humanist Strains* (New York, 1961), p. 38.
[44] "If the connection of Aristotelian methodology to Galileo is on somewhat shaky ground, there can be little doubt of a strong Aristotelian methodological component in the thought of William Harvey. Perhaps nowhere does such a debt become more explicit than in the methodological introduction to his *De generatione* (1651). Here not only does he repeatedly praise Aristotle, saying that he follows him before any of the other ancients, but time and again he puts forward principles of scientific investigation to be used in his work which are derived directly from the *Posterior analytics*. In fact, the 'Introduction' to Harvey's work is in large measure a paraphrase of certain key ideas found in Aristotle's work, supported by several lengthy direct quotations." Charles B. Schmitt, "Renaissance Aristotelianism", in *Studies in Renaissance Philosophy and Science* (London, 1981), pp. 172-3.

[45] Kristeller, *Renaissance Thought*, pp. 31-2.
[46] *Ibid.*, p. 34.
[47] *Ibid.*, p. 36.
[48] According to Schmitt, "We find a blossoming forth of discussions on scientific methodology during the Renaissance, in part surely stimulated by the emphasis placed on the study of the *Posterior analytics* in the statutes of university after university of the time. Though it cannot be denied that even here Aristotelianism was deeply influenced by outside traditions – especially the medical tradition through Galen and the method of mathematical analysis as developed in the Greek world – much of the discussion on the issue, the content as well as the form, was within the closed framework of university Aristotelian philosophy."*Ibid.*, p. 171.
[49] Quoted by Charles B. Schmitt, "Aristotle among the physicians" in *The Medical Renaissance*, p. 10.
[50] *Vesalius' First Public Anatomy*, pp. 57-59.
[51] *Fabrica*, Book I, p. 36.
[52] *Ibid.*, Book I, p. 62.
[53] *Ibid.*, Book I, p. 114.
[54] *Ibid.*, Book I, p. 250.
[55] *Ibid.*, Book I, pp. 383-4.
[56] *Ibid.*, Book I, p. 149.
[57] *Ibid.*, Book I, pp. liii-liv.
[58] *Ibid.*, Book II, p. 332.
[59] *Ibid.*, Book I, p. 190.
[60] *Vesalius' Public Anatomy*, p. 285.
[61] O'Malley, *op. cit.*, pp. 87-8.
[62] *Vesalius' Public Anatomy*, p. 273.
[63] *Epitome*, pp. xxxiii-xxxiv.
[64] *Fabrica*, Book I, p. 247.
[65] *Epitome*, p. 83.
[66] *Fabrica*, Book I, p. 207.
[67] *Ibid.*, Book I, p. 287.
[68] *Ibid.*, Book I, p. 294.
[69] *Ibid.*, Book I, p. 9.
[70] *Ibid*, Book I, p. 32
[71] *Ibid*, Book I, p. 46.
[72] *Ibid*, Book I, p. 60.
[73] *Ibid*, Book I, p. 112.
[74] *Ibid*, Book I, p. 138.
[75] *Ibid*, Book I, p. 158.
[76] *Ibid*, Book I, p. 163.
[77] *Ibid*, Book I, p. 332.
[78] *Ibid*, Book I, p. 355.
[79] *Ibid*, Book I, p. 40.
[80] *Ibid*, Book I, p. 8.
[81] *Ibid*, Book I, p. 10.
[82] *Ibid*, Book I, p. 28.
[83] *Ibid*, Book I, p. 85.
[84] *Ibid*, Book I, p. 138.
[85] *Ibid*, Book I, p. 207.
[86] *Ibid*, Book I, p. 215.
[87] *Ibid*, Book I, p. 247 and again p. 260.
[88] *Ibid*, Book I, p. 140.
[89] *Ibid*, Book I, p. lvii.
[90] *Ibid*, Book I, p. 209.
[91] *Ibid*, Book I, p. 299.
[92] *Epitome*, pp. 42, 67 & 91.
[93] David F. Channell, *The Vital Machine* (New York, 1991), p. 32.
[94] Jonathan Sawday, *The Body Emblazoned* (London, 1995), p. 23.

[95] Lewis Mumford, *The Myth of the Machine: The Pentagon of Power* (New York, 1970), pp. 384-5.
[96] Singer, *A Short History*, pp. 111-134.
[97] We have paid careful attention to that masterpiece by David Hackett Fischer, *Historians' Fallacies: Toward a Logic of Historical Thought* (London, 1970).

WILLIAM HARVEY (1578-1657)

In previous chapters, it was noted that two leading Renaissance figures – Leonardo da Vinci and Andreas Vesalius – spontaneously resorted in their anatomical studies to the metaphor of man the machine. We have examined links between the two.

Based on his researches as anatomist, artist, architect and engineer, Leonardo interpreted man as an organic machine, in terms of its mechanical structure and processes. He saw man as a sort of universal machine, a perfected being capable of many different operations simultaneously. Leonardo developed an automaton – a self-operating mechanical robot, which says as much about his view of machines as it does of man. And Leonardo couched his wide-ranging interpretations of man the machine in eclectic terms, drawing at will on ancient Jewish and Christian traditions, Greek mathematics and physics, some knowledge of Aristotle, as well as Renaissance Neoplatonism and hermetic metaphysics.

Vesalius, meanwhile, attacked the outdated aspects of Aristotelian and Galenic orthodoxy. He exhaustively explored and described the instrumentality of the human body. He did so in order to demonstrate a bodily system with intricate mechanical workings, all designed and manufactured by God – the Master Artificer – in the divine workshop or *fabrica* of the human body. Vesalius likewise drew on a wide range of ideas and metaphors to buttress this revolutionary view. He was observing from the "book of life" rather than from the books of traditional authority; he was uncovering the intentions of God and the purposes of Nature; he was establishing the authority of observation and experiment, in place of received ideas; he was improving the knowledge and professional status of anatomists, thus laying new foundations for medicine. Moreover, Vesalius was uncovering the intentions of God and the purposes of Nature.

In William Harvey one finds a new variation on the theme of man the machine: the heart as a mechanical device. One also finds a controversy. Harvey was one of the leading physicians of England during the early seventeenth century, who established the true nature of the circulation of the blood and the operation of the heart as a pump within the body, while offering demonstrative proof in the form of experimentation and quantitative methods. In so doing, Harvey has been widely credited with having set the early modern Scientific Revolution in motion, although exactly how he did that, and even whether he did that, is in dispute.

Did Harvey establish the scientific basis of modern biology, basing himself on the "deduction of general laws on the basis of observation of natural phenomena, correlated with the demonstration of the effect produced by trial and experiment..."?[1] Was Harvey a proto-positivist, bewildered by the extent of ignorance about anatomy, and therefore pessimistic about humanity's capacity to truly know – someone, in short, who preferred to put all his energies into specific hypothesis and experiment as a result?[2] Was he instead a pioneer who elaborated a mechanical system of the body, and who "destroyed, in a single blow, the *a priori* supposition that it is in principle impossible to describe organic processes in mechanical terms"?[3] Was he a Royalist, ever loyal to his two kings, James I (1566-1625) and Charles I (1600-1649), who sought to establish the symbolic sovereignty of the heart within the human body?[4] Did he cautiously negotiate instead with both Royalists and Parliamentarians, during the turmoil of the late 1640s, in order to protect his personal and professional interests?[5] Was Harvey a soft-spoken Protestant rationalist, who did not believe in numerous superstitions of his time, such as witchcraft, quackery and hermeticism?[6] Did Harvey develop a mechanistic view of the body as a substitute for existing hermetic explanations, such as the microcosm myth?[7] Had Copernicus and Vesalius actually already overthrown the microcosm myth?[8] Was Harvey on the contrary sincere in his evocation of the microcosm, since he resorted to the rhetoric of demonic magic, when he could find no straightforward way of explaining organic phenomena?[9] If Harvey promoted experimentation and quantitative methods, did he unconsciously imbibe the Galilean method of measurement in astronomy, while a student of anatomy at Padua?[10] Or was Harvey applying to anatomy that very English method of empirical investigation established by William Gilbert, as well as Sir Francis Bacon, to whom he was personal physician?[11] Did he develop an English technological metaphor for the human heart, based on pumps used in fire fighting in London in his day?[12]

This astonishing range of scholarly opinions has been reduced to a series of questions, mainly as a way to suggest that the same historical evidence can be mustered, selected and presented to support a wide variety of views. Much Harveian scholarship is based on speculative inferences and wishful thinking. Much of it contrasts organic with mechanical explanations, seeks to affirm Harvey's lead role in the early modern scientific revolution, underscores the English character of his work, and downplays any influence of hermeticism on his work. Some Harveian scholarship goes further, suggesting that he was a mechanist, something like Descartes, although not a "reductionist."[13]

A weakness of much Harveian scholarship lies in a tendency to pick and choose among his views and those of his contemporaries, to build up a compelling but fairly simplistic image of Harvey the rationalist, mechanist and anachronistic anatomist, in other words, of Harvey as if he were an anatomist in our own day. Again, whether Bacon was an influence on Harvey has sometimes been couched in terms of how well they liked one another, based on Aubrey's *Life*.[14]

Harvey was actually subject to multiple influences, and was just as eclectic as Leonardo and Vesalius had been. Moreover, he was a transitional figure – and how could it have been otherwise, since he was a bridge between old and new? The metaphor of man the machine has multiple roots in Antiquity and Renaissance Italy, and Harvey overtly referred to many of these roots in his writings. He was by no means the first anatomist to draw on this mechanical metaphor: in fact, he did so, much in the way Leonardo and Vesalius had done.

What was Harvey's exposure to Leonardo and Vesalius? It seems clear that Harvey got to know the Earl of Arundel (1585-1646) and saw Leonardo's anatomical notebooks in 1636. This would have been after the 1628 publication of *Anatomical Disquisition on the Motion of the Heart and Blood in Animals*,[15] but prior to his later books on animal generation. This can be deduced from the following series of facts: Harvey, a close friend of Arundel, was appointed doctor to the British embassy in Vienna,[16] he accompanied Arundel in 1636 on a long journey on the Continent, the Italian portion of which was mainly devoted to looking for pictures that the aesthete Arundel would acquire;[17] during this trip, Arundel acquired what came to be known as the *Codex Arundel*, containing Leonardo's anatomical notebooks, that later ended up partly in the Windsor Collection, and partly with Constantijn Huygens *fils* (1628-

1697), diplomat and poet, secretary to King William III and brother of Christiaan Huygens (1629-1695), the astronomer, mathematician and physicist.[18] It is highly likely that Arundel (who died in Padua) would have shown his new prize possessions to Harvey, the anatomical expert accompanying him on this singular and long journey, since Harvey would have been in a good position to evaluate the accuracy and interest of Leonardo's anatomical drawings. Harvey may have heard of, or seen, these drawings during his earlier years studying at Padua. However, in the absence of documented evidence on the subject, it would be unwise to draw any conclusion.

This leaves another vector of influence on Harvey: Padua itself, the northern Italian university that had been home to Copernicus, Vesalius, Fabricius, Gilbert and Galileo. Harvey may well have acquired the habit of seeing the body as a series of mechanisms at Padua, where conservative Aristotelian and Galenic medical systems, highlighting the instrumentality of the body, were taught, alongside Vitruvius and some Neoplatonism, in a medical curriculum that included study of astronomy. Moreover, a distinction needs to be drawn between Harvey's ocular observations and dissections, which provided him with the "raw material" as it were of anatomy, and Harvey's ideas and values, which helped him to interpret and organize that "raw material" in due course, by means of mechanical metaphors.

How plausible is the idea that Harvey's Paduan years (1600-1602) were decisive in the development of his mechanical metaphor for the heart? There is some evidence to this effect, since Harvey's first mention of the mechanical operations of the heart refers explicitly to Fabricius. But then, Padua is often described as the bastion of Aristotelianism, which itself does not easily lend itself to mechanistic anatomy; besides, many of Harvey's English contemporaries resorted to mechanical metaphors of one kind or another. There have even been highly nationalistic scholarly articles published in the United Kingdom, suggesting that Harvey's mechanical metaphors were based on English rather than Italian technology! Padua was actually the central place where original investigations were being undertaken, that transformed knowledge, led to the development of the scientific revolution, and gave new prestige to the metaphor of Man the machine.

Vesalius also influenced Harvey's work. Many of the claims of Harveian scholars that Harvey was the first rigorous observer and experimental biologist, the first scientist of early modern times, and the first to develop a mechanical model for the operations of the human body, could just as easily be made on behalf of his predecessor, Vesalius. Harvey made thirty-nine references to Vesalius in his *Anatomical Lectures* alone, clearly considering him a leading medical authority. In Chapter 2 of *The Motion of the Heart*, for example, Harvey wrote of "the great Vesalius"; he acknowledged the authority of the author of the *Fabrica*, although occasionally pointing out the latter's errors.

Like Leonardo and Vesalius, Harvey studied anatomy in late Renaissance Italy, where it was common practice to draw on mechanical metaphors, to compare the system of the human body (microcosm) to the system of the world (macrocosm), and to describe individual organs by means of technological metaphors.

Harvey was an anatomist who philosophized a little, unlike his contemporary and occasional critic, Descartes, who was a philosopher who anatomized a little. Harvey was not ready for the abstract mechanistic philosophy of Descartes, preferring to maintain a modified Aristotelian outlook. In fact, Harvey remained vitalist in his biological philosophy,[19] and developed a theory of the heart as a mechanical device in continuity with the ancient traditions already mentioned. On several occasions, he used mechanical metaphors overtly, but in the course of his anatomical writings, about 99% of which are devoid of any metaphors and consist of dry demonstrations of particular facts, the motions of the heart and circulation of the blood are described as an intricate series of mechanisms, of observable processes regulated by immutable mechanical laws. It may be tempting to conclude from this that Harvey described the body in terms of organic matter in motion: but that phrase should more properly be applied to Descartes, who can be said to have "invented" a symbolic body, based less on ocular observation than on abstract principles. Descartes drew inspiration from Harvey; he sought to demonstrate that the body's structure and workings were machine-like; he redefined the body as organic matter in motion.

Below is a table summarizing some influences on Harvey:

Harvey's interpretation	Sources	Key features
The heart as a mechanical device	Plato, Aristotle, Vitruvius, Galen & teaching at Padua, including works by Vesalius & Fabricius, classical & medieval view of God's Creation having order and rationality and thus being measurable	This metaphor flows from the microcosm, since the world itself was considered a "machina mundi" or machine in its own right, of God's invention
Man in God's image and likeness	Judaism, Christianity, Greek & Roman mythology, hermetic philosophy, neo-Platonism	Man is like God: he has a soul, powers of observation, an ability to serve as a mirror of nature; ideal proportions of man are divine
Man as a microcosm	Classical and medieval heritage; Renaissance Paduan teaching of anatomy and astronomy together, of individuals like Copernicus, Vesalius, Gilbert, Fabricius and Galileo, as well as English thinkers like Bacon and Fludd	Parallel between God's orderly and rational universe and man and his destiny; ideal proportions of man are divine
Man as self-mastering individual	Platonic, Stoical, Christian, neo-Platonic ideals and growing awareness of self among humanists	Harvey's commitment to his personal programme of research; his claim to have discovered circulation of the blood
Man as a psychological being	Humanism and Shakespeare	His astute handling of the witchcraft controversy, and his attention to the psychological needs and foibles of his patients
Man as a being endowed with reason and devoted to the pursuit of happiness	Absent	
Man as a cog within an Automated State	Absent	

William Harvey was born in 1578, in Folkestone, Kent. His father and subsequently his five brothers were prosperous merchants, trading in the Levant.[20]

After studying at King's School, next to Canterbury Cathedral, Harvey studied at Gonville and Caius College, Cambridge, graduating with a B.A. in 1597. He then went to the University of Padua, one of Europe's greatest centres of learning during the Renaissance, for a two-and-a-half-year course. According to Sir Geoffrey Keynes, Padua's reputation "steadily rose until it took its independent place as Italy's foremost University and School of Medicine. Padua profited also by its proximity to the Republic of Venice, being officially adopted as its university quarter. While the cosmopolitanism of medieval days was passing away elsewhere, Padua's broadminded outlook proved particularly attractive to students from England and other Protestant countries. Artists, scientists, and liberal-minded people came to work there in an atmosphere of civil and academic freedom such as could be found hardly anywhere outside the domains of Venice."[21] English merchants trading with the Levant would have had frequent contacts in Venice itself, which maintained throughout the Renaissance a far-flung commercial empire, with castles and trading posts through the Eastern Mediterranean.

In Padua, Harvey studied with Hieronymus Fabricius ab Aquapendente, under whose influence he first began to consider the functions of the beating heart and the properties of blood flowing through it.[22]

The heart was variously interpreted during the Renaissance. On a metaphorical level, it had been deemed since the time of Aristotle to be the sovereign and therefore the most important organ of the body. In addition, Galen had conceptualized the movement of the blood in the heart, as leaving by the arteries and returning by the veins in an ebb and flow fashion. The Galenic model was to remain dominant for some 1400 years, until it came under fire during the Renaissance.

Harvey had been frustrated by the poor quality of his medical studies at Cambridge. He was exposed, at Padua, to stimulating ideas about the instrumentality and organic functions of the body, as well as some anticipations of the circular motion of blood through the heart. In addition to studying the *Fabrica* of Vesalius, Harvey was exposed to the works of Realdus Columbus of Cremona, the assistant to Vesalius, who advanced the idea of pulmonary circulation, something that was subsequently demonstrated by his student, Andreas Cesalpinus. Harvey was not satisfied by the description of the heart's system of valves offered by his Paduan professor Fabricius Acquapendente.

But Harvey was not a disembodied rationalist, studying anatomy in the abstract: he was also a man of his times. As Keynes has shown, Harvey was admitted to the College of Physicians in 1603. He practiced in London at St. Bartholomew's Hospital in 1609. He was involved in the resolution of many professional conflicts between physicians and both barber-surgeons and apothecaries. And he was made Physician Extraordinary to King James I, likely in 1618. During the first two decades of the century, he busily developed some of the ideas he had acquired in Padua, about the role of observation, experiment and measurement in anatomy, as well as the circulation of the blood, at least in a limited sense. But he did this against the social and political backdrop of serving a British King fascinated if not obsessed by demonology;[23] of fighting plague in Cambridge and London with the inadequate medical means of the time; of playing the role of courtier promoting a highly specialized approach to natural philosophy, at a time when Gilbert (1544-1603) and Bacon (1561-1626) were putting the early modern enterprise of natural philosophy on the national political agenda; of investigating malpractice and promoting standards in the face of sharply conflicting views on diagnostics and therapeutics, in a highly disorganized medical field, rife with professional competition among surgeons, obstetricians and apothecaries, as well as totally unregulated faith healers and other quacks. On the death of James I, in 1625, Harvey was appointed physician to Charles I, with whom he developed a close friendship, as evidenced by Charles allowing him to do experiments on deer in the royal park,[24] and their traveling together a number of times.

Harvey first became interested in the value of comparative anatomy in Padua, under the influence of Fabricius Acquapendente, and he devoted himself to dissections of everything from human cadavers to deer, reptiles, earthworms and insects. Although Parliamentary forces destroyed his scientific papers during the Civil War, there are records of some of his medical consultations, which show his humanity, his sympathetic and sometimes bemused understanding of psychology, and also his concern for the welfare of his patients.

Harvey wrote five primary works: *Prelectiones Anatomiae Universalis*, originally published in 1616, of which two modern English translations exist, Gweneth Whitteridge's *Anatomical Lectures* and C.D. O'Malley et al.'s *Lectures on the Whole of Anatomy*;[25] *The Motion of the Heart*, published in 1628, and translated by Robert Willis among many others; and finally *The First and Second Disquisitions on the Circulation of the*

Blood, addressed to John Riolan, published in 1649, and *Anatomical Exercises on the Generation of Animals* and *On Animal Generation*, published in 1651, these last works having been studied in the Willis translation.

In the *Anatomical Lectures*, given before the College of Physicians, Harvey noted "anatomy is that branch of learning which teaches the uses and actions of the parts of the body by ocular inspection and by dissection. The study of anatomy falls into five main divisions: the general account of each part; its use, action and usefulness for what; the observation of rare things and things which occur in disease; discussion of the problems arising from the opinions of the authorities; manual skill or dexterity in dissection and the preparation of the embalmed body."[26]

Although he emphasized the role of ocular inspection and dissection, Harvey expressed the teleological views of Aristotle and Galen in conventional terms. There is frequent mention of the use, function, instrumentality and necessity of different bodily organs. Indeed, "another division of the parts [of anatomy] therefore classifies them philosophically and medically according to the end for which they were designed… There is no part which in some way or other is not fashioned for some instrumental purpose…."[27] But Harvey went on to say, citing St. Augustine, that "from their usefulness and pre-eminence the parts may be classified as simply necessary, or indispensable, or beneficial, or for protection or for ornament."[28]

Then came the question of how to interpret the findings of ocular inspection and dissection. Here Harvey departed from Aristotle a moment, to advise his students to "review your own and other people's observations in order to consider carefully your own opinion, or, in the strictest form, deal with other animals according to the rule of Socrates where it is fairer written." He returned to promote the Socratic method "concerning argument from analogy", in discussing the lower belly.[29] The word "analogy" here cited is not sufficient grounds for us to assume that Harvey used the analogy or metaphor of the machine because of Socrates.

He then summarized the purposes of the study of anatomy: it is to establish the situation or delimitation of the body, the shape of the parts, their proportion, symmetry, beauty (these ideas are clearly a reference back to the Vitruvian ideal, and indeed Vitruvius is twice cited by Harvey[30]), the amount, the movement both in terms of augmentation and diminution and in accordance with diseases, with habit and with age, and finally the division into parts of the body. Moreover, anatomy should establish the actions of the body.

In writing of the divisions of the body, Harvey approvingly cited the Aristotelian and Galenic notion of a hierarchy of bodily organs: "The brain and the senses are in the anterior part and in the higher and lofty place. Their use is, for example, purposeful choice, and particularly of food and movement, in what direction to move in the avoidance of things harmful. As in buildings, the kitchen where the food is cooked is in the lowest part, so that the brain and the heart may not be harmed by the foul and sooty vapours of concoction."[31] The divisions of the body, for Harvey, include the skin, fat, the fleshy membrane, the peritoneum, umbilical vessels, the lower belly to which he devoted considerable attention, the upper belly which contains the heart among other organs, the head, and the muscles.

For our purposes, it is worth noting some of the non-mechanical metaphorical descriptions as they apply to the heart. The diaphragm serves as a partition between the bellies, "to protect the place of the heart, its chamber, from the noisome, sooty, crude vapours which arise steaming from the concoction in the kitchen and from the excrements; to protect the heart also from being oppressed by the distension of the stomach, womb and colon by food, wind etc. and by the fomentation of humours when there is distension below... and in man it serves as an apron to support the heart and lungs when the body is erect."[32] These non-mechanical metaphors, while unoriginal, serve to show the value of metaphorical description in early Harveian anatomy.

Harvey's discussion of the heart draws on the traditional views of Aristotle and Galen, the more contemporary researches of Italian anatomists, and some comparative anatomy. Then demonstrating to his audience on an animal with its thorax gaping wide open, Harvey stated: "but that the heart drives out and sends forth the blood in a movement of erecting is evident from these things which can be observed, particularly with regard to the auricles; also from the experiment of the ligature when the parts become very cold ... next from the position of the valves; when the arteries are wounded the blood spurts out; the artery has a thicker coat; second, from the colour, for the heart is whiter and more glistening in erection, as can be seen in frogs and fish etc.; third, from a wound [in their walls] the blood spurts out alike in the ventricles, the arteries and the pulmonary artery; fourth, the ventricles of the heart answer the movement of the auricles, so that the heart itself drives out the blood which has just been driven into it."[33] This passage is totally devoid of any mechanical metaphors. The anatomy theatre was a place for direct observation and demonstration, not for a literary explanation of the workings of the heart and circulation of the blood, which would require the liberal use of mechanical metaphors.

Harvey broke with Aristotle, however, in affirming that the brain, not the heart, was the centre of sensation, and he did so in a metaphorical way: "the Brain is set in the topmost part of the body which serves as the safest tower with, as its defences, hair, skin, etc. As Nature made no part more greatly defended, so is it deemed the prince of all the parts... Just as in some small state the same man is judge, king and counselor, while in larger states these offices are separate, so it is in animals and their parts; politicians indeed take many analogies from our medical art." [34]

Moreover, Harvey describes the rational soul whose powers are located in the brain, implicitly supporting the age-old value according to which Man is in God's image and likeness: "The utility of the brain lies not only in its power to comprehend the different kinds of sensation brought to it, but also to create from these comprehended concepts, this is fantasy, and to recall those which are no longer present, and this is memory... With this faculty he joins or separates concepts, which he affirms or denies; he conceives, comprehends and defines. By affirmation and denial he demonstrates his ratiocination ... because this is in the highest degree the peculiar property of the rational soul."[35]

Harvey is best known for a work published in 1628, *The Motion of the Heart.*[36] This work described an important medical discovery of the seventeenth century, namely that a finite amount of blood circulated on a continuous basis throughout the body of humans and animals. The work is significant for several reasons. It reflects the mature attitude of an anatomist and comparative anatomist who had taken the time to digest ocular observations and dissections – so that it is at some remove from the anatomy theatre itself. It bears witness to Harvey's advocacy of experimentation in natural philosophy. And it shows the value of quantitative methods. Harvey's work did not mark a radical break with the speculative legacy of Hippocrates with his four humours, or with Aristotle. On the contrary, Harvey was fearful of breaking with authority, since he knew this would force personal and professional sacrifices. Nevertheless, the work marked an important stage in the development of a new way of looking at things. Harvey certainly claimed to have discovered the circulation of the blood – a claim made by several other natural philosophers.

The main line of argument is as follows. Harvey observed that the action of the heart was like that of any other muscle. In cold-blooded animals, the ventricles became paler in colour when they contracted, and darker when they expanded. The apex of the heart strikes the chest wall during contraction. The contraction of the heart and the contact of its apex with the chest wall are simultaneous with the expansion of the arteries, as felt at the pulse. The contraction of the heart was thus the probable cause of the expansion of the artery. Moreover, in a series of experiments, the auricles were shown to have somewhat similar relations to the ventricles as the ventricles have to the arteries. The same blood that is driven into the ventricle by the contraction of the auricle is subsequently driven into the arteries by the contraction of the ventricles. Harvey insisted that the flow of blood is not only in one direction, but moves continuously. It can only be from the veins that all this blood must come, and it is then sent out continuously by the aorta. The motion of the blood is indeed circular.

Harvey's methods in arriving at these conclusions should be noted. He criticized Galen and Renaissance natural philosophers for having developed their views of the human body in the abstract, without constant reference to the fabric of nature. He had not only studied a wide range of contemporary Italian works on anatomy, he had also performed a wide range of dissections. He then studied the action of the heart and the blood in living animals, whether fishes, frogs, snakes, pigs or dogs. After showing that the mechanism of the valves in the veins enabled the blood to flow to the heart, he demonstrated that ligatures in the human arm could block blood flow in arteries and in veins. On this basis, he concluded that the blood followed a circular movement throughout the body.

This is Harvey's argument, as many modern scholars would like to see it. The argument, as just stated, seems to deliver a consistent and clear message about the specialized function of one bodily organ; it has been cleaned of any ambiguous references to hermetic philosophy or Renaissance Italian anatomists; it seems original and ground-breaking enough to be considered a "new paradigm", laying the foundations of a new science. But Harvey was not a specialist dealing in the abstract, in ways that would have much appeal to twentieth and twenty-first century observers. He was very much a product of his age. Renaissance humanism was highly eclectic: this accounts for the apparent paradox of inconsistencies in Harvey's highly metaphorical – and metaphysical – discourse, which may have been grounded in Aristotle but was also coloured by some Neoplatonism.

The remaining works of Harvey's lifetime include two replies to the French anatomist Riolan's attacks on the Harveian system of motions of the heart and circulation of the blood, an unfinished work on the motions of animals, and

Anatomical Exercises on the Generation of Animals. While these works are not as explicitly devoted to a mechanical interpretation of anatomy as *The Motion of the Heart*, they do contain important information about Harvey. The Introduction to *Anatomical Exercises on the Generation of Animals* contains a glowing account of his own methods of observation, which he claimed to have largely derived from Aristotle. "Diligent observation is, therefore, requisite in every science, and the senses are frequently to be appealed to.... For as all true science rests upon those principles which have their origin in the operation of the senses, particular care is to be taken that by repeated dissection the grounds of our present subject be firmly established."[37] Harvey here affirmed that anatomy was a self-correcting public enterprise, based on rigorous observation, and repeatable experiment, both of which should be related back to an understanding of universal principles.

Harvey was a witness of the decline and fall of his patron and friend, Charles I, who had taken a keen interest in his researches. Christopher Hill claimed that Harvey remained "as neutral as possible between the two sides in the civil war. He took great pains in 1642 to get not only Parliament's permission to attend Charles I as his personal physician, but even their command."[38] However, the phrase "as neutral as possible" does not mean that Harvey lost any of the fervour of his loyalty to Charles I! If anything, Harvey took pains to tell his reading public how much he resented the way the Parliamentarians destroyed all his research papers on insects.[39] And long after the execution of Charles I, Harvey wrote glowingly of the opportunities Charles had afforded him to perform experiments on deer in the royal park: "The game during the three summer months was the buck, then fat and in season; and in the autumn and winter, for the same length of time, the doe. This gave me an opportunity of dissecting numbers of these animals almost every day during the whole of the season when they were rutting, taking the male, and falling with young; I had occasion, so often as I desired it, to examine and study all the parts, particularly those dedicated to the offices of generation."[40]

Harvey clearly appreciated the King's patronage of natural philosophy, while bitterly resenting the destructive rages of the Parliamentarians. In his later years, he apparently contemplated suicide, as a way of hastening his end during illness, but the laudanum did not work, and he finally died of natural causes in 1657.

It is not a valid historical exercise to separate what one likes in Harvey's theory from what one dislikes – four centuries after the fact. It is true that he internalized the human machine, and used mechanical metaphors in a highly dynamic fashion, where Vesalius had alluded to them more passively. But Harvey did not simply state that Man was a machine. He only arrived at the idea that the heart had machine-like functions, because this idea could be integrated into his belief system, according to which God was the Creator of the world, Man was in God's image and likeness, Man was a microcosm, and ultimately the circular movement of blood throughout the body denoted a perfected symmetry, which was also part of God's design. These beliefs cannot be reduced to mere empty rhetorical devices, since they were often repeated in many different contexts, and thus can be said to have served as the underlying fabric of Harvey's theory of causation.

In *Animal Generation*, for example, Harvey praised God for His role in Creation, and generation. "Wherefore, according to my opinion, he takes the right and pious view of the matter, who derives all generation from the same eternal and omnipotent Deity, on whose nod the universe itself depends. Nor do I think that we are greatly to dispute about the name by which this first agent is to be called or worshipped; whether it be God, Nature, or the Soul of the universe – whatever name is employed – all still intend by it that which is the beginning and end of all things; which exists from eternity and is almighty; which is author or creator…"[41] Harvey wrote that this first cause of all things was variously referred to, as the *Divine Mind* by Aristotle, the *Soul of the Universe* by Plato, the *Natura Naturans* by others, *Saturn and Jove* by the ancient Greeks and Romans, and "by ourselves [Christians], and as is seeming in these days, the Creator and Father of all that is in heaven and earth, on whom animals depend for their being, and at whose will and pleasure all things are and were engendered."[42] In terms reminiscent of Vesalius and many other Renaissance thinkers, Harvey wrote that God's hand in generation operated "in the same way" as the hands or various instruments employed in the mechanical arts by the "blacksmith, statuary, potter, &tc." In so doing, he affirmed that heaven and earth (the "world" as it was then known) had been designed in God's mind and created by His hand, and that human and animal generation was part of this masterful design and creation.

In addition, Harvey associated the sovereignty of God and the Sun of Creation (macrocosm), with the sovereignty (microcosm) of his absolute monarch, Charles I. In the opening sentences of *The Motion of the Heart*, dedicating the work to his friend, "the Most Illustrious and Indomitable Prince, Charles, King of Great Britain, France, and Ireland, Defender of the Faith," Harvey wrote that "the heart of animals is the foundation of their life, the sovereign of everything within them, the sun of their microcosm, that upon which all growth depends, from which all power proceeds. The King in like manner, is the foundation of his kingdom, the sun of the world around him, the heart of the republic, the fountain whence all power, all grace doth flow. What I have here written of the motions of the heart I am more emboldened to present to your Majesty, according to the custom of the present age, because almost all things human are done after human examples, and many things in a King are after the pattern of the heart. The knowledge of the heart, therefore, will not be useless to a Prince, as embracing a kind of Divine example of his functions – and it has still been usual with men to compare small things with great. Here, at all events, best of Princes, placed as you are on the pinnacle of human affairs, you may at once contemplate the prime mover in the body of man, and the emblem of your own sovereign power…"[43]

In this passage, it will be noted, Harvey combined the image of the microcosm with the Aristotelian idea of the sovereignty of the heart, which he then immediately related to the absolute monarchy of King Charles I. That in itself suggested that the microcosm had taken on political dimensions. Harvey was thus not just describing the relationship of Man to the newly-understood universe, he was also justifying that description, in the eyes of the King, and ensuring that the King was rhetorically associated with a new way of thinking promoted by Copernicus, himself and others. Harvey also subscribed to the ancient convention, according to which nature does nothing that is not perfect or necessary (meaning that there is a purpose in the universe). In other words, if the heart was the sun and sovereign of the animal microcosm, and the King was sun of all about him, this simply had to be, it was part of natural law.

As is apparent from the concluding passages of *Animal Generation*, Harvey had developed a schema of Sun-Blood-Man, according to which the Sun was the macrocosm, Blood was a vital substance containing divine faculties, issuing from the Sun and created by the "Great Workman", while Man was the microcosm: "Since the blood acts, then, with the forces superior to the forces of the elements, and exerts its influence through these forces or virtues, and is the instrument of the Great Workman, no one can ever sufficiently extol its admirable, its divine faculties. In the first place, and especially, it is possessed by a soul which is not only vegetative, but sensitive and motive also; it penetrates everywhere and is ubiquitous; abstracted, the soul or the life too is gone, so that the blood does not seem to differ in any respect from the soul or the life itself (*anima*); at all events, it is to be regarded as the substance whose act is the soul or the life."[44]

God had designed and created the macrocosm of heaven and earth; he had designed and created the microcosm of man in his own image and likeness;[45] blood contained man's soul, in the image and likeness of God. It was only natural that Harvey should then explain the mechanical operations of blood moving through the body. This form of explanation was nothing less than a departure from Harvey's much-heralded Aristotelianism, and an incursion into hermeticism.

In a highly significant passage, Harvey noted that systematic application to vivisections helped *persuade* him of the mechanical motion of the heart. "The motion of the heart is as follows... two motions, one of the ventricles, another of the auricles, take place consecutively, but in such a manner that there is a kind of harmony or rhythm preserved between them, the two concurring in such wise that but one motion is apparent, especially in the warmer blooded animals, in which the movements in question are rapid." But then Harvey made a highly important statement: "Nor is this for any other reason than it is in a piece of machinery, in which, though one wheel gives motion to another, yet all the wheels seem to move simultaneously; or in that mechanical contrivance which is adapted to firearms, where the trigger being touched, down comes the flint, strikes against the steel, elicits a spark, which falling among the powder, it is ignited, upon which the flame extends, enters the barrel, causes the explosion, propels the ball, and the mark is attained."[46]

More important than the mechanical details in Harvey – the various actions of wheels and triggers – is that his schema of Sun-Blood-Man led him to develop a mechanical metaphor for a specific bodily operation, which helped him to explain the dynamic process of the circulation of blood.

In Chapter 8 of *The Motion of the Heart*, after a stirring evocation of Aristotle, Harvey reaffirmed that "the heart, consequently, is the beginning of life; the sun of the microcosm, even as the sun in his turn might well be designated the heart of the world; for it is the heart by whose virtue and pulse the blood is moved, perfected, made apt to nourish, and is preserved from corruption and coagulation; it is the household divinity which, discharging its function, nourishes, cherishes, quickens the whole body, and is indeed the fountain of life, the source of all action."[47]

Harvey appreciated the microcosm. His observation of the circular motion of blood was at least an implicit reference once more to the microcosm, since it corresponded to the circular motions of the macrocosm. In Chapter 8 of *The Motion of the Heart*, for example, he stated that he had long bethought himself, and "revolved" in his mind (!) what quantity of blood passed through the heart from the veins to the arteries. "I began," he wrote, "to think whether there might not be a

MOTION, AS IT WERE, IN A CIRCLE. Now this I afterwards found to be true; and I finally saw that the blood, forced by the action of the left ventricle into the arteries, was distributed to the body at large, and its several parts, in the same manner as it is sent through the lungs, impelled by the right ventricle into the pulmonary artery, and that it then passed through the veins and along the vena cava, and so round to the left ventricle in the manner already indicated."[48] Likewise, in *Animal Generation*,[49] he returned to the circular model of Aristotle, quoting from *On Generation and Corruption, II.10.*

Whereas Harvey could be expected to draw a parallel with the circular motion of heavenly bodies in the Galilean (or Copernican) universe (this circular motion having previously been advocated by Plato), he referred instead to circular motions in Aristotle: This "motion we may be allowed to call circular, in the same way as Aristotle says that the air and the rain emulate the circular motion of the superior bodies; for the moist earth, warmed by the sun, evaporates; the vapours drawn upwards are condensed, and descending in the form of rain, moisten the earth again; and by this arrangement are generations of living things produced; and in like manner too are tempests and meteors engendered by the circular motion, and by the approach and recession of the sun."

In many different passages of his works, Harvey wrote that man is a microcosm. In *The Motion of the Heart*, Harvey made periodic references to the microcosm; he advocated reliance on dissection ("vivisection") rather than on non-empirical medical traditions from Antiquity; he affirmed that dissection had moreover persuaded him that the heart operated like various machines; and he accurately described the role of the heart in the circulation of blood throughout the body, making an implicit link, as Aristotle had, with the circular movement of the sun.

Harvey's microcosm was part and parcel of his mechanical metaphors; and he shared this view with a number of moderns, whether in Pavia (see the chapter on Leonardo da Vinci, above) or in Padua (see Vesalian references to the microcosm, above), or in the Britain of Gilbert, Bacon, Shakespeare, Fludd or Burton.

William Gilbert, who had studied medicine at Padua, considered that he had penetrated the secret things and hidden causes of Nature to discover that the Earth itself was a giant loadstone or magnet; at the same time, in an implicit reference to the microcosm of the human body, Gilbert advocated the medicinal virtues of the loadstone in the treatment of human disease.[50]

Sir Francis Bacon, for his part, referred to Hermes Trismegistus in *A Device for the Gray's Inn Revels*, in a clear hermetic allusion to the power of the *magus* to penetrate the secrets of Nature and thus gain ascendancy over the world, becoming in the process a miracle and source of wonderment in his own right. However, Bacon cautioned in *The Advancement of Learning* that "the ancient opinion that Man was Microcosmus, an abstract or model of the world, hath been fantastically strained by Paracelsus and the alchemists, as if there were found to be in man's body certain correspondences and parallels, which should have respect to all varieties of things, as stars, planets, minerals, which are extant in the great world... [But] this variable composition of man's body hath made it an instrument easy to distemper; and therefore the poets did well to join Music and Medicine in Apollo: because the office of medicine is but to tune this curious harp of man's body and reduce it to harmony."[51] Bacon was not, strictly speaking, disclaiming any interest in the microcosm myth, however, since a consistent feature of interpretations of musical harmony from the time of Pythagoras and Plato up to Galileo and Kepler was that harmony was diffused throughout the universe.

Shakespeare, who also subscribed to the *magus* view of the natural philosopher (one has only to think of Prospero in *The Tempest*), alluded to the microcosm in at least one play, *Coriolanus*, in the phrase "the map of my microcosm" or face. Sir Geoffrey Keynes noted a possible poetic allusion to circulation of the blood (which we consider to have been an allusion once again to the microcosm of the human body) in the famous speech of Menenius Agrippa: "True it is my Incorporate Friends (quoth he)/That I receive the generall Food at first/Which you do live upon; and fit it is,/Because I am the Store-house, and the Shop/Of the Whole Body. But if you do remember/I send it through the Rivers of your blood,/Even to the Court, the Heart, to th'seat o'th'Braine/And through the Crankes and Offices of man."[52]

For Sir Geoffrey Keynes, it is tempting to consider that Harvey was familiar with Fludd's hermetic work *Anatomia Amphitheatrum*, "in which every part of the human body is given its mystical significance. Seven chapters are devoted to the mystic anatomy of the heart, the sun of the microcosm, the seat of the passions. The contraction of the heart is that hardening of the heart which was Pharaoh's doom."[53]

Harvey did not abolish the hierarchy, within the human body, of heart, liver and brain.[54] If anything, Harvey demoted the liver; but as was noted above, he wrote in the *Anatomical Lectures* that "as Nature made no part more greatly defended, so is it deemed the prince of all the parts" and in *The Motion of the Heart* he wrote that the heart was the sovereign and sun of the microcosm. In other words, Harvey explicitly maintained a hierarchy of bodily organs. His statements on the brain and the heart may be compared with virtually identical statements by his contemporary Robert Burton, whose *Anatomy of Melancholy,* coming out of the Aristotelian and hermetic traditions, constituted a kind of proto-psychiatry. For Burton, the brain "is the most noble organ under heaven, the dwelling house and seat of the soul, the habitation of wisdom, memory, judgment, reason, and in which man is most like god: and therefore nature hath covered it with a skull of hard bone, and two skins or membranes..." The heart for Burton "is the seat and fountain of life, of heat, of spirits, of pulse, and respiration: the sun of our body, the king and sole commander of it: the seat and organ of all passions and affections..."[55]

In the opening pages of this chapter, the wide range of scholarly opinion on Harvey was noted. Harveian scholarship is prone to speculative inferences and wishful thinking, often for nationalist reasons, since paternity of the modern scientific revolution is at stake. The question of influences on Harvey should not be framed in an either/or fashion, as if he were *either* subject to Italian-based influences, whether those of Fabricius or Vesalius, *or* to English-based influences. Quite likely, he was subject, like most of us, to many, diverse influences. Nor does it really matter whether Harvey got the idea of the mechanical metaphor from *either* Italian technology of his day, *or* from English technology. Besides, the view that Harvey was a pure rationalist, dealing only with ocular observation and experimentation in the abstract, does not stand up. Nor is there any substantiation for the view that Copernicus and Vesalius demolished the microcosm – since the microcosm so clearly underlay Harvey's own theory of causation. Finally, the case seems to have been overstated for Harvey's supposed neutrality during the Civil War.

Harvey was an Aristotelian, with some modifications; he was a specialized observer, experimenter and quantifier very much in contact with the thinking of other natural philosophers of his time. While his belief system featured overtly hermetic elements, such as his belief in the Sun-Blood-Man schema, he also resorted to metaphorical descriptions in order to identify, articulate and explain medical novelties. Harvey may have played a lead role in establishing the scientific basis of modern biology, but he was only one leader among many. The idea that he was the first to explain organic processes in mechanical terms is indefensible – Leonardo and Vesalius had both done so in the previous century. Harvey cannot be considered to have been a proto-positivist, if one considers the rich allusions he made to many ideas and values taken from Neoplatonic demonology.[56] In fact, the strongest Neoplatonic and hermetic statements that Harvey made were in the closing chapters of his last work – *Animal Generation.* Perhaps he was summing up his life work, observations, experiments and beliefs. Harvey must have scanned Leonardo's anatomical manuscripts, but at a time when he had already formed his original views on the motions of the heart.

A question worth asking is which came first in Harvey's work – the ocular observation or the metaphor? We put the question, since myth and metaphor have long been important in developing conceptual frameworks in order to evoke and allude to processes that people do not consciously experience. There is nothing particularly surprising in the fact Harvey should be calling forth the metaphor of man the machine. What is more important is that Harvey's systematic observation and experiment through dissection *"persuaded"* him of the validity of the machine metaphor, and that this metaphor in turn helped him to understand an utterly new scientific concept.

The demonstration proper of *The Motion of the Heart* begins with Chapter 1, in which Harvey stated his motives for writing: "when I first gave my mind to vivisections, as a means of discovering the motions and uses of the heart, and sought to discover these from actual inspection, and not from the writings of others, I found the task so truly arduous, so full of difficulties, that I was almost tempted to think, with Fracastorius, that the motion of the heart was only to be comprehended by God." In the introduction, Harvey presented the truth as a mystery, even as a "labyrinth" from which he needed to extricate himself and escape.[57] It is noteworthy that he spoke of *truth* at all.

He laboured for many years to extricate himself from the labyrinth and escape from uncertainty about the *true* motions of the heart. He meant by this, that it was terribly difficult for him to identify, to conceptualize, to "capture" the circulation of the blood and the motions of the heart. The mechanical metaphor may not have led him on to discovery, but it was an indispensable rhetorical tool in helping him to "put together" and articulate a theory, and then to communicate that discovery to others. In other words, the metaphor was positioned in between the raw observation and the refined theory; it opened Harvey's eyes onto what was evidently a new reality.

Harvey thus not only described the human body by means of dissection, observation and experimentation. By drawing together various different metaphors –

the microcosm, Aristotle's model of circular movement, and early modern mechanistic symbols such as the fountain, the trigger and various mechanical contrivances, Harvey also persuaded himself of the circular motion of the blood. In so doing, he was very much in continuity with Leonardo and Vesalius, and, as we shall see in the next chapter, with Descartes. One of his most important – and unexpected – contributions was to have provided in the mechanical action of the heart a graphic image for *la philosophie mécanique*, which in turn helped to transform natural philosophy into modern science.

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1 H.P. Bayon, "William Harvey, Physician and Biologist" in *Annals of Science* 4 (1939-1940), p. 385.

2 E.A. Burtt, *The Metaphysical Foundations of Modern Science* (Atlantic Highlands, 1980), p. 186.

3 J.A. Passmore, "William Harvey and the Philosophy of Science" in *The Australasian Journal of Philosophy* 36 (1958), p. 86.

4 Sir Geoffrey Keynes, *The Life of William Harvey* (Oxford, 1966).

5 Christopher Hill, "William Harvey and the Idea of Monarchy" in *Past and Present* 27 (1964).

6 Roger French, *William Harvey's Natural Philosophy* (Cambridge, 1994).

7 Michael T. Ghiselin, "William Harvey's Method in 'De Motu Cordis'" in *Bulletin of the History of Medicine* 51 (1967), p. 78.

8 Charles Singer, *The Evolution of Anatomy*, subsequently reprinted under the title *A Short History of Anatomy and Physiology from the Greeks to Harvey*, p. 122. The passage in question is worth quoting at length: "We now turn to examine some details of the anatomical masterpiece of Vesalius. We may remind the reader that this book is not only the foundation of modern Medicine as a Science, but the first positive achievement of science itself in modern times. As such it ranks with another work that appeared in the same year, the treatise of Nicholas Copernicus, *On the Revolutions of the Celestial Spheres*. The work of Copernicus removed the earth from the centre of the Universe: that of Vesalius revealed the true structure of man's body. Between the two they destroyed for ever the favourite mediaeval theory of Macrocosm and Microcosm." This passage is also quoted in Frank Livingstone Huntley, "Sir Thomas Browne, M.D., William Harvey and the Metaphor of the Circle" in *Bulletin of the History of Medicine* 25 (1951), pp. 236-247.

9 Charles Webster, *From Paracelsus to Newton: Magic and the Making of Modern Science* (Cambridge 1982), p. 92.

10 Charles Singer, *A Short History of Scientific Ideas* (Oxford, 1959), p. 275.

11 Sir William Hale-White, "Bacon, Gilbert and Harvey", Harveian Oration (London, 1927).

12 Charles Webster, "Harvey's Conception of the Heart as a Pump" in *Bulletin of the History of Medicine* 39 (1965).

13 J.A. Passmore, "William Harvey and the Philosophy of Science", p. 93.

14 According to Aubrey, Harvey "had been Physitian to the Ld Ch. Bacon, whom he esteemed much for his witt & style, but would not allow him to be a great Philosopher. 'He writes Philosophy like a Lord Chancellor,' he said to me, speaking in derision, 'I have cured him.'" Quoted in Keynes, p. 433.

15 Henceforth referred to as *The Motion of the Heart*. Also known by its Latin title, *De Motu Cordis*.

16 According to David Howarth, Harvey, "inspired by Arundel's descriptions ... went on to Italy to try his hand as an agent for [Arundel's] collection. He traveled down to the Veneto with Hendrik van der Borcht whom Arundel had made keeper of paintings and drawings at Arundel House.

Unfortunately, Harvey went to Treviso without having bothered to go through quarantine and the authorities encarcerated him in the plague 'lazaretto' for three weeks. The episode caused tremendous flurry in the embassy in Venice and much anxiety at Arundel House. Fortunately, however, all was well and Harvey, or the 'perpetual movement' as Arundel called him, returned home unscathed after having called upon Galileo in Tuscany." *Lord Arundel and his Circle*, p. 124.

[17] Details of the journey made by Arundel and Harvey are contained in Sir Geoffrey Keynes' biography.

[18] For more details on Leonardo's anatomical books, a good source is the second book of the *Notebooks of Leonardo da Vinci*, compiled by Jean-Paul Richter, pp. 105-133. Richter noted that eighteenth-century visitors to Windsor Castle could not make head or tail of Leonardo's words, although they were impressed by his anatomical drawings. A good source of information on Arundel's possession of works by Leonardo is contained in an article by Tancred Borenius, entitled "Leonardo in England", contained in *Leonardo da Vinci*, Istituto Geografico De Agostini (New York, 1997), pp. 191-193. Sir Constantijn Huygens *fils* should not be confused with the more celebrated Sir Constantijn Huygens *père* (1596-1687).

[19] Charles Webster, *From Paracelsus to Newton: Magic and the Making of Modern Science*, p. 69.

[20] These biographical details are drawn from Sir Geoffrey Keynes' *The Life of William Harvey.*

[21] *Ibid.*, p. 22.

[22] Keynes was reluctant to acknowledge Fabricius' influence on Harvey's use of the machine metaphor.

[23] The 1598 work on demonology, penned by James I while still James VI of Scotland, is a remarkable example of political paranoia.

[24] A brilliant description of these somewhat disappointing dissections is given, starting at Exercise 64 of *Animal Generation* (Chicago, London and Toronto, 1952).

[25] We here quote from the translation by Gweneth Whitteridge rather than that by O'Malley et al.

[26] William Harvey, *The Anatomical Lectures of William Harvey*, translated by Gweneth Whitteridge (Edinburgh, 1964), p. 5.

[27] *Ibid.*, p. 9.

[28] *Ibid.*, p.13

[29] *Ibid.*, pp. 17 & 87.

[30] *Ibid.*, pp. 27 & 71.

[31] *Ibid.*, p. 33.

[32] *Ibid.*, p. 243.

[33] *Ibid.*, p. 269.

[34] *Ibid.*, pp. 311 & 313.

[35] *Ibid*, p. 315.

[36] We will refer less often to later works by Harvey, since they are less relevant to our purposes here.

[37] William Harvey, *Animal Generation*, Introduction, p. 333.

[38] Christopher Hill, "William Harvey and the Idea of Monarchy", p. 69.

[39] According to Aubrey, "I remember I heard him say he wrote a booke de insectis, which he had been many years about, & had made curious researches and anatomicall observations on them; this booke was lost when his lodgings in Whitehall were plundered in the time of the Rebellion: he could never for love or money retrieve them or heare what became of them and sayed *'twas the greatest crucifying to him that ever he had in all his life.*" Keynes, *The Life of William Harvey*, Appendix I, p. 436.

[40] *Animal Generation*, Exercise 64, p. 473.

[41] *Ibid.*, Exercise 50, p. 428.

[42] *Ibid.*, Exercise 54, p. 443.

[43] William Harvey, *The Motion of the Heart* (Chicago, London and Toronto, 1952), p. 267.

[44] *Animal Generation*, Exercise 71, p. 493.

[45] This statement can be inferred from a passage in Exercise 50 of *Animal Generation*, p. 428, where Harvey wrote of the resemblance to God of man's rational soul.

[46] *Ibid.*, p. 279.

[47] *The Motion of the Heart*, Chapter 8, p. 286.

[48] *Ibid.*, p. 285.

[49] *Animal Generation*, Chapter 50, p. 427.

[50] William Gilbert, *On the Loadstone and Magnetic Bodies and on the Great Magnet of the Earth* (Chicago, London and Toronto, 1952), pp. 1-21.

[51] Francis Bacon, *The Advancement of Learning*, Book Two, in Brian Vickers (ed.) *Francis Bacon: The Oxford Authors* (Oxford, 1996) pp. 208-209.

[52] William Shakespeare, *Coriolanus*, Act 1, Scene 1.

[53] Keynes, *op. cit.*, p. 134.

[54] Christopher Hill, "William Harvey and the Idea of Monarchy", p. 54.

[55] Robert Burton, *The Anatomy of Melancholy*, p. 97.

[56] In this respect, Charles Webster has written: "Neoplatonic demonology embraced the idea of infinite worlds, each being governed by its own particular pattern of intelligences... The earth and other planetary bodies were not merely regarded as sharing some diffuse force characterized as the *anima mundi*, but were also thought to possess a complete organic constitution analogous to the human body. The planetary body was revitalized by the circulation of its physiological fluids. Harvey proposed an analogous function for the circulation of the blood which he had demonstrated in animals. Just as the earth was thought to gain sustenance from the vital heat at its centre, so Harvey's blood was revitalized by the heart. When seeking an appropriate image to explain this revitalization Harvey fell back on the *lar familiaris*, or household deity, of the ancients." *From Paracelsus to Newton*, pp. 91-92.

[57] *The Motion of the Heart*, p. 273.

RENÉ DESCARTES (1596-1650)

In the works of René Descartes, the metaphor of Man the machine undergoes a sudden transformation. Leonardo, Vesalius and Harvey were anatomists who did some philosophizing. Their interpretations of man as an organic machine were frequently couched in terms of colourful analogies, which served to explain their own rigorous observations and experiments. But Descartes was a leading philosopher of the scientific Renaissance[1] who did some "anatomizing." His use of the metaphor of Man the machine was based less on observation, than on an abstract and even dogmatic principle, which he used as a point of departure, then sought to demonstrate by means of subsequent speculation on anatomy, and occasionally buttressed with illustrative material drawn from Vesalius and Harvey.

Whereas Harvey had developed a theory of the mechanical operations of the heart, based on many years of ocular observation and experiment, Descartes sought to provide a mechanistic demonstration first of the system or physiology of the human body (subject to universal mechanical laws, which could be mathematically established), and second of the union of body and soul. In other words, he was looking to prove an abstract theory, and to support it by transferring the newly acquired prestige of mathematics and medical science to his own ideas.

Descartes restated in a compelling way the two-centuries-old view that Man was an organic machine – in the sense that a living creature could be interpreted in terms of mechanical structure (pipes, fountains, etc.) as well as mechanical processes (thrusting, raising, lowering, seeing, smelling, feeling etc.). Man was like a calculating and measuring machine – such as a clock – capable of mathematical predictability, harmony and rationality (we should not forget that Descartes greatly prized the certainty offered by mathematical explanation). Man could be represented on the model of an automaton – a relatively self-operating mechanical object, such as a trick fountain or water-operated robotic animal; that Man had been produced by the mind of God. And finally Man could be seen as a sort of universal machine, a being not nearly so perfect as God, yet nonetheless capable of some God-like operations. In this respect, Descartes found a novel way to join together many of the values we have already identified: Man's body as a machine, Man in God's image and likeness, Man as a microcosm, Man as a self-mastering individual, Man as a psychological being.

Descartes' understanding of mind has also proven to be important in the development of artificial intelligence. "On the basis of his neuroanatomical and physiological studies, as well as philosophical arguments," wrote Murat Aydede and Güven Güzeldere, "Descartes had … argued that human and animal bodies could be mechanically understood as complicated and intricately designed machines. What differentiated Descartes from Hobbes lay in Descartes' belief that human beings, unlike non-human animals, were not merely bodies; they were unions of material bodies and immaterial souls. The immaterial soul was necessary for Descartes to explain the peculiar capacities and activities of the human mind. As such, materialist mechanical explanations could never be sufficient to account for the whole human being. The fundamental assumption of Artificial Intelligence (AI) as a research program is that human minds operate on computational principles, and its grand goal is to build material artifacts that genuinely possess the very same mental capacities that humans have."[2]

One of the greatest of all mathematicians and philosophers of modern times, Descartes played a key role in articulating the methods of the new mechanistic science. He brought to his work the mathematician's penchant for certainty; the logician's taste for sharp distinctions; the experimental scientist's passion for experience and observation; the man of faith's desire to reconcile the physical universe with belief in God and His Creation. Indeed, his interpretation of the dualism of body and soul led him to delve into what can only be called "speculative anatomy" – the practice of attributing to particular organs the seat of the imagination, the common sense and the soul. This compromise seriously weakened the case he made for dualism.

It is perhaps not surprising, in view of the crucial importance of the Cartesian man-machine to Descartes' philosophical programme, that a qualitative change took place in the metaphor of Man the machine. For Leonardo, Vesalius and Harvey, the metaphor had been an *analogy*, which served to explain the organic structure and processes they observed. For Descartes, the metaphor became an abstract *equation*, linking the human body and the machine.[3] And that equation became one of the pillars of an entire philosophical system. The use here of the word "equation" should not come as a surprise: it seems to have been one of Descartes' main habits of thought, given his passion for geometrical equations, his equation of matter with extension, and his equation of mind with existence.[4] Expressed another way, metaphor as analogy *likens* one thing to another; metaphor as equation affirms that one thing *is* another.

Descartes can be said to have "invented" an idealized, mechanistic body, and to have fashioned the union of body and soul, which in turn served as one of the foundations for his mechanistic philosophy. This is important for the history of Man the machine. We have been unable to identify any thin, dotted speculative line that would link Leonardo to Descartes, although in 1623-1624 Descartes traveled to Italy. Constantijn Huygens, secretary to William III, who acquired some of Leonardo's notebooks in 1690, was the son of the Constantijn Huygens who corresponded with Descartes in the 1630s and 1640s![5] But Descartes openly acknowledged he had learned particular mechanical details about the human organism from Vesalius and Harvey, although he disagreed with the latter on a number of points, and as we have seen Vesalius had likely and Harvey had certainly been exposed to Leonardo's works. Descartes' philosophy of Man the machine stood in stark contrast to the materialistic view of Hobbes, with whom he corresponded.

Descartes is a daunting figure. His philosophy was as wide-ranging as Bacon's, and indeed he had the same life ambition as Bacon: to establish a new systematic basis for certain and true knowledge, which would help overcome the limitations of the variety of Aristotelianism then prevalent.[6]

According to Friedrich Lange, the nineteenth-century historian of materialism, Descartes was an ambivalent figure. He was, in many respects, an idealist, for whom "the whole external world appears as mere phenomenon and only the ego has any real existence". For Lange, Descartes applied the standard of number and of geometrical figure to all the phenomena of nature; the mechanistic philosophy of this idealist appealed to later materialists because it was based on an obviously shallow and fallacious Idea of God's existence! [7] According to Etienne Gilson, Descartes was a perpetual exile, seeking neither fame nor fortune, a man turned "towards the age of machines, industry and scientific medicine" who believed that true science was destined to transform the material conditions of our existence.[8] Recent scholarship has seen Descartes as linking in a single system according to mediaeval precedent both mere extension (mathematically expressible) and the human soul, planning for himself the role "of a new Aristotle, who should found a new Scholasticism on the basis of recent scientific discovery."[9]

That Descartes had these ambitions is understandable: a number of sixteenth and seventeenth century thinkers, struggling with the dogmatic form of Aristotelianism then prevalent, sought to become the new Aristotle, setting up counter-dogmas of their own. Bacon and Galileo serve as examples. What is most interesting for our purposes is the extent to which the Cartesian mechanistic philosophy was illustrated by Descartes' incomplete understanding of anatomy and physiology.

In the early 1980s, Richard B. Carter noted "very few scholars of Descartes even briefly refer to his physiological investigations when they discuss such characteristically Cartesian problems as the 'mind-body' problem."[10] According to the same author, Descartes articulated a medicine based on the mathematical physics of general body, and then considered the organization of the human body in terms sufficient to allow it to carry the mathematical operations of his new mathematical physics. Indeed, Carter considered the Cartesian mechanistic body to have been a precursor of Pavlov's conditioned response. More recently, Gary Hatfield has written on the limited validity of the conclusions Descartes drew from his physiological investigations: "Descartes' program in physiology was an extension of his generally mechanistic approach to nature. Where previous physiologists had invoked powers, faculties, forms, or incorporeal agencies to account for the phenomena of living things, Descartes would invoke only matter in motion, organized to form a bodily machine... Never timid in speculating about micromechanisms in nature, Descartes claimed that he had observed no part of the body in his many dissections which he could not explain through purely material causes – both as to its formation and its mode of operation."[11] Other scholars have expressed reservations about his mechanical model.[12] But some aspects of Cartesianism have found an echo in Stephen Wolfram's belief that cellular automata can help understand the idea of discrete space.[13]

Below is a table summarizing some of the influences on Descartes:

Descartes' interpretation	Sources	Key features
The body as machine	Plato, Aristotle, Vitruvius, Galen, Vesalius, Galileo & Harvey, classical & medieval view of God's Creation having order and rationality and thus being measurable	This metaphor flows from the microcosm, since the world itself was considered a "machina mundi" or machine in its own right, of God's invention; the body is matter in motion
Man in God's image and likeness	Judaism, Christianity, Greek & Roman mythology, hermetic philosophy & Neoplatonism	Man is like God: he has a rational soul, an ability to serve as a mirror of nature; an ability to create, like that of God
Man as a microcosm	Classical and medieval heritage; Paracelsian alchemy (according to Carter) Vesalius, Galileo, Harvey...	Parallel between God's orderly and rational universe and man and his destiny; ideal proportions of man are divine
Man as self-mastering individual	Platonic, Stoical, Christian, Neoplatonic ideals and growing awareness of self among humanists	Descartes's commitment to his personal programme of research
Man as a psychological being	Scholasticism, humanism	"Cogito, ergo sum" – a psychological account of the acquisition of certain knowledge
Man as a being endowed with reason and devoted to the pursuit of happiness	Partly implicit in Descartes' appeal to reason, although the pursuit of happiness was not a feature of his work	
Man as a cog within an Automated State	Implicit in Descartes' equation of man with machine, but not stated explicitly	

René Descartes was born in 1596 at La Haye, Touraine, to a family of the minor nobility. He studied at the Jesuit college of La Flèche, graduating in 1616, took a Bachelor's degree from the University of Poitiers two years later, and entered the service of Prince Maurice of Nassau in Breda, Holland the following year.

Descartes was a driven man, who wanted to make his imprint on the natural philosophy of his age. That he should have a three-part dream in November 1619 of discovering "the foundations of a wonderful science" (such is the phrase attributed to him by his early seventeenth-century biographer Adrien Baillet),[14] suggests that this personal drive operated on an unconscious level. That Descartes should, in turn, seek to base his life work of *rationality* on three traumatizing dreams, suggests there was a neurotic strain in his personality, verging on narcissism and messianism. There is some irony in the fact that this avowed rationalist should use these vivid but involuntary dreams to build up a personal mythology, placing the dreams at the centre of a bold life mission, which in itself was purportedly to establish true knowledge of rational order throughout the universe.

His correspondence shows to what extent Descartes was a tortured soul. This anxiety in large part motivated his decision, in 1629, to leave the intellectual orthodoxy of France for the tolerance of Holland. In 1637, for example, he took great pains to negotiate a sort of intellectual truce with the Jesuits: "I know that the main reason your Colleges take great care to reject all sorts of innovations in philosophical matters is their fear that these innovations may bring about some change in theology as well. That is why I want especially to point out that you have nothing to fear on this score so far as my own innovations are concerned..."[15] There was a rather cringing side to Descartes' personality, which he sometimes used to half shield the messianic image he had formed of himself. On February 15th 1638, he thanked a friend for sending some books, which "shore up my views with the authority of Aristotle. How fortunate that man was: whatever he wrote, whether he gave it much thought or not, is regarded by most people today as having oracular authority. So there is nothing more I could wish for than, without departing from the truth, to be able to follow in his footsteps in all things."[16] A week later, in a more boastful vein, he wrote to another correspondent that his conscience and the force of truth gave him the courage to describe the creation of the universe in terms which even he, ten years previously, would never have believed.[17] In a letter to Marin Mersenne (1588-1648) written on Christmas Day, 1639, is an expression of Descartes' belief that humans have an unlimited will to achieve God-like perfection.[18] About a year later, Descartes wrote to Mersenne, implying that his own philosophical views were of the same degree of certainty as the revealed truth of Catholicism: "since I have firm faith in the infallibility of the Church, and in addition have no doubts about my own arguments, I cannot have any fear that one truth may be in conflict with another."[19] A few months later, Descartes nervously referred to the Church condemnation of Galileo, maintaining that he was confident he could show that his doctrines accorded with the Faith better than the supporters of Aristotelianism.[20] But he also anxiously contemplated burning all his manuscripts, because of what had happened to Galileo.[21] He proposed publication strategies to friends, in order to avoid problems with the Catholic Church in France. His attacks on Aristotelianism got him into trouble with Dutch Protestantism as well. Ultimately, he developed a long correspondence with Princess Elisabeth of Bohemia, and accepted an invitation from Queen Christina of Sweden (1626-1689) to move to her Court, where he would rarely meet her. He died in Stockholm in 1650.

The Cartesian method of acquiring knowledge should be set in the context of the scientific Renaissance, during which several original thinkers charted out approaches to the acquisition of scientific knowledge. Descartes yielded to some logical fallacies, which were actively denounced by some of his contemporaries.

In 1620, Francis Bacon sought to break with Aristotelian syllogism or deductive inference, by promoting the "untried" method of induction instead. By syllogism, observations had to fit into broad speculative patterns, instead of proceeding from concrete observations to more general theories. Bacon attacked Aristotelian dogma head-on: "The syllogism consists of propositions – propositions of words; and words are the tokens and signs of motions. Now if the very notions of the mind (which are the soul of words and the basis of the whole structure) are improperly and over hastily abstracted from facts, vague, not sufficiently definite, and faulty – in short, in many ways, the whole edifice tumbles. I therefore reject the syllogism, and that not only as regards principles (for to principles the logicians themselves do not apply it) but also as regards middle propositions, which, though obtainable no doubt by the syllogism, are, when so obtained, barren of works, remote from practice, and altogether unavailable for the active department of the sciences."[22]

In place of the Aristotelian syllogism, Bacon proposed an altogether different method. Inductive science consisted in analyzing experience and taking it to pieces, and by a due process of exclusion and rejection leading to an inevitable conclusion.[23] "The true method of experience," Bacon wrote in the *New Organon*, "first lights the candle, and then by means of the candle shows the way; commencing as it does with experience duly ordered and digested, not bungling or erratic, and from it educing axioms, and from established axioms again new experiments; even as it was not without order and method that the divine word operated on the created mass. Let me therefore cease to wonder that the course of science is not yet wholly run, seeing that they have gone altogether astray, either leaving and abandoning experience entirely, or losing their way in it and wandering round and round as in a labyrinth. Whereas a method rightly ordered leads by an unbroken route through the woods of experience to the open ground of axioms."[24] Using this more systematic approach to experience, Bacon was convinced that it would be possible to collect a store of particular observations sufficient in number, in kind, and in certainty, to inform the understanding. These observations, derived from systematic experience, would in turn be duly investigated and verified, counted, weighed and measured, in order to provide trustworthy information.[25]

While Bacon was by no means an original natural philosopher, and never showed much interest in mathematics, he was good at conceptualizing how knowledge should be acquired. And he was instrumental, through the rich imagery of *The New Atlantis* of 1627, in setting a model for a community devoted to scientific cooperation and experiment.

Between 1629 and 1638, Galileo Galilei developed a four-part theory of sense experience and its role in building more certain knowledge.[26] In the *Dialogue Concerning the Two Chief World Systems*, he cautioned, in the person of Sagredo: "It always seems to me extreme rashness on the part of some when they want to make human abilities the measure of what nature can do. There is not a single effect in nature, not even the least that exists, such that the most ingenious theorists can ever arrive at a complete understanding of it. This vain presumption of understanding everything can have no other basis than never understanding anything."[27] First, sense experience could be used to refute false ideas.[28] Second, sense experience could be appealed to, in order to build up new knowledge of natural philosophy.[29] Third, Galileo's insistence on sense experience turned science into a self-correcting, forward-looking enterprise.[30] This is an important statement, since it meant that natural philosophy did not consist of a static body of ancient texts, which should be commented upon and reinterpreted in the light of authority. Instead, it involved a dynamic process of posing new questions and seeking evidence to provide answers, which could subsequently be overshadowed by fresh questions and evidence pointing to new answers. And fourth, sense experience redirected the enterprise of natural philosophy away from *a priori* speculative reasoning on the occult properties of objects, towards rigorous experimentation for the purpose of recording their observable properties. Whereas speculative reasoning on occult properties owed much to the eloquence of the speaker, the advantage of rigorous experimentation lay in the fact it could be repeated by anyone respecting a protocol. This in turn emphasized the truly competitive and collective nature of the enterprise.[31]

While Bacon and Galileo both deliberately confronted Aristotelianism for their own reasons, it is important to note that Harvey, writing in *Anatomical Exercises on the Generation of Animals*, published in 1651, upheld Aristotle's views on the manner and order of acquiring knowledge. This is significant, since it has often been claimed, that the new scientific method developed as a reaction to Aristotelianism. Harvey attacked the validity of innate ideas, advocating instead the fundamental role of sense perception, leading to the following chain of mental operations: "the thing perceived by sense remains; from the permanence of the thing perceived results memory; from multiplied memory, experience; from experience, universal reason, definitions, and maxims or common axioms, the most certain principles of knowledge... There is no perfect knowledge which can be entitled ours, that is innate; none but what has been obtained from experience, or derived in some way from our senses..."[32] Despite the anti-Aristotelian views of Bacon and Galileo, it was not difficult for Harvey to justify his defence of Aristotle, who had remained far more relevant to biology than to other branches of natural philosophy such as astronomy.

Descartes proceeded along an altogether different pathway. He sought to identify one absolute element, which would explain the order and system of the world. He believed that this element was to be found firstly in a method of acquiring knowledge: to accept as true only what is clearly recognized as such; to analyse problems systematically in order to solve them; to move from simple to ever more complex considerations; and to pass over everything again to ensure that nothing has been left out. This painstaking application of doubt as the foundation of knowledge, whether divine or human, consisted in suspending beliefs long enough to test them in the light of reason. Descartes believed that his ultimately psychological account of knowledge, which was slowly built up by means of systematic doubt and self-questioning, would not only result in truer principles, but also in a better life.

Secondly, the absolute element, which would explain the order and system of the world, was to be found in rising from the fragmentary nature of our consciousness to the infinite and perfect existence of God. Thirdly, that element could be reached by reducing the material universe to extension and local movement.

Descartes equated thought with existence. God's thought had produced the great machine of the universe, which was indefinitely extended, in constant motion, harmonious and well ordered. God's thought had also produced the self-moving machine of Man, which was like a watch or automaton. Man's skill in constructing automata could be likened to divine creation, although in terms of intricacy or complexity, it fell short of what God had wrought. But Man was nevertheless in God's image. Just as Descartes could assert "Cogito, ergo sum" – "I think, therefore I am" – equating thought with existence – he related all phenomena to the idea that God had of them.

Some of his contemporaries picked holes in Descartes' arguments. In *Objections and Replies*, Mersenne criticized the idea that God's existence could ever be proven simply by virtue that we have an idea of Him. He argued that Descartes could not claim to have proven something to exist, simply by affirming it. This in turn led Descartes to compose a highly dogmatic answer, in the form of the following speculative propositions: the existence of God can be known merely by considering his nature; the existence of God can be demonstrated *a posteriori* merely from the fact that we have an idea of God within us; God's existence can also be demonstrated from the fact that we, who possess the idea of God, exist; God created the heavens and the earth and everything in them – moreover he can bring about everything which we clearly can perceive in a way exactly corresponding to our perception of it; there is a real distinction between the mind and the body.[33]

These propositions are cited in order to illustrate the challenge posed by Descartes' circular manner of reasoning, which rests on speculative affirmations and equations, backed up in many cases by an uncertain grasp of detail.

Descartes "invented" an idealized, mechanistic body, and refashioned the union of body and soul, which in turn served as one of the foundations for his mechanistic philosophy. The Cartesian point of departure was the assumption that "The number and orderly arrangement of the nerves, veins, bones and other parts of an animal do not show that nature is insufficient to form them, provided you suppose that in everything nature acts exactly in accordance with the laws of mechanics, and that these laws have been imposed on it by God," he wrote to Mersenne on February 20th 1639.[34] This statement in itself was crucial. The reduction of Nature to a body of laws enacted by God in order to govern the movement of matter marked a definitive break with Scholasticism.[35]

If God was supernatural lawmaker, in a material universe where everything in Nature moved according to these immutable laws, then it was Descartes' stated goal to understand those laws and how they governed human physiology as well as possible. His approach to Man the machine was thus related to his understanding of mathematics and philosophy.

In *Rules for the Direction of the Mind*, he clearly stated his ambition of establishing a general science – *mathematica universalis* – covering everything, which entitled other sciences to be considered branches of mathematics.[36] In *Principles of Philosophy*, he evoked the metaphor of the tree, to explain the nature of philosophy: "The roots are metaphysics, the trunk is physics, and the branches emerging from the trunk are all the other sciences, which may be reduced to three principle ones, namely medicine, mechanics and morals."[37] This entirely coherent attitude helps to explain why Descartes considered that he made a *mathematical* demonstration of the movements of the heart.[38] It also explains why he sought to remove from physiology any possible intervention of vital spirits. Finally, it supports his view that human physiology and even the passions of the soul can be reduced to the intricate flow of matter in motion, derived from the imperceptible movements of particles in the body.

Once Descartes had reduced Nature to a body of laws, and affirmed that medicine required mathematical demonstrations, then he was really waiting for a single convincing principle of a bodily mechanism to come along, from which he could build the rhetorical fabric of his new mechanistic philosophy. This principle lay in the circulation of the blood. Although he disagreed with Harvey on the finer points of the circulation, although he can be said to have "misapprehended" the Harveian theory, he did much to establish the reputation of the mechanical workings of the heart, particularly as they served the metaphor of Man the machine. As the Harveian scholar Roger French has written, "The motion of the heart and blood remained, as Descartes had intended it to be, the most potent example of his natural philosophy's ability to explain the nature of the machine of the body. It was in association with his idea of forceful diastole that many people met the second half of Harvey's doctrine, the circulation. In Descartes' campaign to insert his natural philosophy into the universities the importance of the example of the motion of the heart and blood was that Descartes could fight his battle on the medical front as well as in the arts course (with his physics)."[39]

Once he affirmed his initial premise, Descartes then referred to anatomical observations made by Vesalius and Harvey, but always in a way that subtly disparaged their originality. For example, Descartes wrote: "I have taken into consideration not only what Vesalius and the others write about anatomy, but also many details unmentioned by them, which I have observed myself while dissecting various animals." In a letter to Mersenne of November or December 1632, Descartes explained that the discussion of man in a projected work, *The World*, "will be a little fuller than I had intended, for I have undertaken to explain all the main functions in man. I have already written of the vital functions, such as the digestion of food, the heart beat, the distribution of nourishment, etc., and the five senses. I am now dissecting the heads of various animals, so that I can explain what imagination, memory, etc. consist in. I have seen the book *De Motu Cordis* which you previously spoke to me about. I find that it differs slightly from my own view, although I saw it only after having finished writing on this topic."[40]

The Cartesian circulation was not the same as the Harveian. In a letter to Mersenne on February 9th 1639, however, Descartes claimed that his views on the circulation of the blood were "radically different" from Harvey's."[41] Indeed, Harvey took Descartes to task in *A Second Disquisition to John Riolan*, published in 1649, for failing to identify how much the relaxation and subsidence of the heart and arteries differ from their distension or diastole, and for his inapt explanation of the efficient cause of the pulse.[42] As Etienne Gilson has pointed out, the heart for Descartes was a passive organ; the expansion and the contraction of the heart had only one cause; and he disagreed with Harvey on systole and diastole.[43]

Over a sixteen-year period, between 1632 and 1648, there is a remarkable consistency in Descartes' view of Man as a machine, which he initially developed under the impulse of both Vesalius and Harvey.

The *Treatise on Man* appears to have been written in 1633. Here is found Descartes' first complete philosophical articulation of the metaphor of Man the machine. He advanced the idea that the soul was joined to this human machine: "First I must describe the body on its own; then the soul, again on its own; and finally I must show how these two natures would have to be joined and united in order to constitute men who resemble us. I suppose the body to be nothing but a statue or machine made of earth…"[44]

Just as people saw around them clocks, artificial fountains, mills and other man-made, self-moving machines, so they could understand by analogy the perfections of God's machine: "I am supposing this machine [the human body] to be made by the hands of God, and so I think you may reasonably think it capable of a greater variety of movements than I could possibly imagine in it, and of exhibiting more artistry than I could possibly ascribe to it."[45]

Descartes then went on to affirm that the parts of the blood, which penetrate into the brain, produce there "a very lively and pure flame, which is called the animal spirits."[46] The actions of these animal spirits nourish the brain and sustain its substance. They have the power "to change the shape of the muscles in which the nerves are embedded, and by this means to move all the limbs." In developing this mechanistic explanation of the nervous system, Descartes likened the action of the nerves, to the grottos and fountains in the royal gardens, from which water is thrust with such force as it emerges that it powers various machines. "Indeed, one may compare the nerves of the machine I am describing with the pipes in the works of these fountains, its muscles and tendons with the various devices and springs which serve to set them in motion, its animal spirits with the water which drives them, the heart with the source of the water, and the cavities of the brain with the storage tanks."

After further developing this analogy between bodily functions and the action of fountains, Descartes introduced the soul into the brain: "when a *rational soul* is present in this machine it will have its principal seat in the brain, and reside there like the fountain-keeper who must be stationed at the tanks to which the fountain's pipes return if he wants to produce, or prevent, or change their movements in some way."[47] Moreover, external objects striking the sense organs act through tiny fibres coming from the innermost region of the brain. But the rational soul does not just happen to be joined to the body: "Now I maintain that when God unites a rational soul to this [bodily] machine (in a way that I intend to explain later) he will place its principal seat in the brain, and will make its nature such that the soul will have different sensations corresponding to the different ways in which the entrances to the pores in the internal surface of the brain are opened by means of the nerves." Movements in the brain can thus explain body pleasure such as titillation; the perception that surfaces are smooth or rough; and such qualities as moisture, dryness, weight and the like.

Just as the soul is seated in the fountain-like brain, "you can think of our machine's heart and arteries, which push the animal spirits into the cavities of its brain, as being like the bellows of an organ, which push air into the wind-chests; and you can think of external objects, which stimulate certain nerves and cause spirits contained in the cavities to pass into some of the pores, as being like the fingers of the organist..."[48]

In *Treatise on Man*, Descartes sought to explain in the purely material terms of mechanistic science, that animal spirits formed ideas on the surface of the pineal gland, which was the seat of the imagination, of the common sense, and indeed, as he would later affirm, of the human soul: "But in so far as we have one simple thought about a given object at any one time, there must necessarily be some place where the two images coming through the two eyes, or the two impressions coming from a single object through the double organs of any other sense, can come together in a single image or impression before reaching the soul." This "place" was the pineal gland.[49]

And in his search for order and rationality in the structure of the human body, Descartes concluded that bodily functions "follow from the mere arrangement of the machine's organs every bit as naturally as the movements of a clock or other automaton follow from the arrangement of its counter-weights and wheels. In order to explain these functions, then, it is not necessary to conceive of this machine as having any vegetative or sensitive soul or other principle of movement or life, apart from its blood and its spirits, which are agitated by the heat of the fire burning continuously in its heart – a fire which has the same nature as all the fires that occur in inanimate bodies."[50]

In the *Discourse on Method*, written between 1634 and 1637, Descartes discussed Harvey's discovery of the circulation of the blood at some length. The discussion is interesting for our purposes, since it shows up the highly speculative nature of Cartesian affirmations about physical properties of the body, which were a departure even from Harvey's wildest flights of hermetic prose about the magical properties of blood. Descartes claimed that the precise location of the common sense, the memory and the corporeal imagination "will not seem at all strange to those who know how many kinds of automatons, or moving machines, the skill of man can construct with the use of very few parts, in comparison with the great multitude of bones, muscles, nerves, arteries, veins and all the other parts that are in the body of any animal. For they will regard this body as a machine which, having been made by the hands of God, is incomparably better ordered than any machine that can be devised by man, and contains in itself movements more wonderful than those in any such machine."[51]

Two years after finishing the *Discourse on Method*, Descartes wrote once more to Mersenne (February 20th 1639), that "the number and the orderly arrangement of the nerves, veins, bones and other parts of an animal do not show that nature is insufficient to form them, provided that you suppose that in everything nature acts exactly in accordance with the laws of mechanics, and that these laws have been imposed on it by God. In fact, I have taken into consideration not only what Vesalius and the others write about anatomy, but also many details unmentioned by them, which I have observed myself while dissecting various animals."[52]

In the *Meditations on First Philosophy*, the first edition of which was published in 1641, Descartes addressed the problem posed by disease for his machine model of the human body.[53] In the *Fourth Set of Replies* II:161, written in 1641, he addressed the difficulty of involuntary motions of the body.[54]

Descartes' maintained a lifelong commitment to this idea. In his last years, in a discussion with Burman, apparently in 1648, he reaffirmed that "God made our body like a machine, and he wanted it to function like a universal instrument which would always operate in the same manner in accordance with its own laws. Accordingly, when the body is in good health, it gives the soul a correct awareness; but when it is ill, it still affects the soul in accordance with its own laws, and the necessary result of this is a state of awareness whereby the soul will be deceived. If the body did not induce this misleading state, it would not be behaving uniformly and in accordance with its universal laws; and then there would be a defect in God's constancy, since he would not be permitting the body to behave uniformly, despite the existence of uniform laws and modes of behaviour..."[55]

Finally, in 1647, Descartes returned to this subject in *Description of the Human Body*. He acknowledged that it was hard to believe that the mere disposition of the bodily organs is sufficient to produce in us all the movements, which are in no way determined by our thought. "So I will now try to prove the point, and to give such a full account of the entire bodily machine that we will have no more reason to think that it is our soul which produces in it the movements which we know by experience are not controlled by our will than we have reason to think that there is a soul in a clock which makes it tell the time."[56]

Descartes wanted the reader to have a general notion of the entire machine, which he was describing, and he could think of no better way to convey this general notion, than by comparing the structure of the human body to specific technologies of his day. "So I will say that the heat in the heart is like the great spring or principle for all the movements occurring in the machine. The veins are pipes which conduct the blood from all the parts of the body towards the heart, where it serves to fuel the heat there. The stomach and the intestines are another much larger pipe perforated with many little holes through which the juices from the food ingested run into the veins; these then carry the juices straight to the heart. The arteries are yet another set of pipes through which the blood, which is heated and rarefied in the heart, passes from there into all the other parts of the body, bringing them heat and material to nourish them. Finally, the parts of the blood that are most agitated and lively are carried to the brain by the arteries coming directly from the heart in the straightest line of all: these parts of the blood make up a kind of air or very fine wind which is called the 'animal spirits'. These dilate the brain and make it ready to receive these impressions both from external objects and from the soul; and in receiving these impressions the brain acts as the organ or seat of the 'common sense', the imagination and the memory. Next, this air or these same spirits flow from the brain through the nerves into all the muscles, thus making the nerves ready to function as organs for the external senses; they also inflate the muscles in various ways and thus impart movement to all parts of the body."[57]

Descartes was obviously mistaken in many points of his discussion of anatomy: he re-interpreted the facts of other people's observations, in order to suit his own philosophical conclusions. In so doing, he appeared frequently to have misunderstood those facts. On this subject, M. Foster has written: "If we judge Descartes from the severe standpoint of exact anatomical knowledge, we are bound to confess that he, to a large extent, introduced a fantastic and unreal anatomy in order to give clearness and point to his exposition." However, the same author acknowledged that Descartes "did succeed in showing that it was possible to apply to the interpretation not only of the physical but also of the psychical phenomena of the animal body, the same method which was making such astounding progress when applied to the phenomena of the natural world."[58]

The problem was surely that Descartes applied the wrong method to the human body: he assumed that he could build up knowledge about anatomy by proceeding from known causes deductively to their effects. The fallacy of this approach, according to Norman Kemp Smith, is evident: " In the case of a machine, made by human hands, its several parts, being visible to the eye, can be directly and adequately known. But in the case of the animal organism, the visible organs are minutely articulated in their invisible parts, and the nature of these articulations can be learned only very indirectly."[59]

There were weaknesses in Descartes' reasoning. His medical legacy has proven to be somewhat ambivalent. He was less interested in the Galenic instrumentality and the Renaissance functionality of bodily organs and processes, than in the abstract values which he could attribute to them. He represented a departure from Leonardo, Vesalius and Harvey, by trying to provide a rational explanation for, and indeed a specific material location to, the imagination, the common sense and the rational soul. Descartes' own speculative anatomy in the *Treatise on Man* betrayed the very four-part approach to acquiring certain knowledge he had developed, and in its details was often materially inaccurate. His insistence on the material unity of body and soul, a unity he claimed was based on his own observations of anatomy, actually opened a rift between body and soul. Descartes took several positions challenging the dogmatism of Scholastic philosophy, although, ironically, he ended up promoting a new dogmatism of his own, which was largely based on false premises and circular arguments.

The discovery that the human body could be interpreted mechanically has led to many innovations in medical science and technology, vastly improving health and saving lives. This discovery is at least partly attributable to Descartes. T.H. Huxley wrote in 1870 that the spirit of Descartes' passages "is exactly that of the most advanced physiology of the present day; all that is necessary to make them coincide with our present physiology in form, is to represent the details of the workings of the animal machinery in modern language, and by the aid of modern conceptions." For Huxley, Descartes led on the one hand to Idealism, from Berkeley to Hume and Kant, and on the other to Materialism, by way of La Mettrie and Priestley.[60]

The tensions that existed between Descartes' religion and metaphysics, on the one hand, and his natural philosophy, on the other, reflected tensions then building during the seventeenth century. His role in leading the "fourth epoch" of the scientific Renaissance, in the terms of Friedrich Lange, must be acknowledged.

In some respects, he is surprisingly modern. Without the impulse given by his mechanical view of the body, it is doubtful whether the Human Genome Project could ever have got off the ground, in the late twentieth and early twenty-first centuries. He established a philosophical view of the mechanisms of the mind that derived much of its strength from the metaphor of Man the machine. For this reason he remains relevant to the artificial intelligence community today, in its drive to replicate the structure of the human mind in ever-more powserful computers, which will greatly accelerate human mental functions.

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1 At the risk of committing an anachronism, by applying the word "scientific" to a historical period when "natural philosophy" was the more appropriate term, we here note the view of Friedrich A. Lange. Descartes and Bacon were leaders of the epoch of philosophy: the fourth and culminating epoch of the two-century-long movement to regenerate the sciences. The first epoch "concentrates the chief interest of Europe upon philology… The domination of theology is sufficiently indicated by the storms of the reformation era: it suppressed for a long time almost all other scientific interests, especially in Germany. Then the natural sciences, which had been gaining strength since the beginning of the renascence in the quiet workshops of inquirers in the brilliant era of Kepler and Galilei, first took up a commanding and prominent position. Only in the fourth line came philosophy, although the culminating point of Bacon's and Descartes' activity in establishing principles falls not much later than the great discoveries of Kepler." Friedrich A. Lange, *The History of Materialism*, 3rd edition, 1st Book, 2nd Section, pp. 215-216. That the term "science" when applied to Descartes is *not* an anachronism may be an inferred from a letter to Hogelande which he wrote on February 8th 1640: "By 'science' I mean the skill to solve every problem, and thus to discover by one's own efforts everything capable of being discovered in that science by means of our native human intelligence…." *Philosophical Works of Descartes*, vol. III, p. 144. Hereafter referred to as *PWD*.

2 "Consciousness, Intentionality and Intelligence: Some Foundational Issues for Artificial Intelligence" in *Journal of Experimental & Theoretical Artificial Intelligence* 12:3 (2000), pp. 263-264.

3 We gave a working definition of metaphor drawn from Aristotle's *Poetics* 21, in note 17 of the Introduction: "Metaphor is the application of an alien name by transference either from genus to species, or from species to genus, or from species to species, or by analogy, that is, proportion." A further distinction can be drawn between metaphorical analogies (Leonardo, Vesalius, Harvey) and metaphorical equations – Descartes' reference to Man the machine falls in the latter category. An illuminating discussion of metaphor in a modern rhetorical context is to be found in Chaïm Perelman and Lucie Olbrechts-Tyteca, *Traité de l'Argumentation* (Brussels, 1988), pp. 534-542.

4 On such equations, see Norman Kemp Smith, *New Studies in the Philosophy of Descartes* (London, 1966), pp. 323-325.

5 See Istituto Geografico De Agostini, *Leonardo da Vinci*, p. 192.

6 Descartes and Bacon developed different strategies in establishing new and reliable methods of building certain knowledge. The ever-anxious Descartes left France for more tolerant Holland; withheld publication of some controversial works until a time when they would prove more palatable; presented some of his ideas as complements rather than substitutes for the more dogmatic form of Aristotelianism; and referred extensively in his correspondence with friends to his worries about persecution for his ideas. Bacon was far more adept at employing the rhetorical tools of persuasion. He deliberately sought the mantle of Aristotle, by giving titles to discursive works such as *The New Organon*. Bacon was also ambiguous, from our latter-day perspective: by turns rationalist, materialist, hermetic, dabbler in alchemy, poet, man of faith, dilettante natural philosopher, politician and prisoner, he wrote works which sometimes resemble rambling, rumbling chains of metaphors. His experiments in natural philosophy were not so successful as those of Descartes (in fact Bacon died when an experiment failed), although he played an important role in reformulating the objectives and methods of natural philosophy.

[7] Friedrich A. Lange, *The History of Materialism*, 3rd edition, 1st Book, 2nd Section, p. 242.
[8] Etienne Gilson, *René Descartes, Discours de la Méthode: texte et commentaires* (Paris, 1966), pp. viii-ix. Our translation.
[9] A. Boyce Gibson, *The Philosophy of Descartes* (New York, 1967), p. 4.
[10] Richard B. Carter, *Descartes' Medical Philosophy* (Baltimore, 1983), p. 20.
[11] "Descartes' Physiology and Psychology", in J. Cottingham (ed.) *The Cambridge Companion to Descartes* (Cambridge, 1992), p. 340.
[12] For example,. Genevieve Rodis-Lewis, "Limitations of the Mechanical Model in the Cartesian Conception of the Organism" in Michael Hooker (ed.) *Descartes: Critical and Interpretative Essays* (Baltimore, 1978), pp. 152-170.
[13] Stephen Wolfram, *A New Kind of Science* (Champaign, Illinois, 2002), p. 1027.
[14] Baillet described the three dreams in detail. A complete English translation is published in Norman Kemp Smith, *New Studies in the Philosophy of Descartes*, pp. 33-39. For our purposes it is interesting to note that Descartes was greatly disturbed by the first two dreams which he interpreted as menacing admonitions of terror and dismay, and took consolation in the third dream, which he saw as an indication of the future path of his life. He vowed the next day to make a pilgrimage to Loreto "to enlist the favour of the blessed Mother of God."
[15] *PWD*, vol. III, p. 75.
[16] *Ibid.*, vol. III, pp. 79-80.
[17] *Ibid.*, vol. III, p .86.
[18] *Ibid.*, vol. III, p. 141.
[19] *Ibid.*, vol. III, p. 161.
[20] *Ibid.*, vol. III, p. 177.
[21] *Ibid.*, vol. III, pp. 40-41.
[22] *The Great Instauration*, in Francis Bacon, *The New Organon*, ed. by Fulton H. Anderson (New York & Indianapolis, 1960), pp. 19-20.
[23] *Ibid.*, pp. 20-21.
[24] Francis Bacon, *The New Organon*, translated by Michael Silverthorne (New York, 2000), Book I, Axiom LXVII, pp. 79-80.
[25] *Ibid.*, Book I, Aphorisms XCVIII, XCIX, C & CI, pp. 94-97.
[26] In 1623, Galileo expressed a faith in mathematics, which seemed close to the esoteric or hermetic tradition, as well as being an outgrowth of Plato's *Timaeus*, with its idealistic insistence on perfect geometric forms and relations in heavenly bodies, and its attempt to express motion as number: "Philosophy," according to Galileo, "is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and to read the letters in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures without which it is impossible to understand a single word of it." Quoted in Stillman Drake, *Experiment and Science: A Galilean dialogue incorporating a new English translation of Galileo's 'Bodies That Stay Atop Water, Or Move In It'* (Chicago, 1981), p. 207.
[27] Galileo Galilei, *Dialogue Concerning the Two Chief World Systems*, translated by Stillman Drake (Berkeley, 1967) p. 101.
[28] In *Dialogue Concerning the Two Chief World Systems*, it is interesting to note that Salviati uses Aristotle's authority to refute Aristotle himself: "Does Aristotle not declare that what sensible experience shows ought to be preferred over any argument, even one that seems to be extremely well founded? And does he not say this positively and without a bit of hesitation?" (p. 55). Salviati then goes on to argue that Aristotle would have changed his views on the inalterable nature of the universe, had he lived in the seventeenth century: Aristotle "admitted such perceptions to be very difficult for him by reason of the distance from his senses, and conceded that one whose senses could better represent them would be able to philosophize about them with more certainty. Now we, thanks to the telescope, have brought the heavens thirty times closer than they were to Aristotle, so that we can discern many things in them that he could not see." *Ibid.*, p. 56.
[29] The creative and highly rhetorical use of Aristotle's authority just alluded to shows that Galileo wanted to demolish the Aristotelian-Ptolemaic world system by stretching the possibilities of the senses, and showing that new discoveries would replace old truisms. Galileo's Aristotelian opponents retorted immediately with appeals to authority as well as deductions and inferences based on the

unaided senses. But there was a time lag between publication of Galileo's findings and their verification by other astronomers. This in turn had the effect of placing new emphasis on his revolutionary techniques of observation, which required rigour and the application of method.

[30] It was in the early seventeenth century that modern science emerged from the confining orthodoxy of Aristotelianism, to become the quickly evolving, self-correcting, forward-looking enterprise that we know today. Much as Galileo was conscious of demolishing false ideas with new observations, in *Dialogue Concerning the Two Chief World Systems*, he argued that natural philosophers should not judge what they couldn't see. He had Sagredo say, "Besides, what does it mean to say that the space between Saturn and the fixed stars, which these men call too vast and useless, is empty of world bodies? That we do not see them, perhaps? Then did the four satellites of Jupiter and the companions of Saturn come into the heavens when we began to see them, and not before? Were there not innumerable other fixed stars before men began to see them? The nebulae were once only little white patches; have we with our telescopes made them become clusters of many bright and beautiful stars? Oh, the presumptuous, rash ignorance of mankind!"[30] At the same time, Galileo noted "although astronomy has made progress over the course of the centuries in investigating the arrangement and movements of the heavenly bodies, it has not thereby arrived at such a state that there are not many things which still remain undecided, and perhaps still more which remain unknown." *Ibid.*, p. 455.

[31] In *Dialogues concerning Two New Sciences*, Salviati says: "I hope therefore it will not appear to be a waste of time if we discuss at considerable length this first and foremost question upon which hinge numerous consequences of which we have in this book only a small number, placed there by the Author, who has done so much to open a pathway hitherto closed to minds of speculative turn. So far as experiments go they have not been neglected by the Author; and often, in his company, I have attempted in the following manner to assure myself that the acceleration actually experienced by falling bodies is that above described." Galileo Galilei, *Dialogues concerning Two New Sciences*, translated by Henry Crew and Alfonso de Salvio (New York, 1954), p. 178.

[32] William Harvey, *Animal Generation*, p. 334.

[33] *PWD*, vol. II, pp. 117-120.

[34] *Ibid*, vol. III, p. 134.

[35] Etienne Gilson, *René Descartes: Discours de la Méthode, texte et commentaires*, p. 383.

[36] *Rules for the Direction of the Mind* was possibly written in 1628, or several years earlier, but not published during Descartes' lifetime. *PWD*, vol. I, p. 19.

[37] *PWD*, vol. I, p. 186.

[38] The most detailed Cartesian exposition of the motions of the heart is contained in Part Five of the *Discourse on Method.*

[39] Roger Kenneth French, *William Harvey's Natural Philosophy*, p. 185.

[40] *PWD*, vol. III, p. 40.

[41] *Ibid.*, vol. III, p. 134.

[42] William Harvey, *A Second Disquisition to John Riolan* (New York, 1952), p. 327.

[43] Gilson, *Discours de la Méthode*, p. 405.

[44] *PWD*, vol. I, p. 99.

[45] *Ibid.*, vol. I, p. 99.

[46] *Ibid.*, vol. I, p. 100.

[47] *Ibid.*, vol. I, p. 102.

[48] *Ibid.*, vol. I, p. 104.

[49] There has occasionally been controversy as to whether the pineal gland exists. According to the fifteenth (1901) edition of *Gray's Anatomy*, "The pineal gland, so named after its peculiar shape (pinus, a fir-cone), is a small reddish-grey body, conical in shape ... placed immediately above and behind the posterior commissure and velum interpositum, which intervenes between it and the splenium of the corpus callosum.... Morphologically the pineal gland is regarded as the homologue of the structure termed the pineal eye of the lizards. In these reptiles the epithysis cerebri is attached by an elongated stalk and projects through the parietal foramen. Its extremity lies immediately under the epidermis, and on microscopic examination presents, in a rudimentary fashion, structures similar to those found in the eyeball." Henry Gray and H. V. Carver, *Gray's Anatomy* (New York, 1997) pp. 651-652.

[50] *PWD*, vol. I, p. 108.

[51] *Ibid.*, vol. I, p. 139.

[52] *Ibid.*, vol. III, p. 134.

[53] "A sick man is no less one of God's creatures than a healthy one, and it seems no less a contradiction to suppose that he has received from God a nature which deceives him. Yet a clock constructed with wheels and weights observes all the laws of nature just as closely when it is badly made and tells the wrong time as when it completely fulfils the wishes of the clockmaker. In the same way, I might consider the body of a man as a kind of machine equipped with and made up of bones, nerves, muscles, veins, blood and skin in such a way that, even if there were no mind in it, it would still perform all the same movements as it now does in those cases where movement is not under the control of the will or, consequently, of the mind. I can easily see that if such a body suffers from dropsy, for example, and is affected by the dryness of the throat which normally produces in the mind the sensation of thirst, the resulting condition of the nerves and other parts will dispose the body to take a drink, with the result that the disease will be aggravated. Yet this is just as natural as the body's being stimulated by a similar dryness of the throat to take a drink when there is no such illness and the drink is beneficial. Admittedly, when I consider the purpose of the clock, I may say that it is departing from its nature when it does not tell the right time; and similarly when I consider the mechanism of the human body, I may think that, in relation to the movements which normally occur in it, it too is deviating from its nature if the throat is dry at a time when drinking is not beneficial to its continued health." *PWD*, vol. II, pp. 58-59.

[54] "Now a very large number of the motions occurring inside us do not depend in any way on the mind. These include heartbeat, digestion, nutrition, respiration and the like, when these occur without the mind attending to them. When people take a fall, and stick out their hands so as to protect their head, it is not reason that instructs them to do this; it is simply that the sight of the impending fall reaches the brain and sends the animal spirits into the nerves in the manner necessary to produce this movement even without any mental volition, just as it would be produced in a machine." *Ibid.*, vol. II, p. 161.

[55] *Ibid.*, vol. III, p. 346.

[56] *Ibid.*, vol. I, p. 315.

[57] *Ibid.*, vol. I, pp. 315-316.

[58] Sir Michael Foster, *Lectures on the History of Physiology* (New York, 1970), p. 268.

[59] Norman Kemp Smith, *New Studies in the Philosophy of Descartes*, pp. 125-126.

[60] T. H. Huxley, "On Descartes' 'Discourse Touching the Method of Using One's Reason Rightly, and of Seeking Scientific Truth", in *MacMillan's Magazine* 22 (1870), pp.76-78.

THOMAS HOBBES (1589-1679)

Hobbes, like Descartes, sought to develop a universal philosophical system on a mechanical basis, and his works cover an astonishing range of subjects and interests, whether they be translations of ancient Greek literature, youthful discourses on classical Roman history, travelogues, treatises on physics, mathematics, religion, rhetoric, political theory, historical accounts of the English Civil War, or autobiographical sketches in prose and poetry.[1]

Leonardo, Vesalius and Harvey were experts on anatomy who did some philosophizing, and Descartes did some anatomizing in order to bolster his mechanistic philosophy. Hobbes was the first thinker to apply the metaphor of Man the machine in any systematic way to political theory. He marked an important departure from the thinkers considered so far. Leonardo, Vesalius and Harvey treated the metaphor of Man the machine as an *analogy*, while Descartes turned it into an *equation*. Hobbes, for his part, while doubtless subject to the influence of Vesalius, Harvey, Descartes and Galileo (as well as Epicurus and Lucretius, by way of Bacon, Mersenne and Gassendi), transformed Man the machine into a *prescription* – an authoritative statement of norms, rules and directions for humankind. It is a moot point whether Descartes or Hobbes was the first to develop an all-embracing mechanical conception of nature.[2]

Many scholars have debated whether Hobbes did not seek to derive norms from facts.[3] In fact, Hobbes sought to derive the single most important of his norms from a metaphor – Man the machine. And in so doing, he consciously made a break with the thinkers already considered (with the possible exception of Leonardo, since

Hobbes cannot have "broken" with someone whom he apparently did not know directly). Whereas Descartes, for example, had "invented" an idealized, mechanistic body, which remained nevertheless largely organic, Hobbes "recast" Man as a perfected, mechanical machine, whose spiritual life, psychology, bodily design and functions, as well as social organization could all be interpreted in terms of matter in motion, and were therefore all machine-like.

Throughout much of the Hobbesian corpus, the metaphor of Man the machine can be found in one way or another, but the most important uses to which Hobbes put it were *political*. He did not develop an ideal society after the manner of the Utopians, whose works enjoyed a wide following in England from Thomas More onwards. Nor can he be considered the first modern to have considered the State to be a machine.[4] On the contrary, Hobbes based his analysis of the commonwealth on a highly pessimistic and reductionist interpretation of the life of man, which is "solitary, poore, nasty, brutish, and short".[5] Indeed, the fact that Hobbes was a *pessimist* about humankind, whose fearful perspective on the universe was reinforced by staunch Calvinism, helps to explain why he seized on the metaphor of Man the machine as a means of control. For Hobbes was an *optimist* where the machine was concerned. It was as if he had taken Plato's body politic, [6] joined it to Harvey's mechanical body, and created a completely new *mechanical* body politic.[7] The metaphor of Man the machine was therefore a rhetorical device, offering the prospect of "tightening up" human society, of establishing order to prevent chaos, and investing the all-powerful sovereign with absolute authority in order to prevent what he feared would be absolute anarchy. His was a system that balanced the rights and obligations of the citizens and required them to submit to an all-powerful, vertical State, in a machine-like fashion. He implied that humans should model themselves on admirably rational, well-constructed and regulated machines. Not only that: humans should work like cogs in an absolutist Automated State.

This may seem surprising, considering that Hobbes sought in the machine an *individual remedy* for the fear he felt throughout his life – but it is only surprising if we forget that Hobbes saw fear as a fundamental and in some circumstances desirable social phenomenon.

As a pessimist about humankind, he compared humans to automata and found them wanting, since they were not so easily described or regulated. He associated automata not with people as they really were, but with people as he felt they ought to be. He admired the machine since it could be taken apart, analysed and reconstructed, since it was rationally designed, regulated, effective, and utterly predictable. But his Man the machine was an intimidating force standing above human society. The Hobbesian Automated State wielded absolute power, derived in part from the fear it inspired among the citizenry, while the individuals were no more than cogs ceaselessly in motion.

In the face of man's warring nature, the machine offered Hobbes advantages at three distinct levels: (1) by mechanizing the Platonic body politic, Hobbes breathed new life into a powerful political myth from classical Antiquity; (2) by applying the Galilean mechanical idea of "matter in motion" to human society, Hobbes transferred the prestige of mechanistic physics to politics; (3) by serving up the machine (a technological device that efficiently repeated the same tasks, was predictable, could be fabricated, controlled, regulated and standardized), he provided a new model for society to emulate.

Hobbes made an original interpretation of the metaphor of Man the machine, drawing on some new sources. He marked a radical departure from the other thinkers considered earlier. True enough, he saw man as a machine. But if man was in God's image and likeness, it was because man and God either had corporeal existence, or no existence at all. Moreover, the microcosm and self-mastering individual were virtually nowhere to be seen in Hobbes. Finally, according to his human psychology, men were nasty, perverse and brutal, bent on waging war to defend their narrow interests; this was nothing like the glorious, sunny horizons that lay before Pico della Mirandola's Renaissance individual, full of dignity and virtually unlimited potential. Hobbesian Man, deprived of spiritual affinity with God (at least in the perspective of philosophical dualism), deprived of the God-given order and purpose of his body, of his unlimited psychological potential and his capacity to master himself, was thus reduced to being a miserable atom-like individual, ever in motion, who needed to be contractually bound to an absolute sovereign in order to have even a hope of peace and security.

Hobbes was a far cry from Leonardo's instrumental vision of the perfectly-proportioned human body. In Hobbes are found the roots of many ideas widespread in our own day: the perfected and regulated machine provides a methodological model for our understanding of complexity; the machine also serves as a norm, which can only mean that we are somehow not "up to" the standards of order and rationality which it represents; the machine can be used as a means of control, on the individual as much as on the collective level; thinking is no more than computation (this in itself is an anticipation of today's artificial intelligence).

Many scholars have looked for linearity in Hobbes, which has required them to identify which came first in his thinking – the principle of matter in motion *or* his methodology. However, if we imagine Hobbes' ideas to be fluid and circular rather than static and linear, we may avoid this problem, by representing his ideas as a continuous loop. The fundamental physical principle of "matter in motion" supported the machine-model methodology, which in turn justified the enunciation of geometric definitions and rules, which finally opened the way to the metaphor of Man the machine, which led back to "matter in motion".

Leonardo, Vesalius and Harvey used the machine as an *analogy* for particular anatomical functions; Descartes used it as an *equation*; and Hobbes seized on the machine as a normative *prescription* for humankind. Hobbes sought in the rationality and order of the machine a model for human society that would serve as a *prescription* for a better world. We can imagine Hobbes saying, "if only disorderly humans were like orderly machines, then we could build a society where order is protected under the power and authority of the absolute sovereign, and disorder has no place." In this respect, Hobbes' "if-only" position has found many adherents in recent centuries.

Hobbes was controversial in his own day. He was attacked in England for his "materialist doctrine", his skepticism of witchcraft, his determinism, his ethical relativism, his "low", pessimistic views of human nature.[8] He was accused of being an atheist whose irreligion had brought on the Great Fire of 1666, which destroyed much of London.[9] Hobbes attacked both superstition and arbitrary rule. The superstitious nature of decisions in politics in the late sixteenth and early seventeenth centuries is well documented: one has only to think of works on demonology by Jean Bodin (1530-1596) and James VI of Scotland (later James I of Great Britain).[10]

Moreover, the arbitrary nature of power had made life difficult for many courtiers, such as Sir Walter Raleigh (c. 1554-1618) and Sir Francis Bacon.[11] Hobbes was trying to establish some rationality in politics, based on proven methods. Indeed, he was respected for the role he played in reformulating the theory of absolute monarchy, during the Restoration in England. By the end of the seventeenth century and well into the eighteenth century, his contribution to mechanistic philosophy was widely acknowledged, although this acknowledgment was selective: the price paid for "the triumph of the mechanical and mathematical outlook on nature" was a violent denunciation of the philosophical materialism at the core of Hobbes' life work.[12]

Below is a table summarizing some of the influences on Hobbes:

Hobbes' interpretation	Sources	Key features
The body as machine	Harvey & Galileo, Hobbes' being impressed by machines & automata; rediscovery of Epicurus through Mersenne and Gassendi	The universe is a machine, and all that it contains is matter in motion; since the body is in the universe, the body is also matter in motion, and therefore a machine; rhetorically, the human body is compared to the more highly-perfected automaton
Man in God's image and likeness	Old and New Testament texts, although one is never sure whether Hobbes gave them any credence	Man is like God, to the extent that both have corporeal bodies, and are matter in motion
Man as a microcosm	Virtually absent	God and the sovereign are compared; there is a parallel between God's orderly, rational universe and the microcosmic absolutist State: Charles I is compared to Jesus Christ
Man as self-mastering individual	Absent	Absent
Man as a psychological being	Psychological realism through Thucydides (the role of the individual in political affairs); Hobbes' pessimistic Calvinist reading of human psychology, which marked a break with humanist optimism during the Renaissance	Psychology is dependent on the motion of sensations; man's dark psychological nature requires an all-powerful State and social controls; mechanical view related to skepticism, determinism and ethical relativism
Man as a being endowed with reason and devoted to the pursuit of happiness		Reason was good; happiness was irrelevant
Man as a cog within an Automated State		This restatement of Plato's ideal State was made overtly by Hobbes in the *Leviathan*

Thomas Hobbes was born on Good Friday, 1588 in the village of Westport, near Malmesbury, Wiltshire. In the *Verse Life,* he described himself at birth as a "poor worm", and then went on to write that an early formative experience was fear: "My

Native place I'm not asham'd to own;/Th'ill Times, and Ills born with me, I bemoan:/For Fame has rumour'd that a Fleet at Sea,/Wou'd thereupon cause our Nations Catastrophe;/And hereupon it was my Mother Dear/Did bring forth Twins at once, both Me, and Fear."[13]

In the view of a recent biographer, A.P. Martinich, this fear afflicted Hobbes throughout his life, and can be seen as one of the motivating forces of his lifework: "Much of Hobbes's life had been a struggle for survival," Martinich wrote. "His family was lower middle class; his father abandoned the family when Hobbes was an adolescent. Much of what he did was motivated by fear. He lived in exile for a decade because he was afraid of being killed in the English Civil War. He returned to England because he feared the French and some exiled English clergy and the possibility of assassination by resentful royalists. There he feared prosecution for atheism, both during the Commonwealth and the Restoration. He also came to fear the loss of his mathematical reputation and battled furiously, if not wisely, some of the most powerful members of the Royal Society. In short, much of his life was spent in fear of war. All other time was peace."[14]

In the face of this perpetual fear, Hobbes sought the security of order, with ever-greater intensity. He graduated from Magdalen Hall, Oxford in his twentieth year, serving as tutor or companion thereafter to William Cavendish, later the Earl of Devonshire. It is not known for certain when the two conducted a tour of the European continent: it may have been in 1610 or in 1614.[15] Three discourses, speculatively attributed in 1995 to Hobbes on the basis of "statistical word printing", may give some indication of his interests and opinions during the 1620s.[16] The first consists of a discourse on the beginning of Tacitus (c. 56-120 AD), an idea Hobbes may have drawn from Machiavelli's *Discourse on the First Ten Books of Livy*, offering maxims about the foundations of political life. He examined the challenges facing Augustus (62-14 BC) as a new prince in a new State: "A new Prince ought to avoid those names of authority, that rub upon the Subjects' wounds, and bring hatred, and envy, to such as use them."[17] The second discourse concerned his visit to Rome: it contained observations about architecture, the institution of the Roman Catholic church, and the attitude for an Anglican to take while visiting there. The third is a *Discourse on Laws*, which contained nothing remotely approaching the mechanical conception of the Commonwealth, although the author, following Plato, affirmed the necessity of great and absolute laws, given the depraved affections and manners of men.[18]

During the 1620s, Hobbes served as secretary to Sir Francis Bacon. We read in Aubrey's *Brief Life* that "the Lord Chancellor Bacon loved to converse with him. He assisted his lordship in translating several of his Essays into Latin, one, I well remember, was the *Of the Greatness of Cities*: the rest I have forgot. His lordship was a very contemplative person, and was wont to contemplate in his delicious walks at Gorambery, and dictate to Mr Thomas Bushnell, or some other of his gentlemen, that attended him with ink and paper ready to set down presently his thoughts. His lordship would often say that he better liked Mr Hobbes's taking his thoughts, than any of other, because he understood what he wrote, which the others not understanding, my lord would many times have hard task to make sense of what they writ."[19]

Despite their affinity for each other, Bacon and Hobbes were as different in outlook as they were in temperament. Hobbes made no attempt to reconcile knowledge of God with knowledge of Nature and of Humanity, the way Bacon had done. In Hobbes' work, God makes only a cameo appearance, almost as an afterthought, as an unknowable force in the universe, and one whose power could not be demonstrated. Hobbes may have lacked concern for God because he had identified motion as the perfect condition of all things, and God's motions could not be apprehended by the senses, and were therefore not in the knowable material world. At the same time, Bacon was lyrical in his portrayal of the mission of science, indulging in the use of rich imaginative metaphors, while Hobbes was to the point, wooden, single-mindedly devoted to the task of providing a grand philosophical system that would explain the universe. However, it is possible that Hobbes owed some of his interest in atomism to his early encounters with Bacon.[20]

During this period, Hobbes translated Thucydides' *The History of the Peloponnesian War*. Much has been made of Hobbes' supposed "discovery" of political realism while steeping himself in this historical work from classical Greece. Laurie M. Johnson has convincingly demonstrated that Thucydides upheld the role of national and individual character as well as civic-minded eloquence in determining the outcome of events, and thus presented "a picture of human nature that is neither wholly free of nor wholly slave to exterior forces." She has contrasted this view with that of Hobbes, whose "image of human nature conditioned his entire theory. His mechanism made it possible for him to depict men as uniformly egocentric individuals naturally at odds with one another."[21] In any case, there is no reason to suppose that a translator automatically agrees with a work he or she has taken pleasure in translating and considers important.

The 1630s marked a series of formative experiences for Hobbes. According to widely accepted although defective scholarly conventions, based in part on his own account, he discovered geometry – possibly in Switzerland, then contemporary natural science in France, and finally Galilean physics in Italy. The order in which these discoveries were made is anything but definite: Frithiof Brandt established his own chronology in the 1920s, but the fragmentary evidence of Hobbes' chronology has been explored in the 1990s by Noel Malcolm and A.P. Martinich.[22]

Hobbes' threefold discovery of geometry, contemporary natural philosophy and Galilean physics does not fully account for his interest in mechanical explanations of nature, or for the development of his mechanistic philosophy. One key element is missing: his much earlier appreciation for the work of William Harvey, who was in 1628, on publishing *Motions of the Heart*, the first to depict the human heart as a mechanism. In the view of Sir Geoffrey Keynes, "it is quite possible that Hobbes and Harvey had met at some time in the years 1621 to 1626 when, according to Aubrey, Hobbes was working as amanuensis to Sir Francis Bacon. For some years before and after this Hobbes was moving about Europe while in attendance, as friend and tutor, on members of the Cavendish family, though he would certainly have had opportunities of meeting Harvey during intervals spent in London." Keynes went on to suggest that Hobbes may have taken an interest in geometry, the physiology of motion and sensation and Galileo, on account of having known Harvey's work already.[23] Keynes considered it possible that Hobbes attended one of Harvey's dissections of the King's deer, when the compound motion within their bodies was investigated. According to Martinich, "Hobbes and Harvey must have been together occasionally during the 1630s when Harvey was doing autopsies on the king's deer.

Near the end of his life, Hobbes mentioned these activities: 'At the breaking up of a deer, I have seen it plainly in his bowels as long as they were warm. And it is called peristalique motion, and in the heart of a beast newly taken out of his body, and this motion is called systole and diastole. But they are both of them compound motion, whereof the former causes the food to wind up and down through the guts, and the later makes the circulation of the blood.'"[24] Given the lifelong friendship between Hobbes and Harvey, starting from the 1620s and continuing through to Harvey's death in 1657 (he left Hobbes the sum of £10 in his will); given that "Hobbes was more generous to Harvey in his public praise than to almost anyone else ... [putting] Harvey in the small class of great scientists that includes Copernicus, Johannes Kepler, Mersenne and Gassendi [and] perhaps more impressively, in *Six Lessons*, Hobbes compares Harvey favorably to himself";[25] given the likelihood that Hobbes accompanied Harvey during some dissections of the king's deer to see the mechanical workings of the heart in person – it seems perfectly reasonable to affirm that Harvey was an important influence on Hobbes that actually predated the latter's threefold discovery of geometry, contemporary natural philosophy and Galilean physics. From the available evidence, Hobbes would only appear to have studied Vesalius carefully around 1645, along with William Petty.[26]

It would seem that Hobbes became suddenly aware of Geometry around 1628 (according to Aubrey) or 1630 (according to the more recent Martinich), in one of those sudden personal conversion experiences that occasionally have marked the history of science. The stark simplicity and rigour of geometry would utterly transform Hobbes' outlook on life. As Aubrey wrote, "He was (*vide* his life) 40 years old before he looked on geometry; which happened accidentally. Being in a gentleman's library, Euclid's Elements lay open, and 'twas the 47th Element [i.e. proposition} at Book I. He read the proposition. 'By G–,' he said, 'this is impossible!' So he reads the demonstration of it, which referred him back to such a proposition; which proposition he read. *Et sic deinceps* [and so on], that at last he was demonstratively convinced of that truth. This made him in love with geometry."[27]

In one fell swoop, Hobbes was won over to Geometry. As he would write later, he came to recognize that "The end of knowledge is power; and the use of theorems (which, among geometricians, serve for the finding out of properties) is for the construction of problems; and, lastly, the scope of all speculation is the performing of some action, or thing to be done."[28]

Mathematical explanation was much prized by mid-seventeenth century scientists. Not only were the subject areas of mathematics greatly expanding, due to advances in calculation and analytic geometry, but at the same time, mathematics had been applied to open up so many new areas of knowledge and to solve so many scientific problems that it had acquired enormous prestige. Galileo was the first to apply mathematics to an analysis of mechanics. Applied mathematics had brought prodigious feats of engineering and round-the-world navigation, the systematic observation of planets and stars, within reach.

Geometric theory did not by any means revolutionize seventeenth century science, but is rather symptomatic of the heightened awareness of the prestige and value of mathematical explanation, and of the desire to break away from the God-centred universe of the Scholastics. The ultimate result of this theory of knowledge is to focus man's attention on the images of his senses, to get him to join these images to conceptions and so, ever questioning himself, build up to affirmations and conclusions, and thus reach an understanding of consequences dependent on his own observation and reasoning. It is interesting to note that Hobbes, in seeking to use geometry in order to emancipate thought, ended up creating a counter-dogma with which to attack the old dogma.

After geometry came natural science. In *The Prose Life*, we learn that when Hobbes "was staying in Paris, he began to investigate the principles of natural science. When he became aware of the variety of movement contained in the natural world, he first inquired as to the nature of these motions, to determine the ways in which they might effect the senses, the intellect, the imagination, together with the other natural properties. He communicated his findings on a daily basis to the Reverend Father Marin Mersenne, of the Orders of the Minim Brothers, a scholar who was venerated as an outstanding exponent of all branches to philosophy. He returned to England with his patron in 1637, and remained there, continuing to correspond with Mersenne on the natural sciences."[29]

Mersenne challenged Hobbes to investigate the natural sciences more extensively. The earliest surviving correspondence between Mersenne and Hobbes dates from January 1641: it is a letter from Descartes to be forwarded by Mersenne, and shows an early, biting Cartesian disdain for the English philosopher. Mersenne had been instrumental in the French revival of Epicurean philosophy, which depended largely on the humanist work of conservation, reconstruction and commentary undertaken by Pierre Gassendi, and which supported "the primary importance of experience as the touchstone of truth"[30] as well as rigorous discussion of Epicurean doctrines on the existence of the void, on atoms as eternal and uncreated, and on the role of God in the universe. Naturally, Gassendi sought to reconcile Epicurean philosophy with Christianity. This atomism offered "a conceptual framework within which sensory information concerning qualities and effects can be analysed and co-ordinated in a way that reduces the observable world to a meaningful pattern."[31] This French revival of Epicurus was of lasting importance for modern science.

We have seen how Hobbes underwent a conversion experience, becoming fascinated with geometry. Then he discovered in France the power of natural science, and pored over new interpretations of virtually lost Epicurean theories of natural philosophy. Finally, Hobbes owed to Galileo, whom he met during a visit in Italy, the view that physical phenomena could be universally explained by the theory of motion applied in the light of mathematical science. As E.A. Burtt wrote in, Hobbes acquired "a profound respect for Galileo, whom he visited at length on his third journey to the continent (1634-37) and from whom he received helpful confirmation of the notion already simmering in his own mind, that the sole and adequate explanation of the universe is to be found in terms of body and motion."[32] It is hard to believe that this visit represented Hobbes' first acquaintance with the thought of Galileo, however. He must have heard an earful about the great Italian during his first European tour in 1610 or 1614.

Galileo Galilei is one of the fathers of early modern science. His observations with the telescope in the early seventeenth century revealed many heavenly wonders invisible to the naked eye, such as the four delightfully named "Medicean Stars" or moons of Jupiter. He laid down the foundations of mechanics, thereby making the triumph of Copernicanism possible. He showed that nature obeyed mathematical laws. He established that falling bodies obey the law of uniformly accelerated motion. And he dealt a deathblow to the physics of the *Bible*, Aristotle and Ptolemy.

Along with such predecessors as Nicolas of Cusa and Giordano Bruno, Galileo had a big hand in replacing the Aristotelian-Ptolemaic view of the universe as spherical, static, perfectly ordered, closed, geocentric and finite – with the revolutionary new view of a universe at once wide open, boundless, full of irregular features, in constant motion and lacking any centre.

Needless to say, this represented a scientific crisis. Rupert Hall has written that "the impression made by Galileo's two great treatises upon the sciences of his century – and all subsequent science – derives not from the imperfections of his new mathematical and mechanical view of the universe but from the tremendous power of this view to explain things. What most aroused the admiration of Galileo's contemporaries was his success in creating a mathematical science of motion and, closely related to this, his persuasive justification of the Copernican theory in which again Galileo's own discoveries with the telescope played a notable part."[33]

Hobbes derived the new idea of motion from Galileo – and this was important. According to the Danish scholar Fritiof Brandt: "If we were to give a general estimate of Hobbes, it is not difficult to see that the whole of his philosophy is built up on the foundation of one single, quite simple idea, the idea of motion."[34] His entire philosophy, political and otherwise, was grounded in motion: his concepts of liberty, equality and natural rights developed as a response to the challenge of managing motion in society. He greatly exaggerated the importance of Galileo's achievements in mechanics. It was overly reductionist for him to seize on an abstract principle, which could be twisted into a universal theory to explain everything. But the way in which Hobbes applied a geometrical analysis of motion to many branches of knowledge beyond physics can be seen as a passionate tribute paid to the new learning then quickly spreading from Italy northwards throughout Europe.

In the 1640s, while exiled in Paris, Hobbes wrote a succession of works: *Human Nature and De Corpore Politico* in 1640; *De Cive* in 1642, and *De Corpore* which was only published in 1655. These were all planned as parts of an overall philosophical system. In Hobbes' own words, "To various Matter various Motion brings/Me, and the different Species of Things./Man's inward Motions and his Thoughts to know,/The good of Government, and Justice too,/These were my Studies then, and in these three/Consists the whole Course of Philosophy:/Man, Body, Citizen, for these I do/Heap Matter up, designing three Books too."[35]

These works are very consistent. Hobbes grounded his philosophy in the view that "matter in motion" was a *fundamental, universal principle*, or even a law, which could be applied to a wide range of phenomena, whether they be God, the movement of heavenly bodies across the sky, the notion of time, the phenomenon of sound, struggles for political power, human psychology or the circulation of blood.

In *De Corpore*, Hobbes recognized that motion offered a number of advantages: motion could be isolated as the one universal cause of things known to nature, in the place of some other universal cause such as God.[36] Motion fully justified the use of geometrical methods – "therefore they that study natural philosophy, study in vain, except they begin at geometry; and such writers or disputers thereof, as are ignorant of geometry, do but make their readers and hearers lose their time".[37] Motion could be broken down into constituent manageable parts and analysed in terms of quality and quantity in its compound motions: "therefore, in the first place, we are to search out the ways of motion simply in which geometry consists; next the ways of such generated motions as are manifest; and, lastly, the ways of internal and invisible motions which is the enquiry of natural philosophers".[38] Motion could be neatly defined: "Motion is a continual relinquishing of one place, and acquiring of another".[39] And finally, motion could be used to explain the universal cause of any phenomenon: *study* – "Study is nothing else but a possession of the mind, that is to say, a vehement motion made by some object in the organs of sense, which are stupid to all other motions as long as this lasteth…"[40]; *blood in the human body* – "now vital motion is the motion of the blood, perpetually circulating (as hath been shown by many infallible signs and marks by doctor Harvey, the first observer of it) in the veins and arteries";[41] *the movement of heavenly bodies across the sky* – "Now as I have demonstrated the simple annual motion of the earth from the suppression of simple motion in the sun; so from the supposition of simple motion in the earth may be demonstrated the monthly simple motion of the moon";[42] *sound* - "Sound is sense generated by the action of the medium, when its motion reacheth the ear and the rest of the organs of sense;"[43] and *time itself* – "Time is the phantasm of before and after set in motion".[44]

Hobbes did not restrict application of Galileo's theory of motion to physical phenomena. He applied this view to motions of every kind from music to human passions. In *Leviathan*, published in 1651, he applied it to the political challenges of preserving liberty and order under law in the Commonwealth. At the same time, Hobbes detected in motion the perfect condition of nature, the very essence of life, a dynamic principle everywhere at work, something to be measured.

From this fundamental principle of matter in motion, Hobbes derived a materialist philosophy of mind with three distinguishing features. First, the universe was purely material; second, the spirit has no incorporeal existence independently of the body; and third, when we assign mental properties to objects, we are really referring to motions of matter. Hobbes was very much a part of the seventeenth century challenge to the Catholic and Aristotelian synthesis of religion and philosophy. He did not detect a divine purpose at work in the cosmos, but presented instead an unsettling, enigmatic God, at a far remove from Nature, something the way the gods of Lucretius had been. Like Lucretius, Hobbes emphasized the role of terror in religion.[45]

This mechanical materialism, almost but not quite denying the existence of God, put Hobbes in direct conflict with Descartes, who had sought to rescue the body/soul dualism of revealed religion from the onslaught of seventeenth century natural philosophy. In fact, the relationship between the two philosophers was marked by considerable bitterness, as well as the competitive desire each nourished to be acknowledged as the founder of a revolutionary new mechanical conception of nature.

Once Hobbes had asserted this fundamental principle of matter in motion, as well as the resulting materialist philosophy of mind, he needed a means of applying the principle to his study of politics. Convinced that much human reasoning was defective, Hobbes borrowed what he considered to be unassailable principles from anatomy, mathematics and physics, in which to ground a new political theory. He did so by adapting an existing methodology for the study of human affairs and the State itself. That methodology is sometimes called "Paduan" in deference to the great

Italian university, which had revolutionized the application of Aristotelian knowledge-building principles to the study of medicine, astronomy and other disciplines.[46] Leonardo had been informally associated with Pavia. But Vesalius, Harvey and Galileo had gained much understanding of method from their studies at Padua. Hobbes acknowledged that this methodology was overtly mechanical, when he described it, in *De Cive*, or *The Citizen*, as a process of taking apart and analysing the commonwealth, much as one would take apart and analyse the workings of an automatic clock or other "fairly complex device", in order "to understand correctly what human nature is like, and in what features it is suitable and in what unsuitable to construct a commonwealth, and how men who want to grow together must be connected."[47]

Having asserted the principle that all existence can be reduced to "matter in motion", and gone on to assert that the admirably rational machine provided an appropriate model for an understanding of human affairs, it is hardly surprising that Hobbes should then seek to "guarantee" the validity of his knowledge-building process, by appealing to the triumphant contemporary prestige of a further principle, namely that geometry was the pathway to truth in all domains of knowledge.

In identifying motion as a fundamental law, which could be applied to such a wide range of phenomena, Hobbes drew attention to the physical, material nature of these phenomena. In so doing, his one-world realistic vision denied these phenomena any immaterial character.

He implied that the basic mechanics of the body had to be understood before one came to an understanding of human nature. And this mechanistic model proved so satisfying to him, that he claimed rather dogmatically it had led to the infallible rules and true science of equity and justice, the infallibility of reason, which he then used to attack previous dogma. Galileo had also claimed that an empirically demonstrated scientific hypothesis was literally true, which got him into a lot of hot water with the Church! In his own way, Hobbes made exaggerated claims for natural philosophy.

He developed these ideas further, but never deviated from them, during the course of his later years, publishing *Leviathan* in 1651 and *Behemoth*, a study of the causes of the English Civil War, in 1668. After returning to the pleasures of translating classical Greek (the two epic poems of Homer), Hobbes died in 1679.

The philosophical materialism of Hobbes came as a shock to many seventeenth century readers, who were slowly being drawn into the huge collective negotiation of Europe's transition from a comforting God-centred "world" to a starker secular universe. Body, motion and endeavour are all that we could sense and therefore know, according to Hobbes, and this left no room for the Christian doctrine of dualism, of the intangible unity of body and soul.

God had been the starting-point in the Aristotelian and Catholic synthesis, the Prime Mover of Nature, the Jewish and Christian Creator of the Universe and Divine Legislator from Whom all things human were derived, the transcendent centre of all existence. But for Hobbes, God seemed to be a supremely disembodied abstraction: God could be acknowledged intellectually, but never directly known.[48]

Hobbes' view of the Universe broke with the body/soul dualism of Christianity, as well as the age-old religious tradition of two worlds: this one and the next. Indeed, he attacked Descartes on this point. By 1655, when he published *De*

Corpore, Hobbes affirmed that Philosophy "excludes Theology, I mean the doctrine of God, eternal, ingenerable, incomprehensible, and in whom there is nothing neither to divide nor compound, nor any generation to be conceived."[49]

While Hobbes recognized that natural and human knowledge were closely inter-related, he denied any unity with divine knowledge. He wanted to provide human knowledge with a secure, stable and above all *independent* foundation. As such, he was determined to emancipate human knowledge from Aristotle and the Schoolmen, and to seek inspiration in Galileo. As we have seen, Hobbes followed body, motion and endeavour in a highly systematic fashion and to their ultimate consequences, analysing physical phenomena as well as phantasms and images in the mind as motions.

Hobbes saw war as the natural or primitive condition of mankind, that in a state of Nature "there is no place for Industry; because the fruit thereof is uncertain: and consequently no Culture of the Earth; no Navigation, nor use of the commodities that may be imported by Sea; no commodious Building; no Instruments of moving, and removing such things as require such force; no Knowledge of the face of the Earth; no account of Time; no Arts; no Letters; no Society; and which is worst of all, continuall feare, and danger of violent death; And the life of man, solitary, poore, nasty, brutish, and short."[50] Not only was man nasty; he was fundamentally self-interested, and motivated by fear to wage war on others. Hobbes had reason to believe this, since he had experienced the English Civil War, at least in exile from France.

Having demonstrated what man naturally *is*, Hobbes then went on to say what man *ought to be*.[51] Hobbes considered the Universe to be Body alone; the spirit has dimensions and is therefore Body; and mental properties assigned to objects are really perceptible motions of those objects. This materialist philosophy was combined with Galilean mechanics in the hopes of finding a universal principle, which could explain all physical phenomena. This mechanistic view was clearly pointing in one direction. Hobbes found a metaphor, which would regulate man's natural inclination towards poverty and violence, and upon which to build a perfectly ordered society: the machine.

In *De Cive*, published in 1642, Hobbes compared human society to "an automatic Clock or other fairly complex device."[52] By the time he came to publish *Leviathan*, his political masterpiece, in 1651, the mechanical metaphor had become far more elaborate. Life is but a motion of limbs, and man is thus a machine, living the way the artificial man (for example, the watch) moves itself by springs and wheels: "For what is the Heart, but a Spring; and the Nerves, but so many Strings; and the Joynts, but so many Wheeles, giving motion to the whole Body, such as was intended by the Artificer?"[53]

Not only was man a machine, but the State was a machine-like artificial man: "For by Art is created that great Leviathan called a Common-wealth, or State (in latine Civitas) which is but an Artificall Man; though of greater stature and strength than the Naturall, for whose protection and defence it was intended; and in which, the Sovereaignty is an Artificall Soul, as giving life and motion to the whole body; The Magistrates, and other Officers of Judicature and Execution, artificall Joynts; Reward and Punishment (by which fastned to the seate of the Soveraignty, every joynt and member is moved to performe his duty) are the Nerves, that do the same in the Body Naturall; the Wealth and Riches of all the particular members, are the Strength; Salus

Populi (the peoples safety) its business; Counsellors, by whom all things needfull for it to know, are suggested unto it, are the Memory; Equity and Lawes and artificall Reason and Will; Concord, Health; Sedition, Sicknesse; and Civill war, Death."

Indeed, the parallels between the natural and artificial man (or automaton) are repeated in several places, for example where public ministers serve as the nerves and tendons of the State, moving the "several limbs of the body naturall", or again where the passage of blood-like money through the veins and arteries of the State is concerned.[54]

Finally, in this machine-like State, countless machine-like individuals have life since they move their limbs, and the State is in turn governed by laws: "Lastly, the Pacts and Covenants, by which the parts of this Body Politique were at first made, set together, and united, resemble that Fiat, or the Let us make man, pronounced by God in the Creation."[55]

How shall we interpret the mechanical body of the artificial man or State in Hobbes? There have been many different views in the latter half of the twentieth century – all of which leave something to be desired. Michael Oakeshott, seeking to rescue Hobbes from his detractors, argued "the mechanistic element in Hobbes's philosophy is derived from his rationalism; its source and authority lie, not in observation, but in reasoning. He does not say that the natural world is a machine; he says only that the rational world is analogous to a machine. He is a scholastic, not a 'scientific' mechanist."[56] This view is clearly deficient, however, since for Hobbes the machine was far more than an analogy; it was a *prescription* for humankind. Besides, as we have seen, Hobbes' view of the mechanism was not a pure rationalist abstraction, but may well have originated in observations he made alongside William Harvey.

There is no dispute about Hobbes being a great philosopher. In the words of Michael Oakeshott, "The *Leviathan* is the greatest, perhaps the sole, masterpiece of political philosophy written in the English language. And the history of our civilization can provide only a few works of similar scope and achievement to set beside it."[57] The stature of Hobbes is generally recognized, yet as a thinker and an individual, his work is exceedingly complex.

Friedrich A. Lange, a great historian of materialism writing in the mid-nineteenth century, wrote that Hobbes' approach transformed "the whole of philosophy into natural science, and completely set aside the transcendental principle, but the Materialistic tendency is still plainer in the explanation of the object of philosophy. It consists in this, that we foresee effects, and so are able to apply them to the purposes of life."[58]

The early twentieth century historian of science Fritiof Brandt considered Hobbes to have been a pioneer philosopher in overthrowing Aristotelianism, and in introducing the mechanical view of nature. "If we must acknowledge Hobbes to be the first and most consistent champion of the mechanical view in modern thought, then we owe him the special attention, as the pioneer of mechanism, which only founders can claim."[59] Unlike Lange, however, who saw Hobbes as a materialist, Brandt preferred to consider Hobbes as a "motionalist": "The concept of matter plays an exceedingly small part [in Hobbes] and tends to disappear. Hobbes should more correctly be called a motionalist, if we may be permitted to coin such a word...."[60]

The devastating political and military experiences of the twentieth century gave new relevance to Hobbes. Writing in the mid-1930s, George Sabine set Hobbes in the context of the early modern scientific revolution, noting that Hobbes' philosophy "was a plan for assimilating psychology and politics to the exact physical sciences."[61] But it was above all the rise of totalitarian regimes in the 1930s that brought Hobbes to public attention once again. In 1935, the right-wing French Catholic Joseph Vialatoux saw the abstract, cold and lonely thought of the author of *Leviathan* leading logically to totalitarian state intervention.[62] For his part, Carl Schmitt, sometimes described as the "crown prosecutor" of Nazism, approvingly identified Hobbes as a "precursor" of totalitarianism.[63] Some scholars have linked Hobbes to fascism.[64] This view was contested during the bitter years of the Second World War by R. G. Collingwood, who rewrote *Leviathan*, modifying it to incorporate his own brand of Platonic Idealism: "The wars of the present century have taught us that there was more in Hobbes than we had supposed," Collingwood wrote. "I believe that I am not reporting my own experience alone when I say that [recent tragic events over the last thirty years have] revealed Hobbes' Leviathan as a work of gigantic stature, incredibly overtopping all its successors in political theory from that day to this."[65]

Nevertheless, Hobbes reached fascism by way of G.W.F. Hegel (1770-1831). In *De Cive* and *Leviathan*, Hobbes saw sovereign power as absolute. This position met with Hegel's approval, close to two centuries later. In *Lectures on the History of Philosophy*, Hegel wrote that *De Cive* and *Leviathan* contained sounder reflections on the nature of society and government than many in circulation in Hegel's own time. He defended the way Hobbes established the absolute preeminence of the State, and ascribed to it determining power, without appeal, over law and positive religion, which in turn were entirely subject to the State. Hegel, it should be noted, exalted the Prussian militarist State and left an intellectual legacy which proved an inspiration both for communism and Nazism.[66]

Since the Second World War, Hobbes has been presented as an early proponent of possessive individualism, whose ideas have once again gained relevance at a time "when the destruction of every individual is now a more real and present possibility than Hobbes could have imagined."[67] He has been characterized as a monstrous political theorist, whose thinking later justified imperialism and the "ideal of machine-conditioned progress" of social Darwinism, which was liberally interpreted as a license for wholesale extermination.[68] He has been seen as a precursor of psychological behaviorism and legal positivism;[69] as an uncompromising defender of seventeenth century absolutism;[70] as a radical in service of reaction;[71] as a philosopher whose concept of thought as ratiocination and computation, laid the ground for recent discoveries in artificial intelligence.[72] More recently, he has been interpreted as an anti-liberal, some of whose ideas nonetheless were capable of sustaining later liberalism.[73] These views are contradictory. Some of them contain anachronisms, or blame Hobbes for planting seeds, whose evil did not sprout until three centuries later! At the very least, they show that Hobbes has become "interesting" again.

C.B. MacPherson held a dispassionate view of Hobbes' machine, noting that it was intelligible, automated, self-moving and self-directing, but unfortunately MacPherson did not go much further.[74] Lewis Mumford, on the other hand, clearly felt threatened by Hobbes' mega-machine. He attacked Hobbes' minimalist definition of life as "but a motion of Limbs", and derided the fictions and mythical constructs in his work: "Hobbes' mythic picture cast aside every positive evidence of spontaneous order, morality, mutual aid, and autonomy: at the same time it magnified, by treating it as an original necessity, the absolute authority that the state was newly seeking to re-establish…"[75] Mumford took a leap over several centuries of history, blaming Hobbes long after the fact for the unforeseen twentieth century consequences of his ideas. But as we have seen with Vialatoux, Schmitt and Collingwood, Hobbes could be made both to justify and to condemn totalitarian ideologies in the mid-twentieth century.

With the recent development of artificial intelligence (AI), some scholars have sought, in a rather inconclusive fashion, to show that Hobbes anticipated AI and can be credited with paternity rights up to a point. Daniel Dennett pushes this argument a little too far in writing that, "philosophers have been dreaming about AI for centuries. Hobbes and Leibniz, in very different ways, tried to explore the implications of breaking down the mind into small, ultimately mechanical, operations…. Descartes' appreciation of the powers of mechanism were colored by his acquaintance with the marvelous clockwork automata of his day. He could see very clearly and distinctly, no doubt, the limitation of that technology. Even a thousand tiny gears – even ten thousand! – would never permit an automaton to respond gracefully and rationally! Perhaps Hobbes and Leibniz would have been less confident of this point, but surely none of them would have bothered wondering about the *a priori* limits on a million tiny gears spinning millions of times a second. That was simply not a thinkable thought for them..."[76] George Dyson called Hobbes "the patriarch of artificial intelligence", for having proposed in *Leviathan* that humans collectively by virtue of their organization and their use of machines, would create a new intelligence.[77] Finally, in a recent article, [78] Murat Aydede and Güven Güzeldere mentioned Hobbes' materialist mechanical explanations in relation to AI, without, unfortunately, going any further. These three views are interesting, but also dependent on wishful thinking.

We may draw a speculative link between the seventeenth century Hobbes and twenty-first century artificial intelligence, but not much more.

In the view of Jonathan Sawday, "by the time *Leviathan* appeared, in 1651, a new set of theoretical conceptions of the body had already appeared, whose origin may be traced to the acceptance of Cartesian modes of analysis: the body (and therefore society) could be analysed in terms of a machine."[79] This view simply does not stand up, however. Hobbes' State was more than a mere outgrowth of Cartesian "modes of analysis." In any case, Hobbes owed an intellectual debt to Harvey and Galileo rather than Descartes.

In his interpretation of Man the machine, Hobbes combined strands from multiple sources. The State had been a *body* politic for Plato, but for Hobbes it was something quite different: more of a machine in the likeness of humans, an artificial man or automaton. Human society could be examined using "Paduan" methodology, to take apart and examine the Clockwork State. Galilean mechanics provided the universal principle of "matter in motion" pervading the universe, which could in turn be studied through the application of geometry. The resulting highly complex metaphor of Man the machine was simultaneously likened to the body politic, an automatic clock and matter in motion, and could be defined in terms of geometrical equations. Besides, in defiance of Sawday's belief in Cartesian "modes of analysis", we share Frithiof Brandt's view that Descartes and Hobbes arrived at their mechanical conception of nature (and human nature) by independent means.

Hobbes was a masterful rhetorician and propagandist, keenly aware of the effect on his reading public if Biblical symbol and myth were combined with Platonic political theory, "Paduan" methodology, Galilean physics and geometry. He called the State an artificial man or automaton, and to that artificial man he gave the name of *Leviathan*, a mythical monster variously described in the Bible as a slippery, writhing serpent, a many-headed beast and a sea-monster, as we know from *Isaiah* 27.1, *Psalm* 74.14 and *Job* 3.8. His historical account of the English Civil War was called *Behemoth.*[80]

This curious juxtaposition of images turned the State into a looming, vertically controlled monolith under the absolute monarch, provided it with scriptural legitimacy, and made it an object of awe and fear at the same time. Naturally, in prescribing the machine model, Hobbes over-simplified human psychology, reduced human society to mere "matter in motion", and overstated the value of mechanical and mathematical analysis of political affairs. His defence of the superiority of absolutism is shocking for us today, after the bitter experience of imperialism in the nineteenth and twentieth centuries, and of totalitarianism in the twentieth and the early twenty-first. In addition, his views were distorted by a single-minded belief that individual fear and insecurity could be banished from society by the machine model, which would create a new, useful level of monolithic fear in order to control society. Over the last century, we have learnt to our cost that the machine model provides its comforts, but has also created new fears and insecurities of its own.

Does this make Hobbes irrelevant today? Not necessarily. Many features of Hobbes' metaphor of Man the machine can be found present in the world today. He provided a theoretical basis which was later used to develop legal positivism, psychological behaviourism and artificial intelligence. Moreover, there is something to be said for his historical perspective. Hobbes gives us today the impression of having made a close study of everything that could go fatally wrong in human society. But then he was searching for answers to the challenges not of our times, but of his own: he was very much a man of his epoch, contending with the growing instability of political life both in England and France in the 1630s, 1640s and 1650s, with the difficulty of maintaining a pluralist society in a climate of competing claims from religious sects and rising social classes, and with the English Civil War itself. He brought about a radical revision of seventeenth century philosophy, partly through his interest in natural philosophy, and partly because of his sense of history. Nevertheless, the very fact that Hobbes developed a historical perspective, sometimes called "realist", is one of the most interesting features of his political philosophy, and possibly the most enduring one.

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[1] For the purposes of this work, we have studied Hobbes' translation of Thucydides, we have been willing to give the benefit of the doubt to the somewhat speculative *Three Discourses* published in 1995, and we have studied the usual works of the Hobbesian corpus, as well as his correspondence, and the always difficult exchanges with Descartes.

[2] The Danish scholar Fritiof Brandt maintained that Hobbes came upon a mechanical conception of nature prior to Descartes, which in the Danish scholar's view helps to explain the extraordinary disdain Descartes felt for Hobbes. "May we consequently not maintain that, provided Hobbes' evidence is reliable, to him the honour is due of having on his own account independently of Descartes, thought out the mechanical conception of nature. To us it would appear that the answer is in the affirmative." Fritiof Brandt, *Thomas Hobbes' Mechanical Conception of Nature* (Copenhagen, 1928), p. 142. Not only was Hobbes independent of Descartes, in Brandt's view; he was "the first and most consistent champion of the mechanical view in modern thought." *Ibid.*, p. 7. Indeed, Brandt defended Hobbes' claims of originality and priority in this discovery.

[3] An interesting discussion of this issue is contained in Preston King's *The Ideology of Order: A Comparative Analysis of Jean Bodin and Thomas Hobbes* (New York, 1974). For example, "Hobbes is of considerable interest because he is one of the first political philosophers to begin his analysis, not with a statement regarding the nature of man's duty, but with a statement regarding the character of man's nature. He begins, in short, or appears to begin, with an *is* rather than an *ought*. His argument is so devised as to suggest that the 'ought' somehow flows from the 'is': given that men are of such and such a character, they *ought* to act in such and such a way... The primary 'fact' to which Hobbes draws our attention is this: men have a fundamental urge, he says, to preserve themselves, to avoid violent death, to live in peace and security. And it is upon this 'fact' that he somehow built the conclusion that men ought or must obey a single and exclusive sovereign, general obedience to whom can usually be expected to yield (to those obeying) security and protection." *Op. cit.*, p. 163.

[4] Although Niccolo Machiavelli's was "not a scientific or rigorous mind," Neal Wood credited him with the idea of the State and army as a mechanism, in his introduction to Machiavelli's *The Art of War*, translated by Ellis Farnworth (Cambridge, Mass., 2001), p. xxxiii. Girolomo Cataneo wrote of the mathematics of military organization. In 1590 Thomas Digges published *An arithmetical warlike treatise named Stratioticos*, which "includes a treatise on arithmetic and algebra, calculations for the officer, the

duties of the officer, a discussion of military law, and mathematics for artillery." (*Ibid.*, p. xxxvi.) Neal noted: "Notions of a mechanistic system of nature and a mechanistic military system seem to have arisen about the same time. The application of mathematics to military organization suggests that the army began to be thought of as a deliberately created system of interacting parts, the movements of which are susceptible to quantification, years before Thomas Hobbes, the first modern political thinker, employed the Galilean method to describe the state as a mechanical contrivance." The influence of Machiavelli on Hobbes is well-established in other respects. The Florentine may well have influenced Hobbes' thinking in this respect. A more purely proto-mechanical view of the State is that of Jean Bodin, in "Of the kinds of state in general and whether there are more than three", chapter I of the Second Book of *Les six livres de la République*, Bodin drew an analogy between a compound of three kinds of State and the harmonic proportion, "which is composed of the arithmetic and geometric", but this analogy is not developed further. Jean Bodin, *On Sovereignty*, translated by Julian H. Franklin (Cambridge, 1992), p. 91. In "If there is a way of predicting the change and ruin of Republics", chapter II of the Fourth Book, Bodin denounced Copernicus for claiming that the influence on human events comes from the Earth, not the heavens, and that the Earth is subject to movements the astrologists have always accorded to the heavens. Instead, Bodin opted for the hermetic predictive method of Platonic numerology, which is far removed from Hobbes' thinking, although Bodin's ideology of order had a decisive influence on Hobbes. Jean-Marie Apostolidès wrote a work entitled *Le roi-machine* which examines the theatrical machine as a spectacular image used by King Louis XIV to astonish his contemporaries, although the analysis in that wordy book is disappointingly thin and has no real bearing on Man the machine (Paris, 1981).

5 Thomas Hobbes, *Leviathan* (Harmondsworth, 1985), Book I, ch. 13, p. 186.

6 In Book III of the *Laws*, for example, Plato wrote: "A God, who watched over Sparta, seeing into the future, gave you [Megillus] two families of kings instead of one; and thus brought you more within the limits of moderation. In the next place, some human wisdom mingled with divine power, observing that the constitution of your government was still feverish and excited, tempered your inborn strength and pride of birth with the moderation which comes of age, making the power of your twenty-eight elders equal with that of the kings in the most important matters." Plato, *Laws* 692, in *The Dialogues of Plato*, vol. IV, p. 260, translated by Benjamin Jowett (Oxford, 1958). Moreover, in the *Republic*, Book III, rulers are referred to as gold, soldiers as silver, husbandmen as bronze and artisans as iron (*Republic* 415 in *Dialogues*, vol. II, p. 266), while in Book IV, man like the city-state is presented as having an intellectual part, a spiritual part and a physical part. (Book IV, pp. 269-301, is rife with such references.)

7 It should be noted that Plato's body politic had been reintroduced in England during the time of Elizabeth I, as a way of supporting her claim, as a woman, to the throne. According to the *Encyclopaedia Britannica*, "Crown lawyers, moreover, elaborated a mystical legal theory known as 'the king's two bodies.' When she ascended the throne, according to this theory, the queen's whole being was profoundly altered: her mortal 'body natural' was wedded to an immortal 'body politic.' 'I am but one body, naturally considered,' Elizabeth declared in her accession speech, 'though by [God's] permission a Body Politic to govern.' Her body of flesh was subject to the imperfections of all human beings (including those specific to womankind), but the body politic was timeless and perfect. Hence in theory the queen's gender was no threat to the stability and glory of the nation." 1999 CD-ROM edition, no page number.

8 Samuel I. Mintz, *The Hunting of Leviathan* (Cambridge, 1962), pp. 147-156.

9 *Ibid.*, pp. 39-44.

10 Hermetic works such as Jean Bodin's *Daemonologie*, James I's *Deomonologie*, and Father Taillepied's *Treatise on Ghosts* were very popular reading for statesmen and women in the late sixteenth and early seventeenth centuries.

11 It is interesting to note, during the early 1620s, that both the disgraced Raleigh and Bacon sought to redeem themselves by writing historical works designed to flatter their arbitrary monarch, James I: Raleigh's *Historie of the World* and Bacon's *History of the Reign of Henry VII*. Bacon's tribulations in writing the latter are recounted in Jonathan Marwil's *The Trials of Counsel – Francis Bacon in 1621* (Detroit, 1976).

12 A. Rupert Hall, *From Galileo to Newton* (New York, 1981), p. 340.

13 Oxford Classics edition of Thomas Hobbes, *Human Nature and De Corpore Politico*, ed. by J.C.A. Gaskin (Oxford, 1994), p. 254.

14 Aloysius Martinich, *Hobbes: A Biography* (Cambridge, 1999), p. 357.

15 *Ibid.*, p. 29.

[16] Thomas Hobbes, *Three Discourses,* edited by Noel B. Reynolds and Arlene W. Saxonhouse (Chicago, 1995).
[17] *Ibid.*, p. 43.
[18] *Ibid.*, p. 106.
[19] In *Human Nature and De Corpore Politico*, p. 234.
[20] In *The New Organon*, for example, which Bacon published around the time that he knew Hobbes, there are several discussions of atomism: Michael Silverthorne translation, pp. 108 & 171.
[21] Laurie M. Johnson, *Thucydides, Hobbes and the Interpretation of Realism* (De Kalb, Illinois, 1993), pp. 212-6 & p. 205.
[22] The two chronologies are developed by Noel Malcolm, "A Summary Biography of Hobbes" in Tom Sorrell (ed.), *The Cambridge Companion to Hobbes* (Cambridge, 1996), and by A.P. Martinich, *Hobbes: A Biography*.
[23] Keynes, *op. cit.*, p. 388.
[24] Martinich, *op. cit.*, p. 218.
[25] Martinich, *op. cit.*, p. 218.
[26] Martinich, *op. cit.*, pp. 194: "William Petty, destined to become one of the founders of economics, left England at the beginning of the Civil War, probably because he sympathized with the king's opponents. Through the good graces of Dr. John Pell, who was then a professor of mathematics at Amsterdam, Petty was introduced to Hobbes in 1645. They immediately liked each other. Their difference in age – Petty about twenty and Hobbes in his late fifties – did not pose a problem. Petty, who was a medical student, was happy to read the works of Andreas Vesalius, the famous Belgian anatomist, with Hobbes. Hobbes's interest in anatomy was dictated by his goal of presenting a complete scientific account of the world. He needed to figure out the mechanics of sensation, and this included finding their precise location in the brain or heart. When simple book anatomy proved to be insufficient, Hobbes attended dissections carried out by Petty."
[27] In *Human Nature*, p. 235.
[28] *De Corpore*, p. 7.
[29] *The Prose Life* in *Human Nature and De Corpore Politico*, p. 247.
[30] Howard Jones, *The Epicurean Tradition* (London, 1989), pp. 174-5.
[31] *Ibid.*, p. 181.
[32] E.A., Burtt, *The Metaphysical Foundations of Modern Science*, p. 126.
[33] A. Rupert Hall, *From Galileo to Newton*, p. 73.
[34] Fritiof Brandt, *Hobbes' Mechanical Conception of Nature*, p. 379.
[35] From the Verse Life, quoted in *Human Nature & De Corpore Politico*, pp. 257-8.
[36] *De Corpore*, p. 69.
[37] *Ibid.*, p. 73.
[38] *Ibid.*, p. 73.
[39] *Ibid.*, p. 109.
[40] *Ibid.*, p. 395.
[41] *Ibid.*, p. 407.
[42] *Ibid.*, p. 429.
[43] *Ibid.*, p. 485.
[44] *Ibid.*, p. 93.
[45] Lucretius, *On the Nature of the Universe*, p. 91. In our view, Hobbes was like Lucretius in some respects. Their ultimate motivation – fear – was similar, although Lucretius sought to dispel fear, whereas Hobbes sought to channel fear into absolute order and obedience. Their determination to break with superstition, and develop a materialist philosophy of nature, bears some comparison, in the sense that Lucretius separated the actions of the gods from Nature, and Hobbes saw God as aloof, remote, not terribly involved in the physical universe. In the words of Alban Winspear, Lucretius "is quite evidently the subject of deep inner compulsions. Human life in his view is crushed by fear, the fear of death and what is to come after death.... Central, therefore, to the poet's purpose is the fight against religion. The whole exposition of his philosophy is intended to banish the supernatural fears and the terror of torments in the world to come.... Against religion he sets up science and the philosophy of science. The calm, clear apprehension of all things that comes from an understanding of physics and nature's law would, he thought, produce a serenity of spirit, a tranquility of mind and a release from fear. Many people find this conviction extraordinary. And yet Lucretius is here at one with the saints and sages of

all ages in prescribing that serenity which comes from a vision of the whole... Lucretius' scientific system was, as we shall see remarkably ordered, complete and coherent. And yet, there is still no function left for the gods. They are banished from all control, creation or ordering of the natural universe. They cannot interfere with the majestic pageant of natural law, the eternal interplay of cause and effect. They have, in short, none of the functions which we normally attribute to the gods of religion." *Lucretius and Scientific Thought* (Montreal, 1963), pp. 30-38. Friedrich Lange noted approvingly that "exactly like Epikuros and Lucretius, so Hobbes also derives religion from terror and superstition; but while they for this very reason declare that to rise above the limits of religion is the highest and noblest duty of the philosopher, Hobbes knows how to turn this common material to account for the purposes of his State. His real view of religion is so trenchantly expressed in a single sentence, that we cannot but be surprised at the unnecessary breath that has often been spent upon the theology of Hobbes. He lays down the following definition: 'Fear of power invisible, feigned by the mind or imagined from tales publicly allowed, RELIGION: not allowed, SUPERSTITION.'" *History of Materialism*, 1st Book, 3rd Section, pp. 283-4.

[46] J.W.N. Watkins, *Hobbes's System of Ideas: A Study in the Political Significance of Philosophical Theories* (London, 1985), pp 52-55.

[47] Hobbes, *On the Citizen*, translated by Richard Tuck and Michael Silverthorne (Cambridge, 1998), p. 10. This description corresponds to J.W.N. Watkins' description of "Paduan methodology" in his work, *Hobbes's System of Ideas: A Study in the Political Significance of Philosophical Ideas* (London, 1965), p. 52, where he presented the intuitive idea informing this methodological tradition as follows: "to understand something is to take it apart, in deed or in thought, ascertain the nature of its parts, and then resolve it and recompose it." This tradition grew out of Aristotelianism, as we have demonstrated above, and was revived and developed by the fourteenth century medical writer Pietro d'Abano, as well as the sixteenth century natural philosopher Jacopo Zabarella – both Paduans.

[48] "Forasmuch as God Almighty is incomprehensible," Hobbes wrote in 1640 in *Human Nature* (pp.64-5), "it followeth that we can have no conception or image of the Deity; and consequently all his attributes signify our inability and defect of power to conceive any thing concerning his nature, and not any conception of the same, excepting only this: *that there is a God.* For the effects we acknowledge naturally, do not necessarily include a power of their producing, before they were produced; and that power presupposeth something existent that hath such power; and the thing so existing with power to produce, if it were not eternal, must needs have been produced by somewhat before it; and that again by something else before that: till we come to an eternal, that is to say, to the first power of all powers, and first cause of all causes. And this is it which all men call by the name of God: implying eternity, incomprehensibility, and omnipotency. And thus all men that will consider, may naturally know that God is, though not what he is; even as a man though born blind, though it be not possible for him to have any imagination what kind of thing is fire; yet he cannot but know that something there is that men call fire, because it warmeth him." Hobbes, in this passage, came close to denial of God's existence, but stopped short, since he left open the possibility that man might know *that God is*, without knowing *what he is*. By the time he wrote *Leviathan* (1651), however, he had developed his thought further. He boldly challenged the idea that God was at the centre of existence, and implied that God, by having no effect on the senses, might even be said not to exist: "Every part of the Universe is Body; and that which is not Body, is no part of the Universe: And because the Universe is All, that which is no part of it is *Nothing*; and consequently *no where.*" *Leviathan*, p. 689.

[49] *De Corpore*, p. 10.

[50] *Leviathan*, p. 186.

[51] There is an interesting discussion of this is/ought contrast in Tom Sorrell's "Hobbes' Scheme of the Sciences" in *The Cambridge Companion to Hobbes.*

[52] *Ibid.*, p. 10.

[53] *Leviathan*, p. 81.

[54] *Leviathan*, pp. 290 & 301.

[55] *Ibid.*, pp. 81-2.

[56] Michael Oakeshott, Introduction to *Leviathan* (Oxford, 1955), p. xxi.

[57] *Ibid.*, p. viii.

[58] Lange, *The History of Materialism*, 1st Book, 3rd Section, p. 275.

[59] Brandt, *Thomas Hobbes' Mechanical Conception of Nature*, p .8.

[60] *Ibid.*, p. 379.

[61] George Sabine, *A History of Political Thought* (London, 1937), p. 458.
[62] Marcel Prélot and Georges Lescuyer, *Histoire des idées politiques*, 13th edition (Paris, 1997), pp. 284-5.
[63] *Ibid.*, p. 285.
[64] James Whisker, in "Italian Fascism: an Interpretation" made an unconvincing leap-like association when he mentioned Hobbes' body politic and moved along in the same breath to Mussolini's body and State. *The Journal for Historical Review*, 4:1 (1983), n. 40. This online journal is of inconsistent quality.
[65] R,G. Collingwood, *The New Leviathan*, edited by David Boucher (Oxford, 1992), p. lx.
[66] G.W.F. Hegel, *Lectures on the Philosophy of History*, translated by E.S. Haldane and Frances H. Simson (New York, 1955), vol. III, pp. 315-319.
[67] C. B. MacPherson, *The Political Theory of Possessive Individualism: Hobbes to Locke* (Oxford, 1964), p. 276.
[68] Lewis Mumford, *The Myth of the Machine: The Pentagon of Power*, p. 102.
[69] Thomas A. Spragens Jr., *The Politics of Motion: The World of Thomas Hobbes* (Lexington, 1973), p. 18.
[70] Preston King, *The Ideology of Order: A Comparative Analysis of Jean Bodin and Thomas Hobbes* .
[71] Arnold Rogow, *Thomas Hobbes: A Radical in the Service of Reaction* New York, 1986).
[72] Martin A. Bertman, *Body and Cause in Hobbes: Natural and Political* (Wakefield, N.H., 1991).
[73] Alan Ryan, "Hobbes' Political Philosophy" in Tom Sorrell (ed.), *The Cambridge Companion to Hobbes*, p. 237.
[74] C. B. MacPherson, *The Political Theory of Possessive Individualism*, pp. 31-35.
[75] Lewis Mumford, *The Myth of the Machine: The Pentagon of Power*, p. 101.
[76] Daniel Dennett, "When Philosophers Encounter AI" in *Daedalus, Proceedings of the American Academy of Arts and Sciences* 117 (Winter 1988), pp. 283-295.
[77] George Dyson, *Darwin Among the Machines: the Evolution of Global Intelligence* (Reading, Mass., 1997), p. 7.
[78] Murat Aydede & Güven Güzeldere, "Consciousness, Intentionality and Intelligence: Some Foundational Issues for Artificial Intelligence" in *Journal of Experimental & Theoretical Artificial Intelligence* 12:3 (2000), pp. 263-277.
[79] Jonathan Sawday, *The Body Emblazoned*, p. 130.
[80] According to *1 Enoch* 60.7, "in that day will two monsters be separated, a female named Leviathan to dwell in the abyss over the fountains of waters. But the male is called Behemoth, which occupies in its breast an immeasurable desert called Dendain."

GOTTFRIED WILHELM LEIBNIZ (1646-1715)

By the middle of the seventeenth century, the revolution in natural philosophy had created a new intellectual environment in Western Europe. The mechanical philosophy of Galileo, Descartes and Hobbes, and the revival of classical atomism by Gassendi seemed capable of sustaining unimpeded investigations in natural philosophy, of building up bodies of truth and natural morality on the solid structure of tight, self-contained reason, and of applying new insights to the development of successful technologies.[1] This in turn added prestige to the new way of thinking, which was taken to correspond to the natural universe and to be of immense practical benefit.[2]

It was as if Bacon's scientific and technocratic dream, articulated in *The New Atlantis*, were becoming a reality.[3] Scientific establishments were growing up across Europe as living laboratories for model closed communities, mobilized around a twin goal: the development of knowledge through the methodical testing of new observations and experiences, and the practical application of that knowledge in the form of profitable new techniques.[4] Many discoveries, particularly in physics and biology, were made as a result.

There could be little doubt that mechanical philosophy and atomism challenged the Christian religion as it was then known and practiced – mechanical philosophy through its claim to offer explicit and absolute correspondences between number and Nature,[5] and atomism by picturing the indivisible atoms that were the ultimate building blocks of matter. Mechanical philosophy and atomism moreover offered attractive and compelling alternatives to the Aristotelian, Scholastic and

Neoplatonic philosophies sometimes used to buttress the Christian religion.[6] The new schools of thought also challenged the Christian view of the soul and the essence of human life itself. The Cartesian compromise of dualism came to be discredited, simply because it was hard to conceive of an immaterial soul located nonetheless in a specific material part of the body. Gassendi's atomism contained a Christian metaphysic,[7] but materialism nonetheless proved unsettling for revealed religion.

Mechanical philosophy and atomism did not everywhere take on the same character. In France between 1670 and 1715, according to Heikki Kirkinen, "this intellectual revolution did not happen suddenly, but matured slowly. From the concept of man inherited from classical Antiquity and the Middle Ages, a transition was made first of all to the rationalist concept of Descartes, and then to a more empirical and materialist view among the predecessors of the *encyclopédistes*."[8] As a result, continental mechanical philosophers and atomists alike were gradually freed from the need to refer everything back to the lyrical obscurities and gnawing contradictions of revealed religion. In England, meanwhile, in the words of Friedrich Lange, "by Newton and Boyle the material world-machine was again provided with a spiritual constructor; but the mechanical and materialistic theory of nature only rooted itself the more firmly the more one could pacify religion by appealing to the Divine inventor of the great machine."[9] As a result, both on the continent and in England, a philosophical God became increasingly popular, as a substitute for revealed religion.

Onto this scene of ferment and change came Gottfried Wilhelm Leibniz (1646-1716). If he took up the idea of Man the machine at all, it was as part of an all-embracing metaphysical system designed to close the rift between mechanical philosophy, atomism and revealed religion. This system – "monadology" – was meant to rescue Man from the demeaning status of a mere collocation of atoms, thereby restoring to Man the God-given pre-established harmony of his body and being, but also a measure of responsibility for his own destiny. By coming up with the idea of monads – indivisible, spiritualized building blocks of Nature – Leibniz sought to remedy the defective dualistic compromise of Descartes, sweep aside the stark mechanical prescription of Hobbes and overcome that aspect of atomism, which created a weak link from matter directly to sensation.

During the eighteenth century, the materialist La Mettrie would complain in the 1750s that Leibniz had "spiritualized nature".[10] This assessment was accurate as far as it went, but it did not do justice to Leibniz, a universal man who wrote incessantly, published little, and bore on his shoulders the political, religious, philosophical and scientific contradictions of seventeenth-century Europe. Closer to the mark was Kirkinen's comment in 1960, that Leibniz had developed the "spiritualist mechanism": the soul "is immaterial, and has no relationship of causality with the external world. All the changes produced [in the soul] arise from its own internal nature according to laws already contained in it from the moment of its creation, but which reflect the external world and the entire universe after its own fashion."[11]

In fact, once Leibniz is placed in the setting of Man the machine, it is clear that he brought together each of these dimensions of Man we have considered in a new and original synthesis: Man as machine, Man in God's image and likeness, Man as microcosm, Man as self-mastering individual, Man as psychological being, and

Man as endowed with reason and devoted to happiness. Leibniz sought through his metaphysics to redefine the role of God and a machine-like Man in a clockwork universe, and thereby bring about a fusion of religion with the new mechanical philosophy – or at least the parts of religion and the parts of mechanism that he chose to keep.

Given the intellectual ferment and conflicts of the seventeenth century, it was perhaps understandable that Leibniz's lifework should be characterized by an eclectic desire to bring about a vast synthesis of knowledge. [12] He was a German Protestant metaphysician steeped in Aquinas and the ancients,[13] and a court historian working for a Hanoverian duke and longing nostalgically for the former unity and idealized hierarchical order of the medieval Holy Roman Empire.[14] He was a jurist seeking to recodify and systematize German law, which he hoped would serve the good of mankind,[15] and something of a hermetic (possibly serving as secretary to the Rosicrucians of Hanover).[16] Leibniz was an irrepressible optimist who would be subject to ridicule during the French Enlightenment, for his bright view that our world was necessarily the best of all possible worlds,[17] as well as a keen observer of nature and a technologist. He was a mining engineer; a brilliant mathematician and the co-discoverer of the integral and differential calculus who invented one of Europe's most successful early calculators.[18]

Leibniz is universally acknowledged to have been a difficult thinker. According to Nicholas Rescher, he "possessed an astounding range of interests and capacities. Mathematics, physics, geology, philosophy, logic, philology, theology, history, jurisprudence, politics and economics are all subjects to which he made original contributions of the first rank. The universality of the range of his abilities and achievements is without rival in modern times. By prodigious energy, ability, and effort, Leibniz managed to be three persons in one – a scholar, a public servant and man of affairs, and a courtier – without letting any one suffer at the expense of the others."[19] Moreover, as his biographer E.J. Aiton has noted, "he contributed to all these fields, not as a *dilettante*, but as an innovator able to lead specialists."[20]

Leibniz may have been three persons in one (Rescher's allusion makes one think of the Trinity), but he was also highly focused. In the view of Leroy Loemker, the best-known English-language editor of his works, Leibniz pursued four lifelong projects: legal reform, religious unification in Europe, the advancement of science and technology, and the well being of man and his happiness.[21]

These four lifelong projects can be traced back to the same motive, and they all pointed forward to the same ultimate objective: synthesis, reconciliation, bringing together old and new, God and the material world, the soul and the body, Catholic and Protestant, justice and politics, one European nation with another.

This desire to synthesize, to do away with sectarianism, is nowhere more clearly stated than in his *Explanation of Bayle's Difficulties*, where, in defence of his philosophical system, Leibniz wrote: "my system shows us that when we get to the bottom of things, we find in most philosophical sects more good sense than we realized. The Sceptics' lack of substantial reality in sensible things; the Pythagoreans' and Platonists' reduction of everything to harmonies and numbers, ideas and perceptions; the one and the whole of Parmenides and Plotinus (though not of Spinoza); the Stoic connectedness, compatible with the spontaneity maintained by others; the vitalistic philosophy of the Cabbalists and the Hermetics, who attributed feeling to everything; the forms and entelechies of Aristotle and the Scholastics; and meanwhile also the mechanical explanations, by Democritus and the moderns, of all particular phenomena, and so on – all these are reunited as in a common center of perspective from which the object (confused when looked at from anywhere else) reveals its regularity and the congruence of its parts. Our biggest fault has been sectarianism, limiting ourselves by the rejection of others."[22]

This humanist "esprit de synthèse" can be found throughout his works, which bear traces of Plato, Aristotle, the atomists, Plotinus, Aquinas, the hermetics, Renaissance Neoplatonism and thinkers of his own century.

There is little agreement among scholars about the significance of the synthesis that Leibniz brought about. In the opening words of his famous study, Bertrand Russell noted that this synthesis was unusually coherent: "the philosophy of Leibniz, though never presented to the world as a systematic whole, was nevertheless, as a careful examination shows, an unusually complete and coherent system."[23] Russell may have overplayed the coherence of Leibniz's system, by ignoring the historical evolution of his ideas, and by abstracting thoughts and reordering them into a new rationalistic whole, which Leibniz might not have recognized as his own.

Then there is Russell's objection that the proofs of God's existence are "the weakest part of Leibniz's philosophy, the part most full of inconsistencies,"[24] and his assumption that Leibniz was insincere in his professions of faith, since he preferred "to remain, in what concerned the Church, the champion of ignorance and obscurantism."[25] This view from a professed agnostic like Russell is understandable, yet it flies in the face of Leibniz's own professed Lutheran piety, as well as his lifelong and sincere promotion of Christian ecumenism. If anything, Leibniz was single-mindedly devoted to defending Christianity, whether it is conceived as a faith or a body of historic institutions. In our view, his metaphysics was offered in defence of revealed religion. The God of Leibniz was certainly compatible with the Christian God.[26]

Commenting on his metaphysics, Donald Rutherford noted that "the details of Leibniz's metaphysics are sufficiently difficult, and in many cases sufficiently obscure, that it is easy to lose track of the central thread of his thought – the basic idea that motivates his metaphysical inquiries and justifies us in regarding them as offering answers to some of philosophy's deepest perennial concerns. For this we must see Leibniz's metaphysics as an intellectual project guided by a moral vision.... The primary importance of metaphysics for him is that it embodies our efforts to discern a rational order in the created world, thereby strengthening our conviction about the operation of divine wisdom."[27]

Rutherford disagreed with Russell, by making Leibniz's view of God and morality not something of incidental importance, but rather the very foundation of his synthesis.

Below is a table summarizing some aspects of Leibniz's Man the machine:

The interpretation of Leibniz	Sources	Key features
The body as machine	Plato, Aristotle, classical atomists, Galileo, Bacon & Descartes, Gassendi, classical & medieval view of God's Creation having order and rationality and thus being measurable	This metaphor flows from the microcosm, since the world itself was considered a "machina mundi" or machine in its own right, of God's invention; the body is matter in motion; computation can replace reasoning
Man in God's image and likeness	Judaism, Christianity, Greek & Roman mythology, hermetic philosophy, Neoplatonism	Man is like God: he has a rational soul, an ability to serve as a mirror of nature; an ability to create like God
Man as a microcosm	Classical and medieval heritage; Paracelsian alchemy, Rosicrucianism (?), Galileo …	Parallel between God's orderly and rational universe on the one side, and man and his destiny on the other
Man as self-mastering individual	Platonic, Stoical, Christian, Neoplatonic ideals and humanist awareness of self	Leibniz's commitment to his personal programme of research
Man as a psychological being with virtually unlimited dimensions to human personality	Platonism, Neoplatonism, Scholasticism, humanism, and also reacting to Locke	Leibniz wrote widely about psychology, for example on understanding & sensation, reason, freedom, theories of motivation, the origins and use of language, etc.
Man as endowed with reason and devoted to happiness	Rationalist traditions; a new reading of Christianity	Happiness is the ultimate object of God's perfections and universe

Gottfried Wilhelm Leibniz was born in Leipzig in 1646, into a Lutheran family noted for its piety. Although he attended school, he largely taught himself in the library of his father, who had died while he was still a boy. He entered the University of Leipzig at the age of just fourteen, and soon aspired to reconcile the works of Galileo, Bacon and Descartes with the medieval Scholastic interpretation of Aristotle.

In our view, Leibniz was consistent, reasonably linear, and, having once taken up an idea, naturally subjected it to modification, but rarely to outright rejection.[28]

In *De Arte Combinatoria*,[29] which Leibniz submitted in 1666 in order to qualify for a position in the philosophical faculty in Leipzig, he began developing ideas, which would later culminate in the universal characteristic and the calculus. It is less important to examine the structure of this work (in the academic form then prevalent of demonstration/corollaries for disputation/definitions/problems etc.), than to understand the importance it came to have for Leibniz, and the way in which he integrated this work into his philosophical system.

From our perspective, four key ideas arise out of *De Arte Combinatoria.* Leibniz praised Hobbes for having rightly stated that everything done by our mind is a computation.[30] He later claimed to have found in *De Arte Combinatoria* the means to accomplish in all realms of thought, through algebra and analysis, what Descartes had accomplished through arithmetic and geometry: "Such a language," he wrote in *On the Universal Science: Characteristic,* likely in the mid-1670s, "would amount to a *Cabala* of mystical vocables or to the *arithmetic* of Pythagorean numbers or to the *Characteristic* language of the magi, that is, of the wise. I suspected something of such a great discovery when I was still a boy, and I inserted a description of it in the little book on the *Combinatory Art,* which I published during my adolescence. I can demonstrate with geometrical rigor that such a language is possible, indeed that its foundation can be easily laid within a few years by a number of cooperating scholars. The study of mathematical analysis provided me with the most genuine and elegant compendium of this general analysis of human ideas. I pursued this study so intensely that I doubt whether many contemporaries have invested more work in the same pursuit."[31]

Besides, this method could be applied to the realms of philosophy, jurisprudence, medicine, music, physics, and theology.[32] In fact, "This characteristic art, of which I conceived the idea, would contain the true organon of a general science of everything that is subject matter for human reasoning, but would be endowed throughout with the demonstrations of an evident calculus.... Since no definite result has yet been reached as to the way these signs must be formed, we shall meanwhile follow the example of mathematics for their future formation, and use the letters of the alphabet, or any other arbitrary notation which in the course of our progress will suggest itself as most convenient."[33] It is interesting to note that the alphabet provided Leibniz with a convenient set of characters or symbols. It also justified him in his claim to have invented an entirely new philosophical language, which by an ordered method, could lead him to find all things with their theorems and whatever is possible to investigate concerning them.

And finally, this new philosophical language would make reasoning into a form of calculation at the reach of most people. "What must be achieved in fact is this: that every paralogism be recognized as an error of calculation, and that every sophism, when expressed in this new kind of notation, appear as a solecism or barbarism, to be corrected easily by the laws of this philosophical grammar. Once this is done, then when a controversy arises, disputation will no more be needed between the two philosophers than between two computers. It will suffice that, pen in hand, they sit down to their abacus and (calling in a friend, if they so wish) say to each other: let us calculate."[34]

De Arte Combinatoria has often been seen as an anticipation of modern computers and even artificial intelligence itself. Raymond Kurzweil, for example, praised Leibniz for the discovery of the basis of modern computation.[35] However, there is a huge difference between Leibniz and many purely materialistic proponents of artificial intelligence today: he understood that a calculator, no matter how sophisticated, would never be a person fully conscious of what it was doing. For Leibniz, "By means of the soul or form, there is in us a true unity which corresponds to what we call 'I'; this can have no place in artificial machines or in a simple mass of matter, however organized it may be."[36]

Since Leibniz was too young to be granted the degree of doctor at Leipzig, he had to move on to the university of the free city of Nürnberg, where he was granted the degree of Doctor of Laws, but where he declined the offer of a university chair. Instead, he was recruited to serve at the court of the Prince Elector, the Archbishop of Mainz, Johann Philipp von Schönborn, where he did research into many issues of politics and law.

Leibniz wrote to Hobbes on two occasions in 1670, apparently without ever receiving an answer, and admired the English materialist for two works: *De corpore* and *De cive*.[37]

The elector sent Leibniz on a diplomatic mission to Paris in 1672, since Louis XIV was a growing threat to the Holy Roman Empire. In Paris, the young scholar became acquainted with the Jansenist theologian Antoine Arnauld, and began to consider how to bring about the reconciliation of the Protestant and Roman Catholic Churches. At the same time, he was exposed to the new thinking in Paris. Indeed, as he wrote in 1714, two years before his death, to Nicolas Remond, it was at the age of fifteen in 1661 that Leibniz first became fascinated by mechanical philosophy, and it was in Paris in 1672, that he really began to understand it: "After having finished the trivial schools, I fell upon the moderns, and I recall walking in a grove on the outskirts of Leipzig called Rosental, at the age of fifteen, and deliberating whether to preserve substantial forms or not. Mechanism finally prevailed and led me to apply myself to mathematics. It is true that I did not penetrate into the depths until after some conversations with Mr. Huygens in Paris in 1672. But when I looked for the ultimate reasons for mechanism, and even for the laws of motion, I was greatly surprised to see that they could not be found in mathematics but that I should have to return to metaphysics. This led me back to entelechies, and from the material to the formal, and at last brought me to understand, after many corrections and forward steps in my thinking, that monads or simple substances are the only true substances and that material things are only phenomena, though well founded and well connected. Of this, Plato, and even the later Academics and the skeptics too, had caught some glimpses, but these successors of Plato did not make as good use of it as he did himself."[38]

In 1673, finding himself at liberty after the death of the Elector, Leibniz invented a calculating machine and presented it at the Royal Society of London. Two years later, he did groundbreaking work in the area of integral and differential calculus – although his right to lay claim to this discovery was hotly contested in England, where even to this day it is attributed to Newton instead. Through his work on the calculus, he freed himself from the Cartesian idea that time and space are substances. By 1676, he was proposing the kinetic energy of "dynamics" as a substitute to the conservation of movement expressed in Descartes' mechanics. This new formulation also convinced Leibniz that he could find the final goal or cause of the ordering of nature.

In a 1675 letter written to Simon Foucher, he reflected on some of the formative intellectual experiences during his early years. The letter is interesting, since it shows to what extent his discovery of monads was an outgrowth of mechanical philosophy and atomism: "...When I think of all that Descartes has said that is excellent and original, I am more amazed at what he has done that at some things which he failed to do. I admit that I have not yet been able to read his writings with all the care that I had intended to give them, and as my friends know, it happened that I read most of the other modern philosophers before I read him. Bacon and Gassendi were the first to fall into my hands. Their familiar and easy style was better adapted to a man who wanted to read everything. It is true that I often glanced through Galileo and Descartes, but since I have only recently become a geometrician, I was soon repelled by their style of writing, which requires deep meditation... Yet what I know of the metaphysical and physical meditations of Descartes has come almost entirely from the reading of a number of books written in a more popular style which report his opinions."[39]

On moving back to Hanover in 1677, where he served variously as librarian and councillor, under the Catholic Duke of Brunswick (a convert from Lutheranism), Leibniz worked on a wide variety of subjects.

Leibniz devoted much energy during the 1680s to the elaboration of a metaphysical system that was grounded in the universal (divine) cause of all being, and that reduced reason to an algebra of human thought. At the same time, he was appointed Court Historian in 1685, and was sent on a three-year mission, beginning in 1687, to Italy, in order to research the genealogical origins (and princely pretensions) of the ducal house of Brunswick. This was, needless to say, an instructive journey for Leibniz: like other figures considered in our thesis – Vesalius, Harvey, Descartes and Hobbes – his Italian travels were an opportunity to meet some of the leading scientists and philosophers of the day.[40]

Starting with the *Discourse on Metaphysics*, which he wrote in 1686, Leibniz pushed ahead his work on combinations and the universal characteristic, and integrated them into an all-embracing philosophical system. This system is too dense and complicated to be exposed in its entirety, although we will give some of the key elements of it in the next section, as they pertain to Man the machine. Leibniz was aware of the need to defend metaphysics, the reputation of which was under pressure during his lifetime.[41]

The modern thrust of Leibniz is striking, his faith in algebra and number. But at the same time, in *First Truths*,[42] he promoted a neo-Platonic idea that has gained new relevance in recent years: "The complete and perfect concept of an individual substance involves all its predicates, past, present, and future. For certainly it is already true now that a future predicate will be a predicate in the future, and so it is contained in the concept of the thing. Therefore there is contained in the perfect individual concepts of Peter or Judas, considered as merely possible concepts and setting aside the divine decree to create them, everything that will happen to them, whether necessarily or freely.... Every individual substance involves the whole universe in its perfect concept, and all that exists in the universe has existed or will exist."[43]

For Rescher, this statement is a startling one. For in it, "Leibniz entertained the radical idea – not projected in modern science until the double helix of contemporary genetics – that information could be encoded in the internal make-up of a substance in such a way as to pre-program in its natural make-up the entire course of its subsequent development."[44]

It was during 1686 that Leibniz elaborated his view of God the Creator of the universe in the *Discourse on Metaphysics*. God is perfect, infinite, supremely good; he does things in the most desirable way, and could not have done anything better. It is impossible for us to understand the particular reasons, which lead God to arrange the universe as he does, and the proper attitude for humans in the face of God is complete contentment and acceptance.

However, according to Leibniz, we can understand divine perfection by means of analogy: "We can say that someone who behaves perfectly is like an expert geometer who knows how to find the best construction for a problem; or like a good architect who utilizes the location and the ground for his building in the most advantageous way, leaving nothing discordant, or which doesn't have the beauty of which it is capable; or like a good head of a household, who manages his property in such a way that there is no ground left uncultivated or barren; or like a clever stage-manager who produces his effect by the least awkward means that could be found; or like a learned author, who gets the most reality into the least space he can."[45]

Leibniz had finally identified the limitations of mathematics and mechanism, and the grounds on which to join part of the mechanical philosophy to his God. He acknowledged, "all particular natural phenomena can be explained mathematically or mechanically by those who understand them." But he maintained, "the general principles of corporeal nature and even of mechanics are nevertheless metaphysical rather than geometrical, and relate to certain indivisible forms or natures, as the causes of appearances, rather than to corporeal or extended mass." The end result of this observation was "a reflection which is able to reconcile the mechanical philosophy of the moderns with the circumspection of some intelligent, well-intentioned people who fear, with some reason, that we might be endangering piety by moving too far away from immaterial beings."[46]

This statement makes clear the ambition of Leibniz to reconcile the new way of thinking with old forms of piety, and discredits Russell's contention that Leibniz supported piety in an insincere fashion, merely out of a desire to promote religious obscurantism!

God for Leibniz was all and in all: the Creator, perfect, infinite and supremely good. The general principles of corporeal nature and mechanics were ultimately derived from a metaphysical basis. And the universe was a vast machine: "I recognize and praise a workman's skill not only by showing what designs he had in making the parts of his machine, but also by explaining the tools he had to make each part, especially when those tools are simple and ingeniously contrived. God is such a skillful worker that he could produce a machine a thousand times more ingenious than those of our bodies, using only various quite simple fluids that we expressly produced, so that ordinary laws of nature were all it took to organize them in the appropriate way to produce such an admirable effect."[47] For Leibniz, this machine-like universe had been created by God to ensure the "greatest possible happiness of the inhabitants.... For happiness is to people what perfection is to beings. And if the first principle of the existence of the physical world is the decision to give it the greatest possible perfection, then the first aim for the moral world or the city of God, which is the noblest part of the universe, must be to spread in it the greatest happiness."[48]

During the 1690s and the first decade of the eighteenth century, Leibniz enjoyed considerable renown for his works on science and mathematics; he worked on linguistics and the prehistoric origins of Europeans, including the Germans;[49] he wrote extensively about ethics and politics; and he developed the notion of the pre-established harmony between body and soul (which set him apart from Descartes), as well as the system of monadology (which, he believed, underlay all physical reality). The influence or lack of influence on Leibniz of F.M. van Helmont and Anne Conway is subject to debate, particularly as to whether Leibniz might have derived the concept of "monad" from these two hermetic philosophers, from Giordano Bruno, or from someone else.

In his final years, he was made a Baron by the Holy Roman Emperor, and was instrumental in the creation of some national academies of science. In addition, during these years, he wrote some of his most important works, such as *New Essays on Human Understanding* (written in 1704, although unpublished during his lifetime), *Theodicy* (published in 1710) and *Monadology* (written in 1714, but unpublished during his lifetime). He died in November 1716.

Leibniz developed his idea of Man the machine through a wide range of works, some of which are long, while others are short; some deal with practical issues of mathematics while others deal with philosophical controversies of his day; some address political and religious issues, while others are more personal. All however are relevant to the subject at hand, since they bear witness to Leibniz's desire to reconcile, to harmonize, to identify in the works of Nature the ordering hand of God, to demonstrate that Man is a metaphysical machine, and to anchor this interpretation in a single, all-embracing philosophical system.

There is no indication that Leibniz borrowed the idea of Man the machine from Leonardo, Vesalius or Harvey.[50] We have already noted that Bacon and Galileo, Descartes, Hobbes and Gassendi influenced Leibniz, although he ultimately felt compelled to modify their thinking on mechanism and atomism, using it instead to support his own metaphysical system.

Given the density and difficulty of Leibnizian metaphysics, we have chosen to summarize the features relevant to our purposes, drawing from several works he wrote before *Monadology*.[51] Since Russell already went ahead and provided his own defective rearrangement, we have to be sure to follow Leibniz's own ideas, and not our own!

If Man was, for Leibniz, a metaphysical machine made up of monads duly created by God, then it is important to start with God and His Creation, and understand how, in a totally inter-connected created, machine-like universe, each indivisible monad implicitly contains a summary or mirror-image of the whole. By coming up with the notion of the monad, Leibniz articulated views, which seem fantastical, intriguing and obscure, but also strangely relevant today. His view of preformation is partially compatible with the idea in genomics[52] today that genes are preformed, have a very long ancestry (in fact going back to the very origins of life) and contain digital information, which will in large part determine the future growth and resistance to disease of each human machine, according to universal laws.[53]

Fortunately, Leibniz was coherent throughout his works, although he was often obscure. God the Creator, for Leibniz, is perfectly powerful and wise.[54] He presides over a great ocean-like universe, "whither flow the rivers of all blessed creatures".[55] He acts according to the laws of physics, but freely.[56] What He has created does not need to be mended – i.e. He does not need to intervene in order constantly to refashion His Creation, since he has pre-established harmony in His universe and foreseen everything.[57] All parts of His Creation are connected.[58]

The majesty of Nature as created by God cannot be compared to the originality of human inventions.[59] It is true that man could make an automaton which could walk around for a time and turn precisely at street corners – but this would still fall well short of the metaphysical machine of Man, as created by God.[60] Spiritual automata contain everything that is beautiful in mechanism – but by virtue of preformation, of mirroring from all time in their monad-like parts the entire universe, as well as the perfections of God, they go well beyond mechanism – "For it is plain that every simple substance embraces the whole universe in its confused perceptions or sensations, and that the succession of these perceptions is regulated by the particular nature of this substance, but in a manner which always expresses all the nature of the universe..."[61] Each created substance mirrors the whole.[62] A sentient or thinking being is not a mechanical thing like a watch or a mill – humans and animals alike have immaterial souls.[63] Nevertheless, the human soul can be conceived as a most exact immaterial automaton.[64]

There are several kinds of correspondences in the machine-like universe that God has created. First, everything is interconnected, so the present is big with the future.[65] Second, Man is a microcosm just as the universe is a macrocosm, as was revealed by seventeenth-century discoveries in natural philosophy.[66] Third, Man is a microcosm since he is like a little god in his own world.[67] And fourth, Man is in God's image and likeness, in having the ability to reason and to exercise free will.[68]

Leibniz's Man the machine went a step further, in the early 1690s, when he developed the concept of the monad, the ultimate, indivisible spiritual substance pervading the entire universe. By expressing the view that the universe was made up of monads, Leibniz managed to find a single principle capable apparently of holding his system of metaphysics together.

According to Rescher, "Any sympathetic reader of the *Monadology* has to accept from the outset that its point of view is altogether olympian. Its purview is not confined to issues of technical philosophy; it seeks to provide a view of the entire range of man's attempts to grasp the world we live in from a unified theoretical perspective, encompassing science, metaphysics, theology, and scholarship in a seamlessly integrated whole. It is this drive to system that makes Leibniz's project both fascinating and admirable and yet rather strange in our eyes. Be it in politics, scholarship, or science, Leibniz insisted on a synoptic perspective from which boundaries are a regrettable, fundamentally irrelevant concession to human frailties."[69]

Monadology, in effect, summed up the essence of Leibniz's life work, as well as his life-long desire to articulate a unified synthetic view of metaphysics in a single reasonably brief text. It described the machine-like universe, and the mechanism of Man, as a way of bringing people back to a greater moral awareness of God's role in the universe.

In *Monadology §64*, for example, he stated that each organic body of a living being is a kind of divine machine or natural automaton, which infinitely surpasses all artificial automata. "For a machine made by human artifice is not a machine in each of its parts. For example, the tooth of a brass wheel has parts or pieces, which to us are no longer artificial things, and no longer have something recognizably machine-like about them, reflecting the use for which the wheel is intended. But the machines of nature, namely living organisms, are still machines even in their smallest parts, *ad infinitum*. It is this that constitutes the difference between nature and artifice, that is, between divine artifice and ours."[70]

From there, Leibniz went on to state, that the soul is indestructible, since it is the mirror of an indestructible universe, and in the same way the animal is indestructible although its bodily mechanism may at death "leave off or take on organic coverings."[71]

Spirits can enter into a kind of community with God, who is to them what an inventor is to a machine, and a prince to his subjects.[72] If the City of God, "this truly universal monarchy" contains the assemblage of all spirits, and is a moral world within the natural world,[73] then He has also created a "perfect harmony between two natural realms", between "the physical realm of nature and the moral realm of grace" – God is both the architect of the mechanism of the universe and the monarch of the divine city of spirits.[74]

Monads have been variously interpreted by scholars. Lange had no time for them, since he considered them to be part of a metaphysical reaction against materialism.[75] Russell was clearly uncomfortable with them, and pointed up many contradictions and internal inconsistencies in the theory of monads – particularly where its relation to God was concerned.[76] Kirkinen wrote that monads were Leibniz's response to Spinoza's materialism as much as to Descartes' spiritualism – Leibniz was concerned not to allow the soul to become purely material, and applied mechanical principles to the soul in his original and brilliant synthesis of ideas prevalent in his day.[77]

Rutherford has suggested more recently that the monads were part of the picture that Leibniz advanced in his mature writings, "of nature as composed of two distinct, but parallel, kingdoms or realms: the material and the substantial, the mechanical and the vital, the world of efficient causes and the world of final causes. The connection between these two realms is mediated by the idea of an organism: a creature formed from a soul-like monad and an organic body, to which the soul is related as a principle of unity and action.... The soul changes its states as a consequence of its own intrinsic force, in accordance with the laws of appetite. The body operates in accordance with the laws of mechanics, under the influence of the forces exerted on it by its constituent parts. Between the body and soul there is only a relation of expression."[78]

Rescher for his part has praised Leibniz for imagining the existence of building blocks which nobody could actually detect: "Leibniz was the first metaphysician of the Western tradition, who sought to construct reality out of units possessing a property structure wholly beyond the reach of our everyday experiences. Anticipating twentieth-century physics in this respect, Leibniz dared for the first time to envision a reality that emerged from the operation of a reality that lies wholly beyond the reach of human observation. His theory of substance is a leap into an order of reality which, for the sake of being intelligible, leaves the sensible domain almost totally behind, a position which the more conservative Kant was to regard as a decisive defect."[79]

As outlined in this chapter, Leibniz's idea of Man the machine sought to remedy the reduction of Nature to mere number and matter in motion; he sought to link sensation and consciousness to the soul, and not just to matter itself;[80] after the ambiguities of Descartes, Leibniz recast the soul as immaterial and perfect in its own kind, beautiful, harmonious, connected to all of the universe, a spiritual automaton in the image of God Himself. This was no mechanical anatomy (Leonardo, Vesalius, Harvey, Descartes), nor was it the dualistic mechanism that Descartes had slapped together, or the enigmatic and purely material mechanism that Hobbes had conceived.

Leibniz interpreted Man the machine as a spiritualistic mechanism, one capable of restoring a metaphysical union of body and soul in a God-ordered universe, one capable of taking the seventeenth-century idea of mechanism, steering it away from materialism, and enlisting it to buttress Christian spirituality instead. This was to all intents and purposes a defensive strategy, but an intriguing one. As is clear from a statement in *New System of the Nature of Substances,* Leibniz recognized early on that artificial machines would never be truly conscious – computers would never know they were computers. In this respect, he was way ahead of his time, and even our time, particularly where artificial intelligence is concerned.[81]

He allied theory and practice more than Descartes and Hobbes. He revolutionized mathematics, discoursed on computation and speculated about mechanical automata (what we would, today, call robots). He invented a calculator and many other technological devices.

The ideas and values serving as the foundation for Leibniz's view of Man the machine were his visionary, albeit speculative reach, the revolutionary character of his mathematics, his passion for practical applications of knowledge of mathematics and natural philosophy, his nostalgic longing for the apparent unity and stability of medieval Europe, his fascination with hermetic values, optimism about the wisdom of God in creating our machine-like world and everything in it, and his desire to bring together the best of the Western philosophical tradition in an original new synthesis.

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[1] A convenient, although somewhat dated, survey of changes in "the Insurgent Century" can be found in Charles Singer, *A Short History of Scientific Ideas to 1900*, pp. 218-287.

[2] In this respect, it is sometimes forgotten that mechanical philosophy and atomism, like religion, had their speculative sides. Like religion, they both needed cunning theories that could glue together disparate and even contradictory principles. They sometimes relied on circular reasoning, which took premises for proofs and threw them up as immutable truths, without taking the time to distinguish clearly between what was given and what needed to be demonstrated. They sometimes relied on far-fetched theorizing, such as Descartes' theory of vortices, which tried and failed to prove that the universe was filled with effluvium, much like the ether of the ancients, the sun meanwhile in its rotation causing this effluvium to swirl in vortices, which carried the planets along.

[3] A convenient modern edition of *The New Atlantis* is contained in Sidney Warhaft (ed.) *Francis Bacon: A Selection of His Works* (New York, 1982).

[4] We have alluded to Bacon's model community of New Atlantis in our M.A. thesis, *Paradise, the Apocalypse and Modern Science: the Myth of an Imminent Technological Eden*, for example on p. 65.

[5] As A. Rupert Hall has pointed out, "the mechanistic outlook originated in an attitude of mind": "Its first assumption – not entirely new in the seventeenth century but never before in the ascendant –was that a natural event was not to be accounted for by its relation to the divine power or some other mysterious universal principle; the correct procedure was to trace its antecedents and through these refer it to simpler circumstances whose mode of action was better understood. Such a procedure must end in the irreducible attributes of matter. Hence the second assumption was that everything happening in the universe – other than miracles – had a material cause; there were no immaterial agencies responsible for the course of events. Moreover, all matter was taken to be essentially alike – there was no matter privileged to be more active than the rest. The third assumption was that the simplest attributes of matter were its quantity (Newton's mass) and its motion.... The fourth assumption was that the uniformity of nature required that the quantities of matter and motion in the universe be unvarying. The rest followed inevitably, for if the ultimate realities of matter and motion were conserved always, all change was a consequence of redistribution. And this in turn required parts that could move more or less, aggregate more or less, and exert more or less force. The final, and for the direction of this attitude of mind specifically towards scientific problems, the major assumption

was that the characteristics of these parts, or particles, could be inferred from those of gross bodies." A. Rupert Hall, *From Galileo to Newton* (New York, 1981), pp. 246-7. These assumptions incrementally detached much natural philosophy from revealed religion.

[6] This challenge was stated early on in the century by Galileo, of whom E.A. Burtt wrote "it was [the] religious basis of his philosophy that made Galileo bold to declare that doubtful passages of scripture should be interpreted in the light of scientific discovery rather than the reverse. God has made the world an immutable mathematical system, permitting by the mathematical method an absolute certainty of scientific knowledge. The disagreements of theologians about the meaning of scripture are ample testimony to the fact that here no such certainty is possible. Is it not obvious then which should determine the true meaning of the other?" E.A. Burtt, *The Metaphysical Foundations of Modern Science* (Atlantic Highlands, 1980), pp. 82-3.

[7] Howard Jones has noted "A critical element in [Gassendi's] strategy is a readiness ... to expose and condemn those features of Epicurean doctrine which are patently at variance with Christian teaching.... The advantages of the approach are clear. At one and the same time Gassendi is able to affirm his own commitment to safeguarding the Christian faith and to imply that those aspects of Epicurean doctrine, which he leaves intact pose no threat to orthodox beliefs.... By taking a pragmatic view of Epicurean theory and introducing God as efficient cause, Gassendi is able to satisfy the demands of orthodoxy without abandoning what he regards as the essentials of Epicurean doctrine." Howard Jones, *The Epicurean Tradition* (London, 1989), pp. 178-9.

[8] Heikki Kirkinen, *Les origines de la conception moderne de l'homme-machine: le problème de l'âme en France à la fin du règne de Louis XIV : 1670-1715* (Helsinki, 1960), p. 5, our translation.

[9] Friederich Lange, *History of Materialism*, 1st Book, 4th Section, p. 3.

[10] Julien Offray de La Mettrie, *Machine Man and Other Writings*, translated by Ann Thomson (Cambridge, 1996), p. 3.

[11] Kirkinen, *op. cit.*, p. 53.

[12] We have studied the best-known of his works – *De Arte Combinatoria* (1666); *On Natural Law* (undated, possibly written between the 1670s and the 1690s); *Caésarinus Fürstenerius* (1677); *On the Universal Science: Characteristic* (1680-85?); *Discourse on Metaphysics* (1686?); *Correspondence with Arnauld* (1686-1690); *Critical Remarks Concerning the General Part of Descartes' Principles* (1692); *Codex Iuris Gentium* (1693); *On the Ultimate Origination of the Universe* (1694); *New System of the Nature of Substances* (1695); *On the Allegiance due to Sovereign Powers* (1695); *Letter about Bayle* (1698); *What is Nature?* (1698); *Reply to 2nd edition of Bayle's comments* (1702); *New Essays on Human Understanding* (1704); *Leibniz's comments on Bayle's Rorarius* (1705?); *Theodicy* (1710); *Judgment of the Works of the Earl of Shaftesbury* (1712); *Monadology* (1714); *A Vindication of God's Justice* (1714); *On the Works of the Abbé de St-Pierre* (1715) and *On the Greeks as the Founders of Rational Theology* (1715). From this impressive output, which represents only a small portion of his writings, it becomes clear why Leibniz is such a difficult figure to characterize. He wrote about many diverse subjects with authority, although few of the minor works were published in his lifetime, and of the major works only *Theodicy* was published.

[13] An interesting discussion of the influence of Aquinas on the German Enlightenment is contained in the Jesuit Frederick Copleston's *A History of Philosophy* (New York, 1985), vol. VII, pp. 101-134, some of which deals with Leibniz.

[14] The sympathies of Leibniz for an idealized hierarchically-ordered medieval age of gold come out in "On Natural Law", an undated work which likely was written sometime between the 1670s and the 1690s, where he wrote that: "If everything in the world were arranged in the most perfect way, then, first of all, parents, children and relatives would be the best of friends, and whole families would have chosen an art of living, would have arranged everything that they have to this end, would abide in it and continue to perfect themselves in their art and direct their children to the same end, and would marry people of the same calling [*Beruf*] in order to be united through education from their parents. These clans would make up guilds or castes out of which cities would arise; these would enter into provinces and all countries, finally, would stand under the church of God." In *Leibniz: Political Writings*, translated by Patrick Riley (Cambridge, 1972), p. 80.

[15] In this respect, Leibniz was part of the early modern movement to reform and systematize European laws, much like his predecessor Grotius and his successors Wolff and Montesquieu.

[16] Whether Leibniz was a Rosicrucian is open to debate. According to the 11th edition of the *Encyclopaedia Britannica* (New York, 1911), "Nuremberg was a centre of the Rosicrucians, and Leibnitz busied himself with the writings of the alchemists, soon gained such a knowledge of their tenets that

he was supposed to be one of the secret brotherhood, and was even elected their secretary." Vol. XVI, p. 385. Frances Yates has been prone to overkill in attributing the origin of modern science to the hermetic tradition (for example, in *Giordano Bruno and the Hermetic Tradition*). She also developed the exaggerated thesis that Rosicrucians were activist/reformers of natural philosophy. ("The Hermetic Tradition in Renaissance Science" in Charles S. Singleton (ed.). *Art, Science and History in the Renaissance* (Baltimore, 1967), p. 263.) From this perspective, Leibniz's alchemical studies were fully compatible with natural philosophy. A more balanced view is that of Allison Coudert, in *Leibniz and the Kabbalah* (Boston, 1995), who has investigated the relationship of Leibniz and the alchemist F.M. van Helmont, suggesting persuasively that Leibniz was influenced both by Kabbalistic mysticism and by hermetic philosophy, from Plato through Renaissance Neoplatonism to Ficino, Lull and van Helmont. In addition, an interesting discussion of the influence on Leibniz of van Hellmont and the Englishwoman Anne Conway is contained in Carolyn Merchant's "The Vitalism of Anne Conway: Its Impact on Leibniz's Concept of the Monad" in *Journal of the History of Philosophy* 17:3 (July 1979), pp. 255-69.

[17] Voltaire, in particular, implicitly held Leibniz up to ridicule in *Candide*.

[18] The debate over whether Leibniz or Newton has the better claim to discovery of the integral and differential calculus has often taken on nationalistic overtones, Germans defending Leibniz, and Englishmen Newton.

[19] Nicholas Rescher, *The Philosophy of Leibniz* (Englewood Cliffs, 1967), pp. 4-5.

[20] E.J. Aiton, *Leibniz: A Biography* (Bristol and Boston, 1985), p. ix.

[21] Leroy E. Loemker (ed.) *Gottfried Wilhelm Leibniz: Philosophical Papers and Letters* (Dordrecht, 1976), pp. 4-9.

[22] *Explanation of Bayle's Difficulties*, in *G.W. Leibniz: Philosophical Texts*, translated by R. S. Woodhouse and Richard Franks (Oxford, 1998), p. 207.

[23] Bertrand Russell, *A Criticial Exposition of the Philosophy of Leibniz* (London, 1992), p. 1.

[24] *Ibid.*, p. 172.

[25] *Ibid.*, p. 202.

[26] In "The God of Leibniz", William E. May concluded that "the God of Leibniz, like the One of Plotinus and the First Cause of the *Liber de causis*, is best regarded under the aspect of perfection or goodness. He is the Infinite, Unlimited Principle of all. Things proceed from God, as they do from the One of Plotinus, necessarily, precisely because the God of Leibniz, like the One of Plotinus, is unlimited Power and the supreme God who cannot suffer any jealousy and is, morally at least, constrained to bring into each being a universe whose individual components or monads each reflect and mirror, in a finite manner, the totally indeterminate perfection that superexists in God." *New Scholasticism*, 36, pp. 526-7. But the God of Plotinus had long been fully compatible with the God of Christianity, as the rich traditions of Christian Neoplatonism and mysticism indicate. On this latter subject, the best source is likely Evelyn Underhill's *Mysticism*.

[27] Donald Rutherford, *Leibniz and the Rational Order of Nature* (Cambridge, 1995), p. 289.

[28] The idea of a reasonably linear evolution in Leibniz's metaphysics is supported by two contemporary scholars. According to Daniel Garber, "Leibniz's later metaphysics does indeed grow out of his reflections on the mechanical philosophy, as he wrote much later. This conclusion should have some bearing on recent debates about the sources of Leibniz's metaphysics. It has been a popular thesis since the turn of the [twentieth] century that Leibniz's metaphysics derives from his logic. This thesis seems clearly false, at least when taken as a historical claim." "Motion and Metaphysics in the Young Leibniz" in Michael Hooker (ed.) *Leibniz: Critical and Interpretative Essays* (Minneaplois, 1982), p. 178. According to Christia Mercer and R.C. Sleigh, Jr., "we should not lose sight of the fact that [his] notion of substance ... is a direct descendent of the metaphysical principles assumed by Leibniz in the 1660s. We have argued that those original principles prompted Leibniz to construct a theory of substance in 1670 that provides the framework for his metaphysical investigations through the period of the *Discourse on Metaphysics*. We propose that a closer study of the principles elaborated and a fuller emphasis of the difficult texts surveyed will provide a more complete picture of Leibniz's mature philosophy." "The early period to the *Discourse on Metaphysics*" in Nicholas Jolley (ed.), *The Cambridge Companion to Leibniz* (Cambridge, 1995), p. 115.

[29] *Dissertation on the Art of Combinations*, in Gottfried Wilhelm Leibniz, *Philosophical Papers and Letters*, edited by Leroy Loemker (Dordrecht, 1976) pp. 73-84.

[30] C.I. Gerhardt (ed.) Leibniz, *Die philosophischen Schriften von G.W. Leibniz* (Hildesheim, 1960-1961), vol. IV, p. 64.
[31] Leibniz, *On the Universal Science: Characteristic*, in *Leibniz: Monadology and Other Essays*, translated by Paul Schrecker and Anne Martin Schrecker (New York, 1965), p. 12.
[32] This can be surmised from *De Arte Combinatoria*, English selections of which are published in Leroy Loemker's edition of Leibniz's *Philosophical Papers and Letters*, pp. 73-84.
[33] Leibniz, *On the Universal Science: Characteristic*, p. 19.
[34] *Ibid.*, p. 14.
[35] Raymond Kurzweil, *The Age of Intelligent Machines* (Cambridge, Mass., 1982), p. 164.
[36] *New System of the Nature of Substances* in R.S. Woolhouse and Richard Francks (ed.) *G.W. Leibniz: Philosophical Texts*, p. 148.
[37] One of these letters is published in Leroy E. Loemker (ed.) *Gottfried Wilhelm Leibniz: Philosophical Papers and Letters* , p. 105.
[38] "Letter to Nicolas Remond", in Loemker, *op. cit.*, p. 655.
[39] "Letter to Simon Foucher", in Loemker, *op. cit.*, p. 152-3.
[40] André Robinet documented this Italian journey in *G.W. Leibniz iter Italicum (mars 1689-mars 1690): La dynamique de la République des Lettres* (Florence, 1988).
[41] "It is true," he wrote in *New Essays on Human Understanding*, translated by Preter Remnant and Jonathan Bennett (Cambridge, 1996), "that the general run of surveys of metaphysics, and of other books of that stamp, teach nothing but words. For instance, to say that metaphysics is the 'Science of Being' in general, which explains the principles of Being and the affections to which it gives rise; and to say that the principles of Being are Essence and Existence, and that its affections divide into the primary ones (one, true, good) and the derivative ones (same and different, simple and composite, etc.); and to use each of these terms in association only with vague notions and verbal distinctions – that is just to abuse the name 'science'. But to be fair to the deeper Scholastics, such as Suarez (of whom Grotius made so much), it should be acknowledged that their works sometimes contain substantial discussions – for instance of the continuum, of the infinite, of contingency, of the reality of what is abstract, of the principle of individuation, of the origin of forms and of a vacuum among forms, of the soul and its faculties, of God's communion with created things etc., and even, in moral philosophy, of the nature of the will and the principles of justice." *Op. cit.*, p. 431.
[42] This work has been variously dated as between 1680-4 by Loemker, *op. cit.*, p. x, and about 1685 by Nicholas Rescher (ed.), *G.W. Leibniz's Monadology: An Edition for Students* (Pittsburgh, 1991), p. 70.
[43] Quoted in Rescher, *op. cit.*, p. 70.
[44] *Ibid.*, p. 71.
[45] *Discourse on Metaphysics*, in R.S. Woolhouse and Richard Francks (ed.) *G.W. Leibniz: Philosophical Texts*, p. 57.
[46] *Ibid.*, p. 72.
[47] *Ibid.*, p. 74
[48] *Ibid.*, pp. 88-9.
[49] Leibniz's researches into a hypothetical original Indo-European language and the common origin of many nations speaking forms of this language have suddenly become relevant again, in the context of research into the human genome.
[50] As Loemker has noted, Leibniz was a preformationist for whom "the growth of the complex organism from a single cell supported his conception that all change is by internal force and not by the interplay of forces between individual and environment. But his preformationism must not be understood in a naïve and materialistic sense. Not every organ already exists in miniature in the original cell; rather the function of every organ is already determined in the laws of the changes of the original living body."*Op. cit.*, pp. 36-7.
[51] These works are: *The Ultimate Origination of the Universe* [1694], *New System of the Nature of Substances* [1695], *Reply to Bayle's Note L* [1702], *New Essays on Human Understanding* [1704], *Theodicy* [1710] and *A Vindication of God's Justice* [1714].
[52] Leibniz was willing to consider the role of heredity, although he placed it in the context, peculiar in our eyes, of Adam's original sin – transmitted by heredity! "We must now deal with the *hereditary transmission of contagion*, engendered by the fall of our first parents and passing from them into the souls of their posterity. There does not seem to be any more suitable explanation for this than to state that

the souls of his posterity were already infected in Adam. To understand this doctrine, we must refer to recent observations and theories which seem to support the opinion that the formation of animals and plants does not proceed from some amorphous mass, but from a body which is already somewhat preformed, enveloped in the seed, and animated long before." G.W. Leibniz, *A Vindication of God's Justice* in *Monadology and Other Philosophical Essays*, translated by Paul Schrecker and Anne Martin Schrecker (New York, 1965), p. 132.

[53] "If the human genome can tell us things about what happened in the primeval soup," science journalist Matt Ridley wrote in 1999 in *Genome: the Autobiography of a Species in 23 Chapters* (London, 1999), "how much more can it tell us about what else happened during the succeeding four millennia. It is a record of our history written in the code of a working machine." *Op. cit.*, p.22. Moreover, in Leibniz's view the human machine contains information or instructions, which are subject to processes of growth in accordance with natural laws. This view seems compatible with Ridley's further comment on the brain: "The human brain is a far more impressive machine than the genome. If you like quantitative measures, it has trillions of synapses instead of billions of bases and it weighs kilograms instead of micrograms. If you prefer geometry, it is an analogue, three-dimensional machine, rather than a digital, two-dimensional one. If you like thermodynamics, it generates huge quantities of heat as it works, like a steam engine. For biochemists, it requires many thousands of different proteins, neurotransmitters and other chemicals, not just the four nucleotides of DNA. For the impatient, it literally changes while you watch, as synapses are altered to create learned memories, whereas the genome changes more slowly than a glacier. For the lover of free will, the pruning of the neural networks in our brains, by the ruthless gardener called experience, is vital to the proper functioning of the organ, whereas genomes play out their messages in a predetermined way with comparatively little flexibility. In every way, it seems, conscious, willed life has advantages over automatic, gene-determined life. Yet … the dichotomy is a false one. The brain is created by genes. It is only as good as its innate design. The very fact that it is a machine designed to be modified by experience is written in the genes. The mystery of how is one of the great challenges of modern biology." *Op. cit.*, pp. 235-6.

[54] God "is infinitely powerful and wise, and maintains order and harmony in everything as far as is possible. But what is more, that which seems so strange when considered in the abstract is a necessary consequence of the constitution of things; and so the universal marvel dispels and, so to say, absorbs the particular marvel, by explaining it. For everything is regulated and bound together in such a way that these natural mechanisms which never go wrong, that we can compare to ships which steer themselves to port despite all the course changes and all the storms, should not be thought any stranger than a rocket which runs along a rope, or a liquid which flows along a channel. Moreover, since bodies are not *atoms*, but are divisible – and indeed actually divided – to infinity, and since everything is filled with them, it follows that the smallest little body is individually affected by the smallest of changes in any of the others, however distant and however small it may be, and so must be an exact mirror of the universe." G.W. Leibniz, *Reply to Bayle's Note L* in *G.W. Leibniz: Philosophical Texts* (Oxford, 1998), p. 245.

[55] "It may be that all suns are inhabited by blessed creatures, and nothing constrains us to think that many are damned, for few instances or few samples suffice to show the advantage which good extracts from evil. Moreover, since there is no reason for the belief that there are stars everywhere, is it not possible that there may be a great space beyond the region of the stars? Whether it be the Empyrean Heaven, or not, this immense space encircling all this region may in any case be filled with happiness and glory. It can be imagined like the Ocean, whither flow the rivers of all blessed creatures, when they shall have reached their perfection in the system of the stars." G.W. Leibniz, *Theodicy*, translated by E.M. Huggard (Peru, Ill., 1985), p. 135.

[56] "It becomes clear also how God acts according to laws of physics, yet freely; how he can be not only the efficient but also the final cause of the world; and how he not only manifests his greatness or power in the machine of the universe which is already working, but manifests also his goodness and wisdom in its construction." *The Ultimate Origination of the Universe* in *Monadology and Other Philosophical Essays*, translated by Paul Schrecker and Anne Martin Schrecker (New York, 1965), p. 90.

[57] "I do not say the material world is a machine or watch that goes without God's interposition, and I have sufficiently insisted that the creation wants to be continually influenced by its creator. But I maintain it to be a watch that goes without wanting to be mended by him; otherwise we must say that God bethinks himself again. No, God has foreseen everything. He has provided a remedy for

everything beforehand. There is in his works a harmony, a beauty, already pre-established." C.I. Gerhardt (ed.) Leibniz, *Die philosophischen Schriften von G.W. Leibniz* (Hildesheim, 1960-1961), vol. VII, p. 358; to Clarke II.8 [1715]

58 "For it must be known that all things are *connected* in each one of the possible worlds: the universe, whatever it may be, is all of one piece, like an ocean: the least movement extends its effect there to any distance whatsoever, even though this effect becomes less perceptible in proportion to the distance. Therein God has ordered all things beforehand once for all, having foreseen prayers, good and bad actions, and all the rest; and each thing *as an idea* has contributed, before its existence, to the resolution that has been made upon the existence of all things; so that nothing can be changed in the universe (any more than in a number) save its essence or, if you will, save its *numerical individuality*. Thus, if the smallest evil that comes to pass in the world were missing in it, it would no longer be this world; which, with nothing omitted and all allowance made, was found to be the best by the Creator who chose it. It is true that one may imagine possible worlds without sin and without unhappiness, and one could make some like Utopian or Sevarambian romances: but these worlds again would be very inferior to ours in goodness. I cannot show you this in detail. For can I know and can I present infinities to you and compare them together? But you must judge with me *ab effectu*, since God has chosen this world as it is." *Theodicy*, pp. 128-9.

59 Some people do not have sufficiently grand ideas of the majesty of nature: "They take the difference between nature's machines and ours to be only that between great and small. This recently led a very able man, the author of *Conversations on the Plurality of Worlds* [Fontenelle], to say that on close inspection nature appears less wonderful than we had thought, it being only something like a craftsman's window display. I think that this gives an inappropriate and unworthy idea of nature, and that it is only my system which shows the true and immense distance there is between the least productions and mechanisms of divine wisdom and the greatest masterpieces produced by the skill of a limited mind – a difference which is not merely one of degree, but of kind. It needs to be recognized, then, that nature's machines have a truly infinite number of organic parts, and are so well provided for and proof against all accidents that it is not possible to destroy them. A natural machine is still a machine even in its smallest parts; and, what is more, it always remains the same machine it was, being merely transformed by being packed up in different ways; sometimes extended, sometimes contracted and as it were concentrated, when we think that it is destroyed." *New System of the Nature of Substances*, p. 148.

60 "There is no doubt that a man could make a machine which was capable of walking around a town for a time, and of turning precisely at the corners of certain streets. And an incomparably perfect, although still limited, mind could foresee and avoid an incomparably greater number of obstacles. And this being so, if this world were, as some think it is, only a combination of a finite number of atoms which interact in accordance with mechanical laws, it is certain that a finite mind could be sufficiently exalted as to understand and predict with certainty everything that will happen in a given period." *Reply to Bayle's Note L*, p. 243.

61 "The foetus forms itself in the animal, and a thousand other wonders of nature are produced by a certain *instinct* that God has placed there, that is by virtue of divine *preformation*, which has made these admirable automata, adapted to produce mechanically such beautiful effects. Even so it is easy to believe that the soul is a spiritual automaton still more admirable, and that it is through divine preformation that it produces these beautiful ideas, wherein our will has no part and to which our art cannot attain. The operation of spiritual automata, that is, of souls, is not mechanical, but it contains in the highest degree all that is beautiful in mechanism. The movements which are developed in bodies are concentrated in the soul by representation as in an ideal world, which expresses the laws of the actual world and their consequences, but with this difference from the perfect ideal world which is in God, that most of the perceptions in the other substances are only confused. For it is plain that every simple substance embraces the whole universe in its confused perceptions or sensations, and that the succession of these perceptions is regulated by the particular nature of this substance, but in a manner which always expresses all the nature of the universe..." *Theodicy*, pp. 364-5.

62 According to Rescher, "The mirror analogy which Leibniz introduces ... plays a very important part in his thought. Nicholas of Cusa already taught that 'The whole is reflected in all the parts; all things keep their own inclination [*habitudo*] and analogy [*proportio*] to the whole universe.' [*Dialogi de ludo globi*, i, 157a.] Leibniz too espouses this Neoplatonic line of thought." Nicholas Rescher (ed.), *Leibniz's Monadology: an Edition for Students* (Pittsburgh, 1991), p. 200.

[63] "A sentient or thinking being is not a mechanical thing like a watch or a mill: one cannot conceive of sizes and shapes and motions combining mechanically to produce something which thinks, and senses too, in a mass where [formerly] there was nothing of the kind – something which would likewise be extinguished by the machine's going out of order. So sense and thought are not something which is natural to matter, and there are only two ways in which they could occur in it: through God's combining it with a substance to which thought is natural, or through his putting thought into it by a miracle. On this topic I am therefore entirely in agreement with the Cartesians, except that I include the beasts and believe that they too have sense, and souls which are properly described as immaterial and are as imperishable as atoms according to Democritus and Gassendi; whereas the Cartesians have been needlessly perplexed over the souls of beasts." *New Essays on Human Understanding*, p, 67.

[64] "I have compared the soul with a clock only with regard to the regulated precision of its changes, which is but imperfect even in the best of clocks, but which is perfect in the works of God. And one can say that the soul is a most exact immaterial automaton." – C.I. Gerhardt (ed.) Leibniz, *Die philosophischen Schriften von G.W. Leibniz* (Hildesheim, 1960-1961), vol. IV, pp. 521-22 [written in 1698], quoted by Rescher, *Leibniz's Monadology: an Edition for Students*, p. 86.

[65] "It is true that God sees all at once the whole sequence of the universe, when he chooses it, and that thus he has no need of the connexion of effects and causes in order to foresee these effects. But since his wisdom causes him to choose a sequence in perfect connexion, he cannot but see one part of the sequence in the other. It is one of the rules of my system of general harmony, *that the present is big with the future*, and that he who sees all sees in that which is that which shall be. What is more, I have proved conclusively that God sees in each portion of the universe the whole universe, owing to the perfect connexion of things." *Theodicy*, p. 341.

[66] "The theater of the corporeal world shows to us more and more of its beauty, even in this life and through the light of nature, since the systems of the macrocosm and the microcosm have begun to be revealed by recent inventions." *A Vindication of God's Justice*, pp. 144-5.

[67] "God, in giving him intelligence, has presented him with an image of the Divinity. He leaves him to himself, in a sense, in his small department, *ut spartam quam nactus est ornet.* He enters there only in a secret way, for he supplies being, force, life, reason, without showing himself. It is there that free will plays its game: and God makes game (so to speak) of these little Gods that he has thought good to produce, as we make game of children who follow pursuits which we secretly encourage or hinder according as it pleases us. Thus man is there like a little god in his own world or *Microcosm*, which he governs after his own fashion: he sometimes performs wonders therein, and his art often imitates nature.... But he also commits great errors, because he abandons himself to the passions, and because God abandons him to his own way." *Theodicy*, pp. 215-6.

[68] "The vestiges of the divine image consist in the innate light of reason as well as in the innate freedom of will. Both are necessary to render our actions virtuous or vicious: we must know and will what we are doing. It must be possible to abstain even from that sin which we actually are committing, if only a sufficiently strong effort were applied. The innate light consists in simple ideas as well as in the complex notions, which derive therefrom. Thus God and the eternal Divine Law are engraved in our hearts, although they are often obscured by human negligence and man's sensual appetites. This innate light can be proved, against certain recent writers [Locke], both by a reference to the Sacred Scripture which testifies that the Law of God is engraved in our hearts, and by rational argument, since the necessary truths can be demonstrated only by principles inherent in the mind, but not by induction from sensorial data. For it is never possible to infer universal necessity by induction from particulars." *A Vindication of God's Justice*, pp. 135-6.

[69] Rescher, Introduction to *Leibniz's Monadology: An Edition for Students*, p. 12.

[70] *Monadology* §64, in Rescher, *op. cit.*, p. 25.

[71] *Ibid.* §77, p. 27.

[72] "§84. This brings it about that spirits are capable of entering into a kind of community with God, and that he is in regard to them not only what an inventor is to his machine (as God is in relation to other created beings), but also what a prince is to his subjects, and even a father to his children)."

[73] "§86. This City of God, this truly universal monarchy, is a moral world within the natural world, and is the most exalted and the most divine of the works of God. And it is in it that that glory of God truly consists, for there would be none at all if his grandeur and goodness were not known and

admired by the spirits. It is also in relation to this divine city that he particularly has goodness, whereas his wisdom and power are manifested everywhere."

[74] "§87. As we have already established a perfect harmony between two natural realms, the one of efficient and the other of final causes, we must here also recognize a further harmony between the physical realm of nature and the moral realm of grace, that is, between God considered as architect of the mechanism of the universe, and God considered as monarch of the divine city of spirits.

[75] Friedrech A. Lange, *The History of Materialism*, 1st Book, 4th Section, p. 127

[76] Bertrand Russell, *A Critical Exposition of the Philosophy of Leibniz*, p. 185.

[77] Kirkinen, *op. cit.*, pp. 175-6.

[78] Donald Rutherford, *Leibniz and the Rational Order of Nature*, pp. 230-1.

[79] Nicholas Rescher, introduction to *Leibiniz's Monadology: an Edition for Students*, p. 12.

[80] Friedrich Lange noted how difficult it was for materialism to explain where sensation came from – he saw Leibniz as part of a wide-ranging, ponderous German reaction to materialism. *The History of Materialism*, 1st Book, 4th Section, p. 127.

[81] *New System of the Nature of Substances*, p. 148.

JULIEN OFFRAY DE LA METTRIE (1709-51)

Julien Offray de La Mettrie does not hold as dominant a place in the history of modern philosophy as Descartes, Hobbes or Leibniz. Nevertheless, he was a leading materialist and physician of the French Enlightenment, who wrote *L'homme machine (Machine Man)* and a number of other highly polemical although clandestine works. He sought to explain the fabric of the human body and mind in materialistic terms, and to show that thought, imagination and the use of reason were ultimately dependent on the changes in organic matter in the brain.

It is striking how coherent and consistent La Mettrie's views are in the philosophical works he has left us. He published six of these works – *Machine Man, Man as Plant, Anti-Seneca, Treatise on the Soul, The System of Epicurus* and *Preliminary Discourse* – over just three years, between 1748 and 1750.[1] He published many other polemical, literary and medical works. Many commentators have seen fit to focus narrowly on *Machine Man*, as if the most celebrated and provocative of his works summed up the essence of his thought. But as we shall see, the other works just mentioned, as well as polemical and medical works that have not yet been translated into English, are just as important for an understanding of La Mettrie's views.

Machine Man was a "best-seller" during the Enlightenment. It attacked Descartes and Leibniz, directly challenged the authority of the Church, denied there was any purpose in Nature, and mocked men as being little more than "vertically crawling machines". It was in some respects the culmination of a rich tradition in French thought – the tradition of the "machine man". This clockwork naturalist tradition articulated a new synthesis of views on the mechanical functions of humans, drawing on a wide range of sources, from pre-Socratics to Plato, Aristotle, Aquinas, medieval and Renaissance natural philosophy as well as the more recent revolution in anatomical knowledge.[2] Descartes and Hobbes (during his Paris exile) can be found at one end of this French tradition, with Leibniz in the middle, and La Mettrie and d'Holbach towards the end.[3]

Descartes advocated the contemporary mechanical view. But in order to preserve the role of the ancient Christian soul, he struck the uncomfortable compromise of philosophical dualism. While he affirmed that man's material body was joined to an immaterial soul, he nevertheless felt compelled to identify the soul's specific material location in the body – the pineal gland. This compromise was exposed to ridicule by La Mettrie,[4] and it was perhaps inevitable that this compromise should fall apart in due course.[5]

Leibniz brought about a synthesis of several contradictory views, by spiritualizing matter[6] – by portraying a universe ultimately composed of metaphysical building-blocks, which he called "monads". Leibniz, the great conciliator, thus reaffirmed the position of Man the machine within a spiritual and indeed a Christian context, accepting some of the insights of mechanistic thinking, while justifying revealed religion. If Man was a machine, according to Leibniz, then that was by God's deliberate although enigmatic design. This position was also emphatically rejected by La Mettrie.

Lucretius, as we have seen, had written a rich, lyrical poem evoking a purely material universe. In a sort of eighteenth century echo of Lucretius, La Mettrie lyrically portrayed Man as subordinate to Nature in a universe where God might or might not exist.[7] In so doing, he couched his philosophical arguments in rich imagery and language. La Mettrie had been exposed to Lucretius through his studies in Leiden under the iatromechanist Hermann Boerhaave (1668-1738). The intellectual debt owed to the classical Latin poet by La Mettrie is noted by the latter's modern-day biographer, Kathleen Wellman,[8] who shows to what extent he gave new relevance to classical atomism, by combining medical and philosophical perspectives of the eighteenth century. Significantly, La Mettrie attributed to Lucretius the view which dominated his own work, namely that "nothing can touch and be touched if it is not body" – at one fell swoop, this ruled out an immaterial soul.[9]

But this is not to suggest that La Mettrie was a lyrical atomist, a latter-day Lucretian – and nothing more. On the contrary, he developed an original synthesis of anatomy and philosophy, based on his own observations and experiments as a practising physician. He placed the conception of Man the machine within a broader materialist conception of Nature, and grounded it in his physician's practice.[10] Drawing in some respects on Lucretius, and in others on Spinoza, La Mettrie characterized man as no more than matter in motion. However, La Mettrie shared neither Spinoza's faith in the geometric method nor his predilection for a pantheistic God.[11]

La Mettrie described Nature lyrically as a powerful, idealized, feminized abstraction – as a secular goddess. Nature "is deprived of knowledge and feeling and makes silk like the *Bourgeois gentilhomme* makes prose, without knowing that she is doing so. She is as blind when she gives life as innocent when she destroys it."[12] The organization of Nature is very hard to penetrate;[13] the path to understanding Nature is overgrown with thorns and obstacles;[14] the way to acquire knowledge of Nature is by means of experiment and observation;[15] physicians (like La Mettrie) are more competent to interpret the labyrinth of man than *a priori* philosophers;[16] the evidence of Nature is to be preferred to the traditions of divine revelation, since "experience alone can justify faith";[17] and Nature provides the source of true morality and politics, which places it in direct contradiction with revelation and the false morality professed by the Church.[18]

This exaltation of Nature presented problems. La Mettrie seemed at times to justify criminal actions, since he considered them inevitable, given the effect that Nature (circumstances and the motions of bodily matter) could have on the criminal.[19]

Although La Mettrie attributed to Nature a blind, impenetrable and arbitrary character, although he saw man as a complex labyrinth, he sought to interpret Man the machine by drawing together in a creative new way some of the metaphors already described. La Mettrie the physician believed that the nature of Man could be understood through the study of anatomy, rather than of speculative philosophy or theology – like the anatomists Leonardo (whom he does not seem to have known), Vesalius (who was part of the canon of eighteenth-century anatomical studies) and perhaps even Harvey (to whom he referred on several occasions).[20]

Descartes, it will be remembered, juggled with the immateriality of the human soul, as well as a purely material, mechanical body to which it was joined. Indeed, he was forced into this position, since he sought to establish the fundamental difference between Man, endowed with body and soul, and animals that were no more than automata.

La Mettrie, for his part, detected no such fundamental difference between Man and animal: both were sentient, intelligent machines, with the difference that

Man had acquired the use of language.[21] From this materialist perspective, La Mettrie thus rejected the dualism of Descartes, maintaining instead that the "soul" was composed of matter and subject to the effects of diet, physical states, etc., and had no existence separate from the body. He took up the familiar image of Man as a clock, with the difference that the clockmaker was not God but a physical substance (chyle) containing a motive principle.[22] Finally, for La Mettrie, the fact that Man was a collocation of organized matter did not imply that there was any divine clockmaker who had organized that matter. There was apparently no God to have given purpose and direction to Creation. Despite the "clever constructions" of Nature, there was a random character to the universe. The divine, for La Mettrie as for Lucretius, was simply "out of the picture."

What we have here is a series of incomplete, paradoxical metaphors: the microcosm without the macrocosm; the clock without the clockmaker; and man as the sum of well-organized machine-like parts in a universe lacking any particular design, governed by a secular goddess called Nature who is at once blind, arbitrary and marvellous. The glue holding these disparate views together was La Mettrie's materialism.

At the same time as he broke with philosophical dualism and evoked the secular goddess of Nature, La Mettrie was attracted to deism, a popular eighteenth-century philosophical belief in God which made no reference to faith, revelation or established religion.[23] It is hard to assert that he was an atheist, as the Jesuit historian of philosophy Frederick Copleston has done.[24] Closer to the mark was Friedrich Lange: "the existence of a Supreme Being Lamettrie will not doubt; all probability speaks for it; but this Existence no more proves the necessity of worship than any other existence; it is a theoretical truth without any use in practice; and as it has been shown by innumerable examples that religion does not bring morality with it, so we may conclude that even Atheism does not exclude it."[25]

If anything, La Mettrie's deism more closely resembled our agnosticism nowadays: he simply felt unable to form an opinion of God, one way or another. Even so, he urged the development of atheism and materialism in order to free society of its prejudices, fanaticism and sectarian violence. Such positions help to explain why publication of *Machine Man* sent La Mettrie into exile in Holland, and why he had to seek the protection and patronage of Frederick II of Prussia (1712-1786).

It should come as no surprise that La Mettrie was subjected to the concerted attacks of the French medical profession, the Catholic Church, and the Crown itself, since his highly polemical works consisted of direct attacks on these institutions. La Mettrie's freethinking and materialism were not the only danger for these *ancien régime* institutions. More provocative still was his chatty, colourful and sarcastic style, which helped him acquire "best-seller" status at a time when ponderous conventional philosophers had a narrower readership.

In his own day, he had few defenders – apart from Frederick II. Diderot dismissed him as "dissolute, insolent, a buffoon and flatterer; made for life in court and the favours of the powerful."[26] After falling into virtual oblivion, La Mettrie was reassessed in the mid-nineteenth century by the historian of materialism Friedrich Lange, for whom he was an unsung precursor of eighteenth and nineteenth century materialism, whose views were highly original.[27]

More recent appraisals of La Mettrie note that he was a precursor of modern physiology, experimental materialism, biology and neuropsychiatry. He has been singled out for having removed study of the brain from the narrow confines of Cartesianism,[28] and as a pioneer who anticipated the development of artificial intelligence.[29] Adam Vartanian noted in his annotated edition of *L'homme machine* that "the ghost of La Mettrie, during the past century and a half, has never been so much alive and abroad as he is today" – largely because of the development of cybernetics as well as behaviourist psychology.[30]

A negative and exaggerated view is that of Ernst Cassirer, for whom the materialism of La Mettrie's *Machine Man* as well as of d'Holbach "is an isolated phenomenon of no characteristic significance. Both works represent special cases and exemplify a retrogression into that dogmatic mode of thinking which the leading scientific minds of the eighteenth century oppose and endeavor to eliminate."[31]

Below is a table summarizing some of the influences on La Mettrie:

La Mettrie's interpretation	Sources	Key features
The body as machine	Plato, Aristotle, Galen, Vesalius & Harvey, classical atomism & medieval view of universe having order and rationality and thus being measurable	The body is matter in motion
Man in God's image and likeness	La Mettrie was skeptical about the legacy of Judaism, Christianity, Greek & Roman mythology as well as hermetic philosophy & Neoplatonism	For La Mettrie, God, if He exists, is unknowable; Man cannot be likened to God and must not take himself to be God on Earth
Man as a microcosm	La Mettrie had been exposed to the Classical and medieval myth of the microcosm, as well as its use by Vesalius, Harvey & Leibniz, but he did not "buy into" the macrocosm/microcosm	Man may be a microcosm but there is no enigmatic correspondence with the greater macrocosm (i.e. with a universe rationally ordered by God)
Man as self-mastering individual	La Mettrie accepted Enlightenment values of reason as the basis for true morality and mastering oneself; knowledge requires casting aside all *a priori* philosophy, and focusing instead on observations and experiments	La Mettrie saw religion and theocracy as dark forces hindering the individual's mastery of himself, through the propagation of hatred, violence, superstition and ignorance – reason and natural philosophy offer the only avenue for self-mastery
Man as a psychological being with virtually unlimited dimensions to human personality	These unlimited dimensions are due to the complexity of combinations of matter – since human psychology is determined by material forces within the brain and body	Psychology is complex since the mechanical workings of organic matter in motion are complex; criminals are not responsible for their actions, which are determined by material forces
Man as endowed with reason and devoted to happiness	Enlightenment values	Happiness is provided by knowledge of virtue and the cultivation of reason
Man as a cog within an Automated State	Absent	

Julien Offray de la Mettrie was born on Christmas Day, 1709 in Saint-Malo, France, into a family of minor provincial nobility. Wishing to pursue his medical studies as a young man, he could not afford the exorbitant fees charged in Paris, and therefore chose to study in Reims instead.[32] He seems to have felt himself an outsider from an early age: not just a provincial, without much money, but also an embittered wanderer dedicated to ideals, always ready to show up the faults of people around him, whether they be members of his family, writers of his own day, theologians, women, or physicians.[33]

His studies of medicine seem to have coincided with disenchantment with religion:[34] medicine was practical and grounded in observation and experiment, whereas theology was shamelessly speculative. He wrote that physicians who rightly understood their profession could penetrate further into the labyrinth of man than theologians: "Physicians have explored and thrown light on the labyrinth of man; they alone have revealed the springs hidden under coverings which keep so many marvels from our gaze. They alone, calmly contemplating our soul, have it a thousand times unawares, in its misery and its grandeur, without either despising it in one state or admiring it in the other."[35] He contrasted this approach to the shameless and ridiculous speculations of theologians, who "have been deflected by obscure studies that have led them into a thousand prejudices and, in a word, fanaticism, which adds to their ignorance of the mechanism of our bodies."[36] La Mettrie thus proclaimed that of all natural philosophers, physicians were the ones most suited to interpret man.

This confidence in medicine was not to last. He also became disenchanted with the practice of medicine in France, which suffered from the sharp division between physicians and surgeons, in terms of intellectual perspectives and corporate interests. As his biographer Kathleen Wellman has noted, "The corporate control of the medical profession, according to La Mettrie, has worked to the detriment of medical education because the faculty determines which areas of scholarship are appropriate or essential for the successful physician. Hence La Mettrie contends that the study of physiology and the adoption of new discoveries have always been absolutely irrelevant to the Faculty, citing only the most notable case, the failure of the Faculty to accept the circulation of the blood more than one hundred years after Harvey."[37]

La Mettrie was appalled by the rift between Paris physicians, on the one hand, and the surgeons, on the other, who grounded their judgments in detailed physiological knowledge, experience at the operating table, a respect for scientific knowledge, and a disdain for theorizing. This rift recalls the situation facing Vesalius more than two centuries earlier. La Mettrie exposed his views in a number of "serious" medical works on vertigo, venereal disease, asthma and dysentery,[38] but also in biting satires, from *Lettre à monsieur Astruc* in 1737 through *De orbis veneris* (1736), *Saint Cosme vengé* (1737), *La politique du Médecin de Machiavel* (1746), *La Faculté vengée* (1747), *Anti-Machiavélisme* (1748) to *Ouvrage de Pénélope* (1748-50).

In these 1600 pages of satire, La Mettrie launched broadsides at the medical profession of France; subjected the practice of medicine to biting sarcasm; accused prominent physicians of being charlatans more interested in professional fees and rubbing shoulders with the high and mighty than in the health of their patients; vaunted the superiority of surgery to medicine, since it is based on observation, experiment and detailed knowledge of anatomy; and advocated greater specialization among physicians, as well as experimental research.[39] To keep people reading his anonymous polemics, La Mettrie sometimes took on pen names and pretended to attack his own previous publications.[40] The general theme of these works was consistent. "Why are Doctors so poorly considered?" he wrote in *Anti-Machiavélisme.* "It is not because Molière has maligned them; it is because they have maligned themselves by the vices and ridiculous practices that existed before this great comic author and which give no sign of disappearing in our day. These vices are: cunning ruses, deceitfulness, ignorance, charlatanism, giving themselves airs, pretensions and fine clothes, in a word everything which denotes pedantry… And what fault do people find with Medicine? It is an uncertain, conjectural Art, devoid of rules and principles, where everything doubtful and ambiguous, if not plainly false."[41]

These polemical works were not only entertaining and controversial, but tended to support the idea of reforming medical education in France, as well as the practice of medicine itself. Needless to say, they made their author a lot of enemies.

It is interesting to note that two formative experiences set La Mettrie on the path of *Machine Man.* The first was the experience of studying under Boerhaave in 1733-4. He was also exposed in Leiden to the works of Albrecht von Haller (1708-1777).[42] The second was a severe fever in 1744, at the siege of Fribourg, where he was serving as army surgeon[43] – and which convinced him of the effect that organic changes in the brain had on psychic phenomena – on sensation.

The influence of his mentor Boerhaave was all-important, and La Mettrie translated some of his works into French. According to Wellman, "Boerhaave's medical theory provided the foundation of his own discussion of the philosophy of nature. In fact, La Mettrie's critical assessment of Boerhaave's medicine enabled him to develop fundamental perspectives from which he later investigated philosophical questions."[44] A significant aspect of Boerhaave's medicine was his work at bringing about a reconciliation between iatrochemists and iatromechanists.[45] In addition, La Mettrie was impressed by his practice of medicine, his concern for public health, and his understanding of the nature of disease.

As to the second formative experience, namely the severe fever from which he suffered in 1744, La Mettrie followed the stages of his illness with a dispassionate medical interest. Frederick II later wrote, referring to La Mettrie's interest in mechanical conceptions of nature, that, "filled with these ideas, during his convalescence, he carried the torch of his experience into the shadows of metaphysics; he sought to explain, having recourse to anatomy, the loosening of the understanding, and he only saw [the effect of] mechanics, where others had imagined [the workings of] some essence superior to matter."[46]

In 1745, he was forced to leave Paris after publishing the *Treatise on the Soul*, a book burned there by the public hangman, although he revised it and published it abroad several years later. Returning to the relative tolerance of Holland, he published *Machine Man* in 1747, followed by *Anti-Seneca*, a discourse on happiness. However, he then had to leave Holland in 1748, for the official protection of Frederick II in Berlin, where he was made court reader, and was named to the academy of science. He died in 1751, apparently from food poisoning, which many of his bitter enemies considered all too fitting for someone who claimed to have superior knowledge of the medical profession.

Much of what La Mettrie said of mechanical functions of the body seems commonplace today. But in the eighteenth century, La Mettrie's materialism was novel, even scandalous. His attacks on Christian revelation, Descartes and the tradition of dualism were certainly a threat to the older world-view, according to which man had a dominant place in a closed, perfect, harmonious Earth-centred universe created by God. For many an eighteenth-century observer, it was hard to conceive of a universe without God the Creator and man in His image and a moral hierarchy of good and evil, without human claims to mastery over Nature, without man in the image of God, a universe without a reason behind the admirable clocklike workings of Nature.

Nowhere is the challenging character of La Mettrie's philosophy more apparent than in his view that the mere fact of order in nature implies no master design whatever, no divine clockmaker behind it all. Like his God-fearing predecessors, he continued to see the natural order in allegorical terms, but he detected a depersonalized power operating in the universe, and saw no use for God. Ears are mathematically constructed and equally serve one single purpose, which is hearing; in the animal kingdom the same purpose is achieved in an infinite number of ways, although each one is geometrical; far from constituting proofs of the existence of a Creator, such examples serve to show that matter is capable of "brilliant productions, and nature is not a worker of limited ability. The ease and pleasure with which she produces millions of men exceed the watchmaker's toil when he creates the most complicated of watches. Her power shines out as clearly in the creation of the meanest insect as in that of the most splendid human."[47]

La Mettrie believed that there is some intrinsic although limited purpose in the universe: "Nature created us solely to be happy – yes, all, from the worm crawling on the ground to the eagle soaring on high. That is why she gave all animals a portion of the law of nature which is more or less refined depending on how well-conditioned are the organs of each animal which possesses it."[48]

As we have seen, the idea of Man the machine had already begun to undergo considerable changes by the early eighteenth century: the discoveries and prestige of natural philosophy, and particularly of anatomy, sometimes under the influence of hermetic ideas, had weakened the attraction of older, more purely spiritual conceptions of Man, grounded in ancient philosophy and divine revelation.

Heikki Kirkinen, noting the often-observed leap in France from the religious orthodoxy of Bossuet to the rationalism of Voltaire over the course of the eighteenth century, wrote "the doctors played a significant role in the evolution of the idea people had of man, since they were both physicians and philosophers. This was due to the fact that, in order to enter the Faculty of Medicine, one had first to obtain the degree of 'Master of Arts' or to devote two years of study to philosophy."[49] The role of medical *philosophes*, La Mettrie among them, thus helps to explain the theoretical and practical attraction of materialism, scientific method, empiricism, and scepticism. Kirkinen's work cuts off around 1715, and does not therefore directly deal with La Mettrie, however.

Few historians of science have given an accurate assessment of the relationship that La Mettrie had with his philosophical and medical predecessors. Leonora Rosenfield only examined the relationship of the beast-machine to man-machine in her whimsical, disappointing work, whereas Man the machine has a long history in its own right, as we have seen.[50] Adam Vartanian, while recounting La Mettrie's relationship with Descartes, Spinoza and Boerhaave, and while deploring the lack of evidence showing he may have been familiar with the works of Hobbes, simply ignored the deep roots of the metaphor of Man the machine, which we have been exploring in this thesis.[51] Deep roots which La Mettrie himself celebrated – whether it was to praise Lucretius or other classical atomists, or to question Plato and Aristotle. David Channell, as we have seen, highlighted the influence of Haller on La Mettrie, leaving other influences in the dark.[52]

Lange, it should be stated, did not suffer from this blinkered view of history: on the contrary, his masterwork on the history of Materialism demonstrated that La Mettrie was in continuity with a long-established tradition of thought.

La Mettrie was well-placed to purge the metaphor of Man the machine of any religious associations, to make the definitive break with philosophical dualism and spiritualized matter, and to ground Man the machine solely in materialism. We will situate the main argument in *Machine Man* (1747) in the context of La Mettrie's views of Nature, before considering relevant aspects of La Mettrie's materialism in *Man as Plant* (1748), *Anti-Seneca* (1748), *Treatise on the Soul* (1750), *The System of Epicurus* (1750) and *Preliminary Discourse* (1750).

Man is a machine, La Mettrie boldly stated, and there is in the whole universe only one diversely modified substance.[53] Our thoughts and actions all depend on how the human machine is variously constructed. Speculative philosophy about the nature of man, while promising exact truth, is based on *a priori* reasoning and is thus less valid than *a posteriori* reasoning, based on direct observation of man's organs: "Man is a machine constructed in such a way that it is impossible first of all to have a clear idea of it and consequently to define it. That is why all the greatest philosophers' *a priori* research, in which they tried, as it were, to use the wings of the mind, have failed. Hence it is only *a posteriori*, or by trying as it were to disentangle the soul from the body's organs, that we can, not necessarily discover with certainty the true nature of man, but reach the greatest possible degree of probability on the subject."[54]

Moreover, La Mettrie said, betraying a certain corporate pride in the medical profession, a close study of anatomy, of the structure of man and animals, will provide insights into man's nature: "The different states of the soul are thus always related to those of the body. But in order to demonstrate better the extent of this dependence and its causes, let us use comparative anatomy here; let us open up the entrails of men and animals. How can we know human nature if we have not been enlightened by an accurate comparison of the structures of men and animals!"[55]

Not only did La Mettrie favour the medical profession over speculative philosophy; he also preferred practising physicians who have acquired a working knowledge of the physics and mechanics of the body: "if we compare two doctors, the best and most trustworthy is always, in my opinion, the one who knows the most about the physics or the mechanics of the human body and who, forgetting the soul and all the worries which this figment of the imagination causes in fools and ingoramuses, concentrates solely on pure naturalism."[56]

Indeed, considering that crimes are sometimes committed in moments of passion, and that passions are in turn determined by diet and other causes, "it would no doubt be preferable if all judges were excellent medical doctors. Only they could distinguish the innocent criminal from the guilty one."[57]

What precisely does the study of anatomy teach us? *Machine Man* is clear about this point: a study of anatomy demonstrates that the human body winds itself up, and is a living picture of perpetual motion; that the way we think and behave directly depends on how our bodily machine is constructed. Bodily reactions can be likened to the action of springs. For example, the body draws back, struck with terror at the sight of an unexpected precipice, the eyelids blink under the threat of a blow, the pupils contract in bright light to protect the retina and dilate to see objects in the dark; the skin's pores close in winter to keep cold outside of the vessels; the stomach heaves on being irritated by poison; the heart, the arteries and the muscles contract during sleep as much as during the waking hours.[58]

Such examples show that the body reacts mechanically to stimuli, whether it is sleeping or awake. Thought and feeling are dependent on the spring-like action of movement in the brain, as well as on the material structure of the brain, and are even inherent in that structure: "does the organisation suffice to explain everything? Once again, yes. Since thoughts clearly develop with the organs, why should the matter which composes them not also be capable of remorse once it has acquired, with time, the faculty of feeling?"[59]

But Man is not just a machine, he is a clock-like machine. La Mettrie was not suggesting that man is necessarily as predictable and accurate as a clock; on the contrary, he speaks of the highly changeable, irrational nature of man, of "the chaos and the perpetual rapid succession of our ideas; they pursue each other as one billow pushes another..."[60]

Instead, man is like a clock in that every organ functions as a cog or spring, contributing to the orderly movement of the whole. It is in this functional movement that we detect both the mechanical nature of man and the complexity of that mechanism, since countless cogs and springs operate independently of one another: "The human body is a clock but so huge and cleverly constructed that if the cog which tells the seconds happens to stop, the one which tells the minutes goes on tuning, in the same way as the cog for the quarters continues to move, and so do the others, when the first ones are rusty or out of order for some reason and stop working." La Mettrie said that the obstruction of a few vessels is not enough to destroy or halt the main movement of the heart, which is like the "mainspring" of the machine. "On the contrary, the fluids, which have diminished in volume, do not have so far to go and cover the distance all the more quickly, as if carried by a new current, because the strength of the heart has increased due to the resistance it meets with at the extremities of the vessels."[61]

In this passage, it should be noted, La Mettrie said that the clock of the human body is "cleverly constructed", although he did not thereby imply that there is any designer behind the bodily construction. On the contrary, he maintained that the clockmaker is a physical substance, chyle, which the *Collins English Dictionary* defines as "a milky fluid composed of lymph and emulsified fat globules, formed in the small intestine during digestion." In so doing, he attributed to an inanimate substance the power to provide order and coherence to the body: "The natural oscillation, a Property of our machine, possessed by every fibre and, so to say, every fibrous element, is like that of a clock in that it cannot always function. It must be renewed as it is depleted, given strength when it languishes, weakened when it is oppressed by too much strength and vigour. That is what constitutes the only true medicine. The body is nothing but a clock whose clockmaker is new chyle. "

Moreover, La Mettrie continued, "Nature's first care, when the chyle comes into the blood, is to stimulate in it a sort of fever which the chemists, who are obsessed by furnaces, must have taken for a sort of fermentation. This fever produces a greater filtration of the spirits, which then mechanically stimulate the muscles and the heart as if they were sent there on the orders of the will."[62]

It will readily be seen how different La Mettrie's use of the clock metaphor was from that of his predecessors. Previously, the clock had been seen in the microcosm/macrocosm perspective of a well-ordered, harmonious universe, in which every thing and being had its place according to the divine plan, and mankind held the preponderant place. Now, the clock image was used to explain the movement and properties of the human body, the physiological functions and mechanisms of particular organs, and the clever construction of the body, which came about without divine intervention.

From the vantage point of the newly acquired prestige of anatomical science, La Mettrie felt confident to attack Descartes directly. He did so on several counts. As we have already seen, he did not believe that God was the Prime Mover of the universe. He did not believe in philosophical dualism. And he did not believe man to be much different from animals: both had material souls; their differences were a question of degree, not of a fundamentally different essence.

La Mettrie held that the soul is not detached from, and coexistent with the body; on the contrary, the soul is dependent on physiological states, and the operations of the soul can be observed in bodily responses themselves: "If the tautness in the nerves which produces pain causes fever, by which the mind is disturbed and has no will left, and vice versa if an overactive mind disturbs the body and lights the fire of consumption which carried off Bayle at such an early age; if a particular titillation makes me want, forces me to desire ardently what I did not care about the moment before; if in turn certain traces in the brain excite the same lust and the same desires, why divide into two what is obviously only one?"[63]

There are cases, according to La Mettrie, in which body and soul seem to be detached, whether because of illness, or the effects of sleep. People subject to illusions and delirium experience all sorts of passions and conditions, depending on their medical state, their diet, whether they are drinking coffee or wine. "Food maintains what is aroused by fever. Without it, the soul languishes, becomes furious and dies dejected. It is like a candle whose light flares up just as it is going out. But if you feed the body, pour into its pipes vigorous sugars and strong liquors, then the soul becomes as generous as they are and arms itself with proud courage, and the soldier who would have fled if given water becomes ferocious and gaily runs to his death to the sound of drums."[64]

In addition, the brain possesses muscles for thinking just as the legs do for walking. Thoughts and feelings are contained in bodily processes. The soul is thus material. Certain operations of the soul, such as judgement, reason and memory, can be detected in physical effects: "modifications of that sort of medullary screen on which the objects painted in the eye are projected as in a magic lantern."[65] In fact, La Mettrie saw the soul as "an impetuous principle" that "exists and has its seat in the brain at the origin of the nerves, by means of which it exerts its control over all the rest of the body."[66]

In short, for La Mettrie, the soul cannot be seen in the traditional dualist sense, as the spirit, as the immaterial and indeed the immortal part of the human, as the seat of the intellect and personality, as an image of God's intelligence. On the contrary, "the soul is merely a vain term of which we have no idea and which a good mind should use only to refer to that part of us which thinks."[67]

We have noted already that La Mettrie considered humans to be "vertically crawling machines", whose physical characteristics were not so very different from those of animals. If there is a difference between man and the animals, it lies in the acquisition and use of language: "From animals to man there is no abrupt transition, as true philosophers will agree. What was man before he invented words and learnt languages? An animal of a particular species, who, with much less natural instinct than the others, whose king he did not yet consider himself to be, was only distinguishable from the ape and other animals in the same way as the ape himself is; I mean by a physiognomy that indicated greater discernment."[68] As a result, language provided the means to polish the human mind, to teach words, languages, laws, science and the arts. "A mathematician learnt the most difficult proofs and calculations, as a monkey learnt to put on and take off his little hat or to ride his trained dog. Everything was done by signs; each species understood what it was able to understand, and that was how man acquired symbolic knowledge."[69]

Ultimately, La Mettrie saw education itself as a mechanism, since it consists of sounds and words transmitted from brain to brain. And, to some extent, animals partake of this mechanism. They are capable of emotions and intelligence, just as humans are: "How could (the animal's) soul, which exhibits the same joys, the same mortification, the same disconcertment as ours, not feel repugnance at the sight of a fellow creature being torn to pieces or after having itself dismembered it without pity? Given this, we must suppose that animals have not been denied the precious gift in question; for, since they give us undeniable signs of both repentance and intelligence, why is it absurd to think that beings, machines almost as perfect as ourselves, were made like us to think and to feel nature's promptings?"[70]

Organized matter is endowed with a motive principle; in animals, matter is organized; in animals, everything is dictated by the diversity of this organization. Thus, man is an animal and animals share in many human attributes: "to be a machine and to feel, to think and to be able to distinguish right from wrong, like blue from yellow – in a word to be born with intelligence and a sure instinct for morality and to be only an animal – are thus things which are no more contradictory than to be an ape or a parrot and to be able to give oneself pleasure."[71] As a result, if animals have man-like qualities such as emotions and intelligence, if animals are clocks in their own right, then man is a more perfect kind of animal: "we can see that there is only one substance in the universe and that man is the most perfect one."[72]

In *Man as Plant*, La Mettrie toyed with the idea that man was like "an upturned tree whose brain is its roots, since this root is the result of the activity of abdominal vessels alone; they are the ones which are formed first, or at least they are formed before the teguments which cover them and constitute man's bark. In the plant's seed, one of the first things that one sees is its little root and its stem; one goes downwards and the other goes upwards."[73] This playful work is rife with mixed metaphors, and is perhaps most important for the author's conclusion firstly that animals and man were alike in having material souls, intelligence, the capacity to learn and to adapt themselves – and secondly that the difference between them was not fundamental, as Descartes had claimed, but more a question of degree.

In *Anti-Seneca*, La Mettrie attacked the Stoics as being "sad, strict and unyielding; we shall be cheerful, sweet-natured and indulgent."[74] While inquiring into the foundation of happiness, he advocated the effects of our internal organization on our happiness, as well as "education, which, so to speak bends our soul and modifies our organs; pleasures of the senses; wealth; honours, reputation, etc."[75] But it is when he turned to reprehensible behaviour that La Mettrie made the most original statement in this work. He had already stated in other works that Man was a machine, subject to the forces of nature on his organization. Now he claimed that criminals could hardly be blamed for committing those reprehensible acts which Nature obliged them to commit: "Criminals have executioners and the executioners have none; their hearts are closed to remorse and repentance. And yet they are murderers! Yes, but stipended murderers. The ones are paid and the others are revered.... But executioners are authorised and assassins are punished; the public good calls for both and is enough to justify the former and condemn the latter to death, but to remorse, to which Pufendorf does not seem to condemn those assassins who are forced into it. The law of nature, which is his foundation, should also shelter them from the laws or make men imagine laws more favourable to these poor wretches."[76] This strikes us today as a rather extreme consequence of Man the machine, since it seems to remove any responsibility from the shoulders of criminals. The great reformer of justice Cesare Beccaria, who published *Of Crimes and Punishments* in1762, provided a more secure foundation for criminal justice, by insisting that a punishment be proportionate to the injury to society of the crime itself. As such, Beccaria focused on whether the death penalty was really useful and necessary for the security and good order of society, and what were the best ways of preventing crimes in the first place.[77]

What was the significance of La Mettrie? We are faced with an enigmatic, sarcastic and dissolute wanderer, making bold although largely anonymous attacks on the medical, philosophical and theological conventions of his day; someone with a passionate desire to reform medical and educational institutions, take up the mission of public health, and bring about greater happiness and justice in society; an inveterate, rather lonely joker who remained hostile to power elites, although he was finally granted asylum and status at the court of Frederick II.

He suggested that the reason for man's existence might well prove to be that existence itself. Perhaps man was "thrown by chance on a point of earth's surface without anyone being able to say how or why, but simply that he has to live and die, like mushrooms which appear from one day to the next, or flowers which grow beside ditches and cover walls. We should not lose ourselves in infinity; we were not made to have the slightest idea, and we are absolutely incapable of tracing things back to their origin."[78] It is enough to know that organized matter is endowed with a motive principle, which alone distinguishes it from unorganized matter.

One detects in La Mettrie a naïve optimism about atheism, although he cannot be said to have espoused this latter view – he was too ambivalent for that. He wrote, for example, that the atheist is well-placed to live out the Golden Rule. With atheism, there will be "no more theological wars, no more soldiers of religion, those dreadful soldiers! Nature, now infected by sacred poison, would regain its rights and purity."[79] The materialist, convinced of his animal nature (and by the same token, of being a machine) "will not ill-treat his fellows ... following the law of nature given to all animals, he does not want to do to others what he would not like others to do to him."[80]

It is striking to note that La Mettrie had few defenders in his day. Even later materialists such as d'Holbach, while drawing inspiration from his views, were careful to distance themselves publicly from him.[81] As Friederich Lange has noted, "Lamettrie was the scapegoat of French Materialism in the eighteenth century. Whoever came into unfriendly contact with Materialism attacked him as its extremest representative; and even those who approached to Materialism in their own views, protected their own backs against the worst reproaches by giving Lamettrie a kick."[82] From the early twenty-first century perspective, however, La Mettrie seems to have been far less categorical in his views than d'Holbach. He was willing, on occasion, to suspend judgment on controversial matters, where d'Holbach elaborated a dogmatic defence of materialism that seemed to leave no room for doubt. There is also a mischievous playfulness in La Mettrie which is totally absent in later materialists such as d'Holbach and Marx.

Moreover, he left a legacy, which few of his contemporaries could appreciate. According to Kathleen Wellman, "La Mettrie defined one of the most enduring legacies of the eighteenth century to the modern world through his medical approach to philosophical issues. He was the crucial figure in integrating public health issues into the Enlightenment, a concern that became more pronounced in the nineteenth century. And in fact the positions taken by La Mettrie, expunged of their radical and antireligious overtones, cross the chasm of the Revolution to provide a link to the anthropological view of man more common to the physiological foundations of social science in the nineteenth century."[83]

Wellman added "La Mettrie's approach to moral and social dilemmas resonates in contemporary issues. For example, La Mettrie's medical approach to ethical questions is significant in the insanity defense and arguments about diminished capacity. His attempt to correlate mental states with brain physiology seems to have been substantiated by twentieth-century findings about brain chemistry (for example, as the sources of Alzheimer's disease and schizophrenia). It is also interesting that biomedical and biochemical explanations of human capabilities more strikingly suggest the influence of La Mettrie than the computer analogies sometimes invoked as the derivations of man-machine."[84]

The relationship of La Mettrie with computers is an interesting one, although we should be careful not to "read back" into his mind notions and technological innovations which have only become current in our own day.

A somewhat exaggerated view has been stated by Keith Gunderson, in *Mentality and Machines.* Gunderson rightly noted that La Mettrie attributed to animals and humans alike sensations, intelligence and the use of language, which could be represented mechanically, since both are complicated machines which give rise to thought and feeling. Then he seized on a remark in La Mettrie about a hypothetical Prometheus of the future. "We can see that there is only one substance in the universe and that man is the most perfect one. He is to the ape and the cleverest animals what Huyghen's planetary clock is to one of Julien Leroy's watches. If it took more instruments, more cogs, more springs to show the movement of the planets than to show or tell the time, if it took Vaucanson more artistry to make his flautist than his duck, he would have needed even more to make a speaking machine, which can no longer be considered impossible, particularly at the hands of a new Prometheus."[85] From this somewhat isolated quotation, Gunderson then imagined that "Cyberneticians and those working in areas of computer simulation of cognitive processes and artificial intelligence may turn out to be a kind of collective 'Prometheus' who will provide us with the linguistically proficient mechanical man envisioned by La Mettrie."[86]

Was La Mettrie, unbeknownst to himself, an eighteenth-century prophet of artificial intelligence? According to Adam Vartanian, it is important to qualify the relationship of La Mettrie with modern computers: "to be sure, the cumulative evidence offered by cybernetics (whatever its most zealous exponents might say) does not prove that a man is literally a machine any more, for that matter, than did La Mettrie's book. Depending on how words are used, machines could well be said to 'think' or to 'act with purpose.' However, unless a dogmatically behavioristic attitude is taken in such matters, it must be admitted that machines neither know that they think, nor what the purpose of their thought might be; and that precisely these capabilities describe the essence of human, and possibly of higher animal, thought.... Cybernetics, in opening up new avenues of investigation for mechanistic psychology, has been merely the most recent and, in some ways, the most convincing illustration of the persistent vitality and indefinite promise that were present from the first in the thesis of *l'Homme machine*."[87]

In any case, rather than create hypothetical links between La Mettrie and today's computers, on the basis of the name "Prometheus", some of his philosophical predecessors, like Pascal and Leibniz, can more accurately be said to have anticipated computation, by inventing calculating machines of their own.

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1 The edition used here is Ann Thomson's *Machine Man and Other Writings*, Cambridge University Press, 1996 (referred to hereafter as *MMOW*), which we have compared to the 1774 Berlin edition of J.O. de La Mettrie's *Oeuvres philosophiques*, as well as Adam Vartanian's annotated edition of *L'homme machine*, published by Princeton University Press in 1960.

2 A study of this idea in the period between Descartes and La Mettrie is Heikki Kirkinen's *Les origines de la conception moderne de l'homme-machine: le problème de l'âme en France à la fin du règne de Louis XIV (1670-1715)*, published in Helsinki in 1960. A serious flaw of this work, however, is in the author's lack of familiarity with the physicians, anatomists and artists who, as we have demonstrated, were among the first Europeans, from the Renaissance onward, to articulate the idea that human functions could be represented and interpreted mechanically. The author mistakenly believed that the interest of physicians in Man the machine was an eighteenth century development.

3 According to E.A. Burtt, *The Metaphysical Foundations of Modern Science*, p. 300, "Such a universalizing of this clockwork naturalism reached its summation in some of the brilliant French minds of the late Enlightenment, notably La Mettrie and the Baron d'Holbach, and in a somewhat different form in nineteenth-century evolutionism."

4 La Mettrie called Descartes a "great genius" (*MMOW: Treatise on the Soul*, p. 64) who indulged in "futile labours" (*MMOW: Machine Man*, p .5); he affirmed that "I believe that Descartes would have been an admirable man in all respects if he had been born in an age which he did not need to enlighten, and had consequently understood both the value of experiment and observation and the danger of straying from them." (*MMOW: Machine Man*, p. 35); he wrote: "Simply open your eyes and ignore what you cannot understand, and you will see that a labourer whose mind and knowledge extend no further than the edges of his furrow is no different essentially from the greatest genius, as would have been proved by dissecting the brains of Descartes and Newton; you will be convinced that an imbecile or the idiot are animals in human form, in the same way as the clever ape is a little man in another form…" (*MMOW: Machine Man*, p. 38) La Mettrie's works are rife with such sarcastic references to Descartes, Leibniz and others.

5 In the words of Frederick Copleston, "La Mettrie refers to Descartes' description of the living body as a machine. But in his opinion Descartes had no warrant for asserting dualism, that is, for speaking of man as composed of a thinking substance, immaterial and free, and of an extended substance, the body. He should have applied his interpretation of the physical organism to the whole man. At the same time, La Mettrie differs considerably from Descartes in his idea of matter. For this is not mere extension: it also possesses the power of movement and the capacity of sensation." *History of Philosophy* (New York, 1985), volume IV, pp. 47-8.

6 We owe this happy expression – "spiritualizing matter" – to La Mettrie himself: "The Leibnizians with their *monads* have constructed an incomprehensible hypothesis. They have spiritualized matter rather than materializing the soul. How can we define a being whose nature is absolutely unknown to us?" *MMOW: Machine Man*, p. 3.

7 La Mettrie considered Lucretius to be a "great poet" with great passions. The most significant reference to Lucretius is contained in *Treatise on the Soul*, where it seems that La Mettrie derived his view of a material soul from the classical Latin poet: "Surely this is to say, with Lucretius, that if the soul is not material it cannot act on the body, or that it is in fact material because it touches and moves in so many ways, which can only be appropriate to a body." As Ann Thomson noted, this is a paraphrase of the Lucretian "tangere nec tangi, nisi corpus, nulla potest res" – "Nothing can touch and be touched if it is not body". *MMOW: Treatise on the Soul*, p. 64 n. 34.

[8] Kathleen Wellman, *La Mettrie: Medicine, Philosophy and Enlightenment* (Durham, 1992), pp. 73, 172, 208 and 211.
[9] *MMOW: Treatise on the Soul*, p. 64
[10] *MMOW: Machine Man*, pp. 4-5.
[11] An interesting discussion on Spinoza's use of the word "God" is contained in Copleston, *A History of Philosophy*, vol. IV, pp. 206-213.
[12] *MMOW: The System of Epicurus*, p. 92.
[13] *MMOW: Machine Man*, p. 37.
[14] *Ibid.*, p. 5.
[15] *Ibid.*, p. 4.
[16] *Ibid.*, p. 4.
[17] *Ibid.*, p. 4.
[18] *Ibid.*, p. 5.
[19] *MMOW: Anti-Seneca*, pp. 135-8.
[20] While we have not uncovered any mention of Leonardo or Vesalius in La Mettrie, he did make approving comments about Harvey. For example, in *Man as Plant*, he drew an analogy between plants and the Harveian circulation of blood: "But what could be more similar than those which have been discovered and described in the Harveys of botany! Ruysch, Boerhaave, etc. have found in man the same numerous series of vessels that Malpighi, Leeuwenhoek and van Royen discovered in plants. The heart beats in animals and swells their veins with those torrents of blood which carry feeling and life into the whole machine. Heat, that other heart of nature, that fire from the earth and sun, which seems to have passed into the imagination of the poets who have depicted it, likewise makes the fluids circulate in the tubes of the plants, which transpire like us." *MMOW: Man as Plant*, p. 79.
[21] This subject is treated in a wide-ranging although defective work, Leonora Rosenfield's *From Beast-Machine to Man-Machine: Animal Soul in French Letters from Descartes to La Mettrie* (New York, 1941), which is written from an animal-lover's perspective, and places exaggerated emphasis on the relations between animal automata and attempts to define man as a machine from Descartes to La Mettrie. Rosenfield knew a lot about secondary French literature about animals. But she did not know about the roots of the metaphor of Man the machine in classical Antiquity, the Middle Ages or the Renaissance.
[22] *MMOW: Machine Man*, p. 31.
[23] There is an interesting discussion of deism, from an atheist point of view, in Baron d'Holbach, *System of Nature* (New York, 1970), vol. II, ch. V, pp. 259-260, which makes clear that deism is not to be confused with eighteenth-century atheism: "We call *theists* or *deists*, among ourselves, those who, undeceived in a great number of grosser errours with which the uninformed and superstitious are successively filled, simply hold to the vague notion of the Divinity which they consider as an unknown agent, endued with intelligence, wisdom, power, and goodness; in short, full of infinite perfections. According to them, this being is distinguished from nature; they found his existence upon the order and the beauty which reigns in the universe. Prepossessed in favour of his benevolent providence, they obstinately persist in not seeing the evils of which this universal agent must be the reputed cause whenever he does not avail himself of his power to prevent them. Infatuated by these ideas, of which we have shown the slender foundation, it is not surprising there should be but little harmony in their systems, and in the consequences which they draw from them." *Op. cit.*, p. 258.
[24] Frederick Copleston, *A History of Philosophy*, vol. IV, p. 38.
[25] Friedrich Lange, *The History of Materialism*, 1st Book, 4th Section, p. 71.
[26] Quoted in Adam Vartanian, *op. cit.*, p. 116, our translation.
[27] Lange, *op. cit.*, 1st Book, 4th Section, p. 88.
[28] Jean-Pierre Changeux, *L'homme neuronal* (Paris, 1983), p. 24.
[29] A discussion of this aspect of La Mettrie's work is contained in Keith Gunderson, *Mentality and Machines* (Minneapolis, 1985).
[30] Vartanian, *op. cit.* p. 134.
[31] Ernst Cassirer, *The Philosophy of the Enlightenment* (Princeton, 1951), p. 55.
[32] A fascinating account of La Mettrie's life, published in Mortain in northern France in 1952, and drawing on many local sources in Britanny and Normandy, is Pierre Lemée's *Julien Offray de La Mettrie: St-Malo (1709) – Berlin (1751)*. Beyond the wealth of detail and insights provided in this work, its most curious distinguishing characteristic is that the author constantly apologized for his inadequate

understanding of philosophy, while evoking in an exuberant and attractive literary style, many of the non-philosophical aspects of La Mettrie's career.

[33] Lemée, *op. cit.*, p. 157.

[34] Lange, *op. cit.*, 1st Book, 4th Section, p. 55. Lange noted that in this respect, he was much like Boerhaave himself.

[35] *MMOW: Machine Man*, p. 5.

[36] *Ibid.*, p. 5.

[37] Wellman, *op. cit.*, p. 55.

[38] Lemée, *op. cit.*, p. 49.

[39] Lemée devoted more attention to these medical polemics than other historians. An interesting account is given in his biography of La Mettrie, pp. 159-235.

[40] Lemée, *op. cit.*, p. 37.

[41] Quoted in Lemée, *op. cit.*, pp. 194-6, our translation.

[42] According to David Channell, *The Vital Machine* (Oxford, 1991), p. 41, La Mettrie "was also influenced by the work of Albrecht von Haller, another student of Boerhaave's, who had attributed the property of irritability to the muscle fibers. Knowing that muscles completely cut off from the body could be artificially stimulated into some type of motion, Haller postulated that the muscle fibers had an inherent property, irritability, that allowed the muscle fiber to move independently from the body. La Mettrie transformed the mechanical idea of material by extending Haller's idea of muscular irritability to all matter, so that, along with such properties as weight and extension, all matter had the inherent property of movement. Given this redefinition of matter, La Mettrie was able to overcome the old Cartesian dualism of body and soul. Since one of the properties of matter is movement, La Mettrie no longer needed to appeal to the idea of a soul as the source of all vital activity. The soul emerges simply from the organization of the motile matter that made up the body." This view exaggerates the importance of Haller, however, by neglecting to mention the role of classical atomism and Lucretius in particular.

[43] Lemée gave a detailed description of the circumstances, pp. 25-6.

[44] Wellman, *op. cit.*, p. 7.

[45] According to Wellman, "Inspired in part by the investigations of Galileo, iatromechanists based their understanding of physiological processes on the laws of mechanics. Thus outstanding seventeenth-century mechanists such as Borelli, Bellini, Pitcairn and Descartes compared artificial machines to the human body, describing specific functions in terms of statics and hydraulics. The iatromechanists also generally relied on atomism as a basic theory of matter and were then able to explain changes in the body by changes in the configuration or movement of these small particles.... But Boerhaave was deeply disturbed by the tendency ... to form schools, suggesting that either iatrochemistry or iatromechanism provided a complete explanation of physiological processes. Boerhaave forged a synthesis of these two theories that served as the foundation of medical thought and education throughout the eighteenth century." *Op. cit.*, pp. 63-4.

[46] Cited in Lemée, *op. cit.*, p. 26, our translation.

[47] *MMOW: Machine Man*, pp. 37-8.

[48] *Ibid.*, p. 22.

[49] Kirkinen, *op. cit.*, p. 24.

[50] Rosenfield, *op .cit.*, especially pp. 141-148.

[51] The limitations of Vartanian's view are most apparent in "The Historical Background of *L'homme machine*", which forms a part of his annotated version of the celebrated work: he set La Mettrie in the context of philosophical thought – going back only to Descartes. This astonishingly superficial view ignored many of the classical philosophical sources to which La Mettrie openly referred. The remark about Hobbes is on p. 65 of Vartanian's work.

[52] Channell, *The Vital Machine*, p. 41.

[53] *MMOW: Machine Man*, , p. 39.

[54] *Ibid.*, p. 5.

[55] *Ibid.*, p. 9.

[56] *Ibid.*, p. 34.

[57] *Ibid.*, p. 19.

[58] *Ibid.*, p. 28.

[59] *Ibid.*, p. 26.

[60] *Ibid.*, p. 17.
[61] *Ibid.*, p. 34
[62] *Ibid.*, p. 31.
[63] *Ibid.*, p. 30.
[64] *Ibid.*, p. 7.
[65] *Ibid.*, p. 14.
[66] *Ibid.*, p. 29.
[67] *Ibid.*, p. 26.
[68] *Ibid.*, p. 13.
[69] *Ibid.*, p. 13.
[70] *Ibid.*, p. 19.
[71] *Ibid.*, p. 35.
[72] *Ibid.*, p. 33.
[73] This interesting short work is devoted to the similarities and differences between man and plants, and shows to what extent La Mettrie enjoyed the use of metaphor in his philosophical discourse.
[74] *MMOW: Anti-Seneca*, p. 119.
[75] *Ibid.*, p. 120.
[76] *Ibid.*, p. 136.
[77] Cesare Beccaria, *Of Crimes and Punishments*, translated by Richard Davies (Cambridge, 1995), pp. 8-11.
[78] *MMOW: Machine Man*, p. 23.
[79] *Ibid.*, p. 25.
[80] *Ibid.*, p. 39.
[81] Charles Taylor noted in *Sources of the Self: the Making of the Modern Identity* (Cambridge, Mass., 1989), p. 334, how La Mettrie's morality of purely egoistic gratification, "which could find a basis in radical materialism" was rejected out of hand by Diderot and d'Holbach.
[82] *Ibid.* Book One, Continuation, p. 49.
[83] Wellman, *op. cit.*, p. 283.
[84] *Ibid.*, p. 285.
[85] *MMOW : Machine Man*, pp. 33-4.
[86] Gunderson, *op. cit.*, p. 38.
[87] Vartanian, *op. cit.*, pp. 134-6.

PAUL-HENRI DIETRICH D'HOLBACH (1723-1789)

In our account of Man the machine, Paul-Henri Dietrich d'Holbach remains an enigmatic figure. Born in Edesheim, near Landau in the Rhenish Palatinate, he became a naturalized French citizen living in a palatial *hôtel particulier* in Paris. He acted as an intellectual bridge between German science and the French Enlightenment (translating the original findings of German mineralogy and geology into French), serving as a vector of new ideas in France. From an uncle, he inherited the title of baron and a large private fortune besides, which gave him not only a comfortable social status during the *ancien régime*, but also the financial means to gather around him a tightly-knit society of men and women devoted to letters and free thought.[1]

The fact that the shadowy d'Holbach played a key role in the Enlightenment, alongside the better-known figure of Diderot (1713-1784), only serves to make him more enigmatic. The *philosophes* were an informal, rather secretive network,[2] and as Hegel pointed out, d'Holbach was "the central figure" of this network of French Enlightenment philosophers – "Montesquieu, d'Alembert, Rousseau were for a time in his circle."[3] D'Holbach was a behind-the-scenes man of influence, where his fellow materialist La Mettrie had been a marginal, exiled figure, venting his frustrated rage on the entire world.

No single publishing venture was more central to the Enlightenment programme of cultural, religious, social and political reform than the *Encyclopédie des sciences, des arts et des métiers.*[4] Alain Pons has written that the *Encyclopédie* was "for the man of the eighteenth century, what cathedrals had been for the man of the Middle

Ages: the faithful mirror of his being, the witness, the profession of faith, the collective masterpiece in which was expressed his vision of the world, a conception of the relations of man with God, with nature, and with other men." And whereas God gave to older theological and metaphysical constructions all their meaning, "now the object of learning ... was the concrete world, nature and man, a biological and social being, as he appeared to reason and not to faith."[5]

This publishing enterprise was revolutionary, and it was of international significance.[6] The *encyclopédistes* courageously supported the enterprise, despite threats of imprisonment, galley slavery and even the death penalty, as well as censorship within France and Pope Clement XIII's condemnation of their work.

From a strategic point of view, d'Holbach quietly promoted the *Encyclopédie*, contributing some three hundred seventy-five or three hundred seventy-six articles – which were only signed starting with Volume III, in 1753[7] – on a wide range of subjects, from science to political representatives, priests and theocracy.[8] These articles give an indication of his two writing styles: the first being scientific, the second didactic and violently anti-clerical.[9] In addition, he was prepared to subsidize publication abroad, if need be, out of his large personal fortune.[10]

Although he came into the world and was buried a Catholic,[11] d'Holbach promoted atheism, materialism and the idea of Man the machine through a series of anonymous, clandestine works, some of which he attributed to friends who had conveniently died by the time of publication. Some of the *habitués* at his literary salon were well aware of this authorship, but declined ever to betray his confidence. These eleven works – from *Le christianisme dévoilé* (published in 1767) to *Système de la Nature* (1770), *Système social* (1773), *La morale universelle* (1776) and *Histoire critique de Jésus Christ*

(1778), to name a few – are dry, declamatory and repetitive expositions of natural, social and moral systems based on pure abstractions.[12] They present Man as a machine devoid of free will, and causality as mere relationships of motion.[13] In a sense, d'Holbach was heir to the entire mechanical tradition we have described. His work is the culmination of a particular interpretation of mechanism – the purely materialist one – although the model of mechanism had pervaded the scientific world, in the domains of the morphology of the universe, the understanding of the terrestrial globe, the transformations of matter and force, and the systematization of biology.[14] While much modern science is materialistic, some of d'Holbach's materialism would be considered unscientific today – for example his belief, with Georg Ernst Stahl (1660-1734), in the existence of igneous fluid in the body[15].

In these works, d'Holbach characterized religion as superstitious, harmful, useless and extravagant, manipulated by a cunning, self-interested and hypocritical priesthood, and fobbed off on a credulous, ignorant public. Much as the works bear witness to a fanatical desire to destroy religion, they are sweetly sentimental in their praise of atheism and materialism. It was as if he compared the worst of religion with the best of atheism, in an idealized, condescending way, musing in the bosom of aristocratic luxury on the benefits for the unwashed masses "out there" of education, social reform, philanthropy, generosity and happiness. He had an aristocratic disdain for institutions, and the solutions he proposed – the temple of Nature, the exercise of Reason – are mannered and genteel.[16]

How can the tone of d'Holbach's writings on religion be explained? He may have come to doubt Holy Scripture while studying geology,[17] but that still does not account for the particular virulence of his attacks on religion. His main objection to the existence of God was that the Divinity could not freely create marvelous animals that were destined to perish and decay, otherwise He would be neither free nor omnipotent.[18] Recent scholarship on France under the *ancien régime* notes a distinction between the Catholic religion and clericalism.[19] But, it should be noted, d'Holbach was violently opposed to both.[20] He was against any form of faith or religion, as is shown by vitriolic passages about Jews and Christians in *Le christianisme dévoilé*.[21] His dogmatic attacks on faith and religion can be taken as a measure of the force that Christian dogma exerted on society.[22]

D'Holbach believed that primitive societies were dominated by fear, which provided the impulse to explain the mysterious, unpredictable forces of Nature in terms of superstitious religion.[23] In this respect, he was part of an age-old tradition of materialism, stretching from Lucretius at least to Hobbes that associated fear and superstition.[24] It has been claimed that he exaggerated the effects of this fear, since geological time had only just begun to diverge from biblical time, and telescoped natural catastrophes such as the Flood into a short time frame, which had proved traumatic for primitive peoples.[25] This is to excuse d'Holbach, however. During the Enlightenment, "primitive" societies were not universally considered to be fear-ridden and superstitious. In 1724, the Jesuit missionary Joseph-François Lafitau (1685-1740) had written *Moeurs des sauvages américains*, drawing a favourable comparison between the Iroquois of Canada and the noblest virtues of Antiquity, and even believing the Iroquois to be remotely of Greek origin.[26] In 1748, Montesquieu (1689-1755) published *L'Esprit des lois*, which articulated an early form of sociological relativism, where political regimes were concerned. For Montesquieu, religion was one of the principles that formed the general spirit, the mores and the manners of a nation. Variations between political regimes could be explained by differences in the principles of government, the simplicity of civil and criminal laws, sumptuary laws and the condition of women, the nature of the climate and the general spirit of the society.[27] In 1755, Jean-Jacques Rousseau (1712-1778) idealized "primitive societies" in the *Discours sur l'origine de l'inégalité*, in which he portrayed the happy innocence of the original state of nature, contrasting it with humanity's ineluctable decline into vice and corruption as it approached contemporary civilization.[28]

D'Holbach played a key role during the Enlightenment, and shared the preoccupations of his Enlightenment contemporaries.[29] But his ideas, personality and writing style seemed strangely out of place. In the *Dictionnaire philosophique*, Voltaire (1694-1778) professed to admire him, while mocking his disbelief in God (but then Voltaire mocked everybody). Rousseau devoted scathing passages to him in his *Confessions* – denouncing the "côterie d'Holbachique"[30] and categorizing the baron as a schemer, hypocrite, persecutor and tormenter, who bought his way into the company of decent people.[31] Johann Wolfgang von Goethe (1749-1832) wrote that he had hoped to find in *System of Nature* "something of nature, our idol.... But how hollow and empty did we feel in this melancholy, atheistical half-light, in which earth vanished with all its images, heaven with all its stars."[32] In the latter part of the eighteenth century, who but the perverse and extravagant Marquis de Sade (1740-1814), held captive in the Bastille, expressed categorical approval of d'Holbach?[33]

We should ask why d'Holbach's ideas, personality and writing style seemed somewhat out of place in his century.

First, there was a stylistic issue: his writings lack all charm, in a century that put great stock in literary eloquence.[34] Hegel took a convenient way out, in noting that the *System of Nature* "is not a French book, for vivacity is lacking and the mode of presentation is dull."[35] D'Holbach's prolixity and rigid absoluteness was mentioned by Friedrich Lange.[36]

Second, there was the framework issue. Ernst Cassirer was only partly right in asserting that seventeenth century philosophers (one thinks of Descartes, Hobbes and Leibniz) were absorbed in the task of developing all-embracing philosophical systems, using the method of proof and rigorous inference, whereas eighteenth century thought sought "another concept of truth and philosophy whose function is to extend the boundaries of both and make them more elastic, concrete and vital." [37]

In our view, d'Holbach's singularity did not lie in his German background or his being an eighteenth-century *philosophe*.[38] Instead, he was a systems-builder, with a destructive agenda. As such, he was like Cassirer's seventeenth-century thinker parachuted into an eighteenth-century salon, taking a rational principle as a point of departure, and laboriously and inexorably building up an edifice of reason from that single principle. By this means, he developed an atheist and materialist metaphysic, based on abstract principles, amounting to a counter-dogma, which could serve as a substitute or replacement for seventeenth-century Christian metaphysical systems. He was very much in *reaction* to revealed religion, the weight of centuries of theology and Christian metaphysics, and the power of the Church as an institution, which helps to explain why his works were so provocative and violent. Unlike La Mettrie, d'Holbach was not reacting to individuals: he was reacting to *systems* of teleology, metaphysics and theology. His strategy towards those systems was therefore destructive.

During the seventeenth century, as we have seen, Descartes was under considerable pressure to shield from the Church's scrutiny and wrath those of his works which challenged religious orthodoxy directly. Gassendi accommodated materialism and Christian orthodoxy. During the French Enlightenment, deism and theism offered many philosophers a way to explore materialism while always keeping in reserve the fallback position, that their exploration did not contradict faith in God. La Mettrie was openly a materialist, but skated around atheism without really committing himself to a benign agnosticism.

It was unusual for a French Enlightenment philosopher like d'Holbach to be so blunt in his atheism. He unambiguously used the principle of atheism as a counter-dogma, in an attempt to wrench materialism away from any purported relationship with the divine or the spiritual. While he considered that institutions corrupted humanity, he believed that a purely material Nature would teach humanity the lessons of natural morality, which boiled down to self-preservation, and the quest for happiness. There was nothing romanticized in his appreciation for Nature. On the contrary, he saw Nature in cold and highly abstract terms, as the sum total of matter and the energy inherent in matter, as a system whose motions, whether in the universe or in humans themselves, determine the course of events.

Needless to say, in this purely material, godless universe where the motions of matter determined everything that Man was, experienced, and could ever become, there was no place whatever for some of the interpretations of Man we have seen so far: for Man in God's image and likeness, for Man as microcosm, and even for Man as self-mastering individual. These concepts simply had no meaning for d'Holbach.

D'Holbach's interpretation	Sources	Key features
The body as machine	Classical atomism, Gassendi, Hobbes, Locke, La Mettrie	The body is matter in motion
Man in God's image and likeness	None	Atheism
Man as a microcosm	None	None
Man as self-mastering individual	None	D'Holbach sees religion and theocracy as dark forces hindering the individual's mastery of himself, through the propagation of hatred, violence and superstition – reason, atheism and materialist science offer the only avenues for self-mastery
Man as a psychological being with virtually unlimited dimensions to human personality	These unlimited dimensions are due to the complexity of combinations of matter – since human psychology is determined by material forces in the brain and body	Psychology is complex since the mechanical workings of organic matter in motion are complex; psychology would be less complex if man were ordered by reason
Man as endowed with reason and devoted to happiness	Enlightenment values	Happiness is provided by a life of true morality, whose principles are derived from a rational understanding of Nature's material laws
Man as a cog within an Automated State		Implicit in d'Holbach's views of Nature and the State, but no more than that

In *The System of Nature – or the Laws of the Moral and Physical World*, we find the most mature and indeed the most complete materialist account of Man the machine. D'Holbach was unlike any of the other seven authors examined thus far. He lacked Leonardo the engineer-artist's fascination for mechanical details; he did not share Vesalius' interest in the nature, intricate series, distribution, construction, harmony and arrangement of the body's machine-like organs; he was unconcerned with Harvey's discovery of the mechanical motion of the heart and the circulation of the blood; he showed nothing but contempt for Descartes' compromise over dualism[39] and his distinction between humans and animals;[40] he betrayed none of the anxiety which characterized the political writings of Hobbes; he did not rely, as Leibniz had, on fantastic metaphysical notions to glue together the fragments of a philosophical system; his work was more systematic than La Mettrie's *Machine Man*.

To understand d'Holbach's idea of Man the machine, it is important to evoke the abstract principles upon which he built up his logical edifice. The first of these principles was atheism. He wrote in *System of Nature* as follows: "What is an atheist? He is a man, who destroys chimeras prejudicial to the human species, in order to reconduct men back to nature, to experience, and to reason. He is a thinker, who, having meditated upon matter, its energy, its properties, and its modes of acting, has no occasion, in order to explain the phenomena of the universe, and the operations of nature, to invent ideal powers, imaginary intelligences, beings of the imagination, who, far from making him understand this nature better, do no more than render it capricious, inexplicable, unintelligible, and useless to the happiness of mankind."[41] Moreover, "Atheism, if well understood, is founded upon nature and reason, which never will, like religion, either justify or expiate the crimes of the wicked."[42]

The second of the principles that d'Holbach used as a foundation for his materialism was that Nature should not be personified as the ancients had done. It could only be explained on rational grounds as the necessary character of the motions of matter.[43]

A third principle, closely related to the second, was to deny the teleological view from Plato through Aristotle, Galen, Aquinas and early modern philosophers from Descartes to Leibniz, according to which there was any design or purpose in the ordering of Nature.[44]

A fourth principle on which d'Holbach founded his system was that Nature "is the great whole that results from the assemblage of matter under its various combinations, with that diversity of motions which the universe offers to our view.... It is thus that MAN is, as a whole, the result of a certain combination of matter, endowed with peculiar properties, competent to give, capable of receiving, certain impulses, the arrangement of which is called *organization*, of which the essence is, to feel, to think, to act, to move, after a manner distinguished from other beings with which he can be compared."[45]

A fifth principle, which was developed more fully in *Morale universelle*, was that the two motivations of Man in Nature are his own self-conservation and the desire for happiness.[46]

From the twenty-first century perspective, there seems to be a leap from a purely material world to a system of morality based on Nature's immutable laws, but that is because d'Holbach's vision of atheism was essentially moral; he believed that discerning the laws of Nature through experience and reason (the methods of natural philosophy) was an emancipating activity, that would free humanity from corruption, vice and superstition. In other words, he claimed a better understanding of Nature would improve morality, which could only rightly be understood by atheists, who held that view because they were moral. The argument was circular.

This string of principles established a godless universe where atheism, rightly understood, would lead to greater justice in society, where Nature was neither personified nor the fulfillment of any divine master plan, where Man was essentially matter in motion and, as part of Nature, motivated by his own self-conservation and the desire for happiness. But in this respect, d'Holbach had departed from his Enlightenment contemporaries, in daring to spell out a coherent atheist system. In his *Encyclopédie* article on atomism, for example, Diderot denounced the absurdity of classical atomism, while implying that his sympathies actually lay with it.[47] Peter Gay noted, "Holbach's work proposes a consistent, somewhat simplistic, and therefore rather tedious naturalism which has, one might say, the virtues of its vices; in its unrelieved seriousness and its courageous confrontation of a world without God it is not without a certain austere grandeur."[48]

On the basis of these five principles, we shall restate the main argument of *The System of Nature*, or at least that part of it which concerns us here in the study of Man the machine, as follows. Man feeds himself with conjectures, rather than experience, and has ended up neglecting the use of his own reason. In this respect, it is interesting to note, d'Holbach's man of Nature was devoted to self-emancipation through the exercise of reason – quite unlike Rousseau's natural man, who was solitary and blissfully indifferent to knowledge.

Man is the work of nature, and subject to her laws, from which he cannot free himself. Man is moreover a purely physical being and ought therefore to search for truth in physics and experience. Experience and a reasoned contemplation of the universe reveal to us nothing but matter in motion. Motion is the motive principle of all existence, connecting our organs to external and internal objects. Matter has always been in motion, and the changes, forms, and modifications of matter alone proceed from motion. Every body in the universe is in motion, and every being is subject to specific laws of motion, such as attraction, repulsion and necessity.[49]

Indeed, "necessity is the infallible and constant tie of causes to their effects: and this irresistible power, universal necessity, is only a consequence of the nature of things, in virtue of which the whole acts by immutable laws."[50] The human mind acquires the idea of order, by means of its perception of the regular motions of nature. Man, an organized whole, composed of different matters, which act according to their respective properties, is always subject to necessity. Man is a product of nature, an organized whole of matter in motion, and thus has none of the spiritual, immaterial attributes (a soul joined to his body) the existence of which speculative philosophers and theologians have long assumed.[51]

Man is a machine, and "every machine is valuable, when it performs well the functions to which it is destined. Nature is but a machine, of which the human species makes a part."[52] As a result, morality should be judged, not in the light of vain assumptions about the existence of God and His divine commands, nor even on the basis of religious opinions, but by means of utility within a purely material universe governed by natural laws.

The metaphor of Man the machine was particularly helpful to d'Holbach: it provided him with a rational model for the proper organization and functioning of matter; a reductionist image which could be used to explain any human thought or feeling, whether it be the product of an orderly mechanism or of confusion in his machine. And a utilitarian justification for his determinist view that universal necessity is only a consequence of the nature of things, in virtue of which the whole acts by immutable laws. We should not forget that d'Holbach considered that utility "ought to be the only standard of the judgment of man."[53]

D'Holbach made three different uses of the metaphor of Man the machine.

First, it provided a rational model. In previous centuries, the metaphor of Man the machine had gone hand in hand with the doctrine of Man in God's image. By 1770, when d'Holbach published *System of Nature*, there was no compelling need to expose and defend the machine-like nature of Man – this idea had become detached from religion, and could even be used as a weapon in the battle against what he considered to be the superstitious convention that Man was in God's image.

As d'Holbach put it: "Man, feeling within himself a concealed force that insensibly produced action, that imperceptibly gave direction to the motion of his machine, believed that the entire of nature, of whose energies he is ignorant, with whose modes of acting he is unacquainted, owed its motion to an agent analogous to his own soul, who acted upon the great macrocosm in the same manner that this soul acted upon his body. Man having supposed himself double, made nature double also."[54]

In other words, once Man's nature was no longer seen as dual, Man's soul no longer corresponded to the spiritual being of God, and the machine model no longer furnished Man with an image of rationality (the microcosm) corresponding to the rational design and purpose (macrocosm) of God the Creator.[55] Instead the machine-like nature of Man – matter in motion – was set in a universe in perpetual motion which itself was held up as a proof that there had never been a Creator. And where the human heart was a labyrinth,[56] the machine model in all its admirable simplicity was not just a description of humankind; it was, for d'Holbach, also a prescription of what humans should become.

Second, the metaphor served as a reductionist image. The metaphor of Man the machine allowed d'Holbach to reduce thoughts, feeling and the very existence of Man to machine-like functions. For example, it is by no means astonishing "that the brain should be necessarily warned of the shocks, of the impediments, of the changes that may happen to so complicated a machine as the human body, in which all the parts are contiguous to the brain – to a whole, in which all the sensible parts concentrate themselves in the brain, and are by their essence in a continual state of action and reaction."[57] The phenomena of physical and moral habit are modified exactly in the same manner as the body, and can therefore be explained by "a pure mechanism".[58] Finally, the disorderly motion within Man could be explained as confusion in the machine: "Those dreams that are troublesome, extravagant, whimsical, or unconnected, are commonly the effect of some confusion in his machine; such as painful indigestion, an overheated blood, a prejudicial fermentation, &c. – these material causes excite in his body a disorderly motion, which precludes the brain from being modified in the same manner it was on the day before..."[59] Although d'Holbach did not devote much of *System of Nature* to a justification of the machine model, he was well aware that some people would find his model overly reductionist.[60]

Third, the metaphor provided a utilitarian justification. It will be seen that the justification for thus reducing Man to a pure mechanism, to a machine-like organization of matter in motion, was utilitarian. And here d'Holbach reached back to the clock-like universe, to turn the first machine metaphor on its head. The image of the clock appeared in *System of Nature* in a negative sense: "An organized being may be compared to a clock which, once broken, is no longer suitable to the use for which it was designed. To say, that the soul shall feel, shall think, shall enjoy, shall suffer, after the death of the body, is to pretend, that a clock, shivered into a thousand pieces, will continue to strike the hour, and have the faculty of marking the progress of time."[61]

In d'Holbach's philosophy, Man was compared to a clock not because of the brilliant artistry of Nature, or of the knowable and wondrous craftsmanship of God, but as an indication that Man was constrained by natural laws, and could not "strike the hour and mark the progress of time" – could not, in other words, function in an orderly fashion – unless he observed those natural laws.[62]

The logical consequences of d'Holbach's view are clear. God does not exist, Nature must not therefore be personified and there is no master plan in the universe. Once Nature is identified with necessity, and Man is subject to that necessity, then Man is deprived of liberty, left to dwell in an ephemeral universe of matter in constant motion, where he will be of greater or less utility. Man is the work of Nature, exists in Nature, and is subject to her laws; Man cannot deliver himself from them; nor can he step beyond them even in thought.

D'Holbach was not content to describe the mechanical workings of a deterministic materialism. He also sought to develop a system of utilitarian ethics on materialist principles. True to the Enlightenment's faith in reform by means of education, d'Holbach believed that atheism had to be inculcated, by promoting those natural virtues identified by and deemed useful to the State: "We boldly assert, that a society of atheists, destitute of all religion, governed by wholesome laws, formed by a good education, invited to virtue by recompenses, deterred from crime by equitable punishments, and disentangled from illusions, falsehood, and chimeras, would be infinitely more honest and more virtuous than those religious societies, in which every thing conspires to intoxicate the mind and to corrupt the heart."[63]

In *Système Social*, he developed many of the same views: morality and politics should be based on natural principles; religion is superstition and provides nothing useful for the citizen in his interactions with his fellows in society; religion preaches false virtues which disserve the cause of human happiness; "if education, public opinion, government and the laws worked together to provide sound and true ideas, it would be as hard to find perverse men as it is hard today to find virtuous men";[64] "the science of morality should be drawn on Earth and not in Heaven; it should be sought in the human heart and not in the bosom of the Divinity";[65] "virtue is the disposition to do what is necessary for our happiness, the idea of which can never be detached from ourselves";[66] "the value of virtue lies in its utility";[67] virtue is not innate, it needs to be learned;[68] "being free does not consist in doing what one wants, but in doing what contributes to one's permanent happiness".[69]

For d'Holbach, the Universe had neither beginning nor end; there was no sense in speaking of a divine, immaterial or spiritual Creator at the origin of all things; neither was there any sense in speaking of the dual existence in Man of body and soul, or the physical and moral man; the Universe consisted of matter in motion and nothing more; Man likewise was a particular organization of matter in motion, whose component organs, thoughts and feelings were governed by the laws of Nature, and could thus be analysed in terms of motion; Man was therefore likened to a machine, a pure mechanism, a lump of matter which would eventually dissolve, disunite, and disperse, assume new activity, and form new combinations.

It will readily be admitted how much of a departure d'Holbach's philosophy represented from that of his mechanistic predecessors. He had, in some respects, been influenced by Leucippus, Democritus, Lucretius and other classical atomists, as well as the materialism of Hobbes. In developing the view that Man was a machine, a collocation of atoms in constant movement and nothing more, he fiercely opposed the metaphysics of Descartes and Leibniz, where their spiritualistic mechanisms of Nature were concerned. Intellectual debts to early eighteenth-century materialists[70] have been noted. Where La Mettrie is concerned, Pierre Naville wrote, "on more than one point … the *System of Nature* corrects or amplifies La Mettrie. The filiation of one to the other is undeniable, but with the years the available scientific data have grown more complicated and numerous. La Mettrie … sees the soul in Aristotle's substantial form (but already in Machine Man this terminology is abandoned.) D'Holbach goes well beyond this conception; the soul, whether substantial or not, does not exist, since the 'moral life' of the conscience, is only the physical life viewed from a particular angle. La Mettrie's psychology is that of a physiologist; d'Holbach's also bears the stamp of a geologist, a geographer, a sociologist, a man interested in politics."[71]

We may ask, in closing, whether d'Holbach's view of Man the machine had much impact on the future history of philosophy. As noted above, the marquis de Sade took to the combination of atheism and materialism in d'Holbach – one of the unanticipated offshoots of this philosophical position was Sade's extravagant nihilism. Karl Marx and Friedrich Engels (1820-1895), writing in *The Holy Family*, considered d'Holbach worthy of mention as a revolutionary bourgeois and materialist philosopher, who was hostile to religious doctrines.[72] G.V. Plekhanov (1856-1918) devoted considerably more attention to d'Holbach, in his *Essays in the History of Materialism.*[73] Plekhanov saw d'Holbach as a theoretician of the bourgeoisie, engaged in a struggle against the institutions of the *ancien régime*, and inspired by an uncompromising hatred for despotism.[74] If there was a flaw in d'Holbach work, Plekhanov considered, it was that he knew nothing of evolution and therefore lacked a dialectical method accounting for changes in Nature.

D'Holbach's faith in the limpid justice of a future atheist State seems naïve today. From the secure and comfortable setting of his *hôtel particulier*, d'Holbach could not have imagined, how atheism could be made into a State religion, whether during the French Revolution or under communism, and how materialism would be used to justify labour camps, mass exploitation and mass murder. Yet his hatred of despotism distinguished him from later totalitarian materialists such as Marx and Plekhanov.

More influential than his atheism, surely, was the utilitarian theory of natural rights which d'Holbach derived from Nature herself. This theory proved of importance during the French Revolution and since then. D'Holbach's advocacy of a natural morality based on abstract principles, and his preference that the State rather than the Church should be the moral educator of the people, was absorbed into English utilitarianism and subsequently into Marxism.[75]

For this reason, it is striking how twentieth-century assessments were marked by ambivalence. At one extreme was Ernst Cassirer, who denied, in 1932, that d'Holbach had made a difference: "In truth this materialism, as it appears in Holbach's *System of Nature* and Lamettrie's *Machine a Man* (*L'homme machine*), is an isolated phenomenon of no characteristic significance. Both works represent special cases and exemplify a retrogression into that dogmatic mode of thinking which the leading scientific minds of the eighteenth century oppose and endeavor to eliminate. The scientific sentiments of the Encyclopaedists are not represented by Holbach and Lamettrie, but by d'Alembert. And in the latter we find the vehement renunciation of mechanism and materialism as the ultimate principle for the explanation of things, as the ostensible solution of the riddles of the universe."[76] At another extreme was the sympathetic socialist Wickwar, who gushingly wrote just three years later that "the modern philosophical reader is easily disappointed by d'Holbach's tendency to mistake scientific generalization for absolute truths, to treat man's idea of causality as something that he learns by experience, and to exaggerate the extent to which nature dictates and serves man's moral ends. But the reader whose historical sense makes him consider d'Holbach in relation to the concrete problems posed by contemporary philosophes – and above all by Montesquieu, Helvétius, Rousseau, and the physiocrats – is astonished less by his shortcomings as a philosopher than by the extraordinary insight, balance, and sanity which he displayed as a publicist."[77]

D'Holbach was able to exert influence during the mid-eighteenth century, to stir up controversy, even though he had by and large chosen anonymity, preferring to remain within the discreet confines of his salon. It was not widely known which works he had written until after he was dead and buried. It does not really come as much surprise, therefore, that his place in eighteenth-century philosophy should be insecure, that his influence should be called into question, and that even those of his contemporaries who felt obliged to take their distance from him, may nonetheless have found some merit in his works.

Whatever the failings of his works, d'Holbach offered the advantage of unambiguous positions, and a clear statement of deterministic materialism, in terse language. Purged of references to the mechanics of the universe and the human body, rendered more tolerant in its positions on religion, *System of Nature* articulates many ideas that would seem to be compatible with science today, particularly in the area of cybernetics, artificial intelligence and artificial life. But some of his arguments were inconsistent.

D'Holbach sought in Nature a series of immutable physical laws that would provide a sound basis for secular morality under the benevolent guidance of the State; he interpreted Man the machine as a rational model, a reductionist image and a utilitarian justification. Doesn't his interpretation of Man the machine deny the dignity of humankind, by portraying them as subject to purely material forces? If it is an illusion that man is a free agent, what can be the point of his seeking education, in order to fulfill himself? Is that not an act of freedom?[78] And doesn't the exercise of reason necessarily imply intellectual freedom? Doesn't the supposition that the State alone is capable of inculcating morality lay the ground for a new form of moral (and political) tyranny?

Finally, d'Holbach claimed in *System of Nature* to take an uncompromising position in denying the existence of God; he made atheism the corner-stone of his philosophy; Yet, in considering the summary of *System of Nature*, we cannot help noting that he was already deifying Nature, destroying the foundations of religion only to erect a new temple of reason on its ruins: "The Morality of Nature," he wrote, "is the only religion which her interpreter offers to his fellow-citizens, to nations, to the human species, to future races, weaned from those prejudices which have frequently disturbed the felicity of their ancestors. The friend of mankind cannot be the friend of God, who at all times has been a real scourge to the earth. The apostle of Nature will not be the instrument of deceitful chimeras, by which this world is made only an abode of illusions; the adorer of truth will not compromise with falsehood; he will make no covenant with error, conscious it must always be fatal to mortals. He knows that the happiness of the human race imperiously exacts that the dark unsteady edifice of superstition should be razed to its foundations, in order to elevate on its ruins a temple to nature suitable to peace…"[79] This almost pantheistic statement is astonishing, considering that d'Holbach believed that religion "renders man a useless being; makes him an abject slave; causes him to tremble under its terrours; or else turns him into a furious fanatic, who is at once cruel, intolerant and inhuman…"[80]

In his *History of Materialism*, Lange made the remarkably prescient observation that "by a poetic impulse, the System of Nature, after having destroyed all religions, becomes itself a religion. May this religion also some day produce an ambitious priesthood? Is the tendency of man to mysticism so great that the principles of the work which rejects even Pantheism, in order to eradicate even the name of the Deity, may become the dogmas of a new church, which will succeed in skilfully mingling the intelligible with the unintelligible, and creating ceremonies and forms of worship?"[81] This new church was to prove destructive, not only of human values and institutions, but also of countless human lives.

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[1] Among twentieth-century scholars, René Hubert provided a brief account and appended some interesting documents in *D'Holbach et ses amis* (Paris, 1928), from the point of view of his conflict with Christianity, W.H. Wickwar made a socialist intepretation in *Baron d'Holbach: A Prelude to the French Revolution* (London, 1935), which trawls through some interesting sources, but is in the main an uncritical hagiography, and Pierre Naville produced *D'Holbach et la pensée scientifique au XVIIIe siècle* (Paris, 1943), a fine, well-documented work offering a broad view of his life and times.

[2] Peter Gay has written that the Enlightenment was "a loose, informal, wholly unorganized coalition of cultural critics, religious skeptics, and political reforms ... united on a vastly ambitious program, a program of secularism, humanity, cosmopolitanism and freedom, above all..." Indeed, for Gay "the philosophic family was drawn together by the demands of political strategy, by the hostility of church and state, and by the struggle to enhance the prestige and increase the income of literary men. But the cohesion among the philosophers went deeper than this: behind their tactical alliances and personal fellowship there stood a common experience from which they constructed a coherent philosophy. This experience – which marked each of the philosophes with greater or lesser intensity, but which marked them all – was the dialectical interplay of their appeal to antiquity, their tension with Christianity, and their pursuit of modernity." *The Enlightenment: an Interpretation* (New York, 1966-1969), vol. I, pp. 7-8.

[3] Frederick Copleston, *The History of Philosophy*, volume III, p. 393.

[4] Diderot began work in 1747 on the *Encyclopédie,* benefiting from the guidance on mathematical matters of d'Alembert. Between 1751 and 1765, seventeen volumes of text were published, with eleven volumes of plates between 1762 and 1772. Four more text volumes and one more plate volume were published in 1776-77, with a two-volume index following in 1780.

[5] Alain Pons, preface to his abridgment of the *Encyclopédie* (Paris, 1963), pp. 77-80. Our translation.

[6] Such is the view of Pons, op. cit., p. 108. In *Esquisse d'un tableau historique des progrès de l'eprit humain*, (Paris, 1988), Epoch 9, which he wrote in 1793, Condorcet indicated that the philosophes had instated the reign of reason and science and globalized it through the use of the French language, thereby supporting the progress of the human spirit, in the lead-up to the French Revolution. *Op. cit.*, pp. 213-263.

[7] Wickwar, *op. cit.*, p. 47.

[8] In 1935, Wickwar published an extensive bibliography of d'Holbach's writings, which he derived from cross references in *l'Encyclopédie*, information supplied by one of d'Holbach's leading allies, and various works of the 1820s. His scientific translations included works on mineralogy, metallurgical chemistry, physics, and pyritology by Wallerius, Henckel, Gellert, Orschall and Stahl; his philosophical and political translations included works by Lucretius, Swift, Hobbes and Toland; his polemics and essays were mostly churned out over a thirty-year period, between the late 1750s and the late 1780s, the evils of Christianity, the nature of oriental despotism, the evils of Antiquity, the evils of Judaism, the importance of tolerance, and works on the system of Nature and the morality and society best adapted to it. Wickwar, *op. cit.*, pp. 236-247. A somewhat different bibliography was published in 1967 by Naville (although he had begun writing the work shortly after captivity during the dark years of Vichy), *op. cit.*, pp. 421-432. A good deal of interpretation is necessary where identifying d'Holbach's works is concerned, not only because of the anonymous nature of his publications, but also because their clandestine publication – a sort of eighteenth-century *samizdat* recopying of manuscripts by hand, sometimes resulted in the copyist adding thoughts of his own.

[9] His violently anti-clerical articles in the *Encyclopédie* on priests and theocracy were published in December 1765.

[10] Naville, *op. cit.*, p. 79.

[11] According to Naville, "d'Holbach died on January 21st 1789, in his palace in the rue Royale-Saint-Roch, at the age of sixty-six years. His death certificate has been conserved. As a noble and Catholic – officially had he ever been anything else? – he was buried in St. Roch Church, just as Diderot had been, five years earlier." *Op. cit.*, p. 133.

[12] A key collaborator was Jacques-André Naigeon, whom d'Holbach had met through Diderot, and who edited many of his works. Naville, *op. cit.*, pp. 103-106.

[13] "What is man? We say, he is a material being, organized after a peculiar manner; conformed to a certain mode of thinking, of feeling, capable of modification in certain modes peculiar to himself, to his organization, to that particular combination of matter which is found assembled in him."*System of Nature*, p. 43.

[14] An interesting overview of the mechanical world is provided in Charles Singer, *A Short History of Scientific Ideas*, pp. 287-416.

[15] "If, at each moment his machine undergoes changes, more or less marked, which are ascribable to the different degrees of elasticity, of density, of serenity of the atmosphere, to the portion of igneous fluid circulating through his blood, to the harmony of his organs, to the order that exists between the various parts of his body; if, at every period of his existence, his nerves have not the same tensions,

his fibres the same elasticity, his minds the same activity, his imagination the same ardour, etc., it is evident, that the same causes in preserving to him only the same qualities, cannot always affect him in the same manner." *System of Nature*, p. 140.

[16] We do not subscribe to the Marxist view that ideological views are determined by class background and interests. Nevertheless, d'Holbach's wealth and aristocratic status have a lot to do with his detached, superior view of society and religion, and his ability to bankroll and protect the *encyclopédistes*.

[17] Hubert, *op. cit.*, p. 35.

[18] "Where is the wisdom, the goodness, the foresight, and the immutability of a workman, who appears only to be occupied with deranging and breaking the springs of those machines, which are announced to us as the *chefs d'oeuvres* of his power and of his ability. If this God cannot do otherwise, he is neither free nor omnipotent. If he changes his will, he is not immutable. If he permits those machines, which he has rendered sensible, to experience pain, he wants goodness." *System of Nature*, pp. 231-2.

[19] Pierre Goubert and Daniel Roche, *Les français et l'ancien régime* (Paris, 1984-1991), volume II : *Culture et société*, pp. 23-48.

[20] We should note that d'Holbach had three main philosophical objections to religion. Objection 1: He could not accept the idea of divine Creation. In a universe where everything is in motion and where the very essence of nature is to act, it is meaningless to speak of God's Creation of the universe, as if the universe could have been produced out of nothing: "To produce from nothing, or the *Creation*, is a term that cannot give us the most slender idea of the formation of the universe; it presents no sense, upon which the mind can fasten itself. Motion becomes still more obscure, when creation, or the formation of matter, is attributed to a *spiritual* being, that is to say, to a being which has no analogy, no point of contact, with it; to a being which has neither extent, nor parts, and cannot, therefore, be susceptible of motion, as we understand the term; this being only the change of one body relatively to another body, in which the body moved, presents successively different parts to different points in space." *System of the World*, p. 21. Objection 2: D'Holbach rejected the body/soul dualism. It was pointless to speak of the dual nature of Man, of body and soul joined together. Indeed, the notions of spirituality, immateriality and immortality are "vague unmeaning words [Man] has invented by degrees, in order to subtilize and designate the attributes of the unknown power which he believes he contains within himself, and which he conjectures to be the concealed principle of all his visible actions.... Thus man became double; he looked upon himself as a whole, composed by the inconceivable assemblage of two distinct natures, which had no point of analogy between themselves: he distinguished two natures in himself; one evidently submitted to the influence of gross beings, composed of coarse inert matter: this he called *body*:– the other, which he supposed to be simpler, and of a purer essence, was contemplated as acting from itself, and giving motion to the body with which it found itself so miraculously united: this he called *soul* or *spirit*...." *Ibid.*, p. 43. Objection 3: He rejected the basis of Christian morality. In seeing man as a certain combination of matter, endowed with particular properties, d'Holbach held at the same time that the distinction between the *physical* and the *moral* man was abusive – the moral man is nothing more than this physical being considered under a certain point of view – in relation to some of his modes of action, arising out of his particular organization, which itself is the work of Nature.

[21] In 1767, d'Holbach published *Le christianisme dévoilé, ou Examen des principes et des effets de la religion chrétienne*, (or *Christianity unmasked*) attributing authorship to his friend Boulanger and the fictional year of publication variously of 1758 and 1761 (we have used the latter "London" edition). The book makes a comparison of his own idealized view of atheism and materialism with wholly negative interpretations of Christianity. The advocates of religion are the "apostles of superstition" (p. i); Christianity will never be able to stand up to critical examination, "since it is nothing more than a tissue of absurdities, disjointed fables, extravagant dogmas, childish ceremonies" (p. ii); moreover a Christian who literally follows the behaviour prescribed by the Gospel, will never know the basis of true morality, and will be either a useless misanthropist or a turbulent fanatic (p. iv); he derides the priesthood for the way it presides over the corrupt alliance of faith and iniquity; the Sovereign instead ought to establish morality in the State, encouraging the people "to become useful members of society, active, capable of serving, fulfilling their duties according to the stable dictates of common sense" (pp. xviii-xix); d'Holbach attacks religion "because it seems to me harmful to the State, the enemy of the progress of the human spirit, and opposed to sound morality" (p. xxvii); he asserts that the Hebrews were "brigands, usurpers and murderers" who felt authorized by Heaven to commit

deceit, cruelty, wanton destruction, superstition, fury, violating good faith and offending justice (pp. 19-20); from its beginnings, Christianity was forced to appeal to the stupidest people among the population, and was only embraced by the most abject among the Jews and pagans (p. 29); Christianity "was the religion of the poor, announcing a poor God, preached by the paupers to ignorant paupers, its mournful ideas corresponding to the condition of unhappy and indigent men" (p. 32); "'peace on Earth and good will toward men' was the watchword of this religion, which has cost more human blood to flow than all other religions of the world taken together" (p. 35); "God was partial in his love for the chosen people, and was needlessly cruel towards the rest of humanity, and ordered fraud, theft, murder, and made it a duty for his chosen people to commit the most atrocious crimes, to violate good faith, and to hold the law of nations in contempt" (p. 45); the structure of faith reposes on miracles, which are things it is impossible to believe; "the prophecies of the Jews are nothing but shapeless rhapsodies, the work of fanaticism and delirium, obscure and enigmatic prophecies ... the work of a few men used to profiting from the credulity of a superstitious people, who placed stock in dreams, visions, apparitions, magic spells and were willing to swallow any number of daydreams as long as they seemed marvellous" (pp. 85-6); d'Holbach offered in the place of the terrors of religion, "the benefits of good laws, a reasonable education and honest principles" (p. 109); he saw the pre-Christian paganism of classical Antiquity as offering many moral examples of equity, humanity, patriotism, temperance, disinterested behaviour, patience, sweetness (p. 140); "Reason is sufficient to teach us our duties towards the other members of our species – what possible benefit could there be in religion, which is forever contradicting and degrading reason?" (p. 142); he considered "that a sound foundation for political will cannot be provided by a changing God, at once partial and capricious, who orders justice and injustice at the same time, harmony and massacre, tolerance and persecution" (p. 142); the basis of politics should be natural morality, which promotes health, respect for mores, the desire to gain the esteem of others, chastity, temperance, virtue (p. 158); there is no need to resort to some supernatural morality, since just laws will be enough to encourage justice and generosity (p. 164); in terms of tolerance, "for a Christian, an infidel was never better than a dog" (p. 183); "it seems that Christianity is only able to propose creating abject slaves, of no utility for the world, in whom virtue is replaced by blind submission to their priests" (p. 186); when the Christian religion "is in agreement with politics, then it crushes, demeans, impoverishes nations, and deprives them of science and industry; when religion separates from politics, it makes the citizens unsociable, turbulent, intolerant and rebellious" (p. 235); "a system founded on marvels, fables, obscure oracles is compelled to be a fertile source for disputes" (p. 263); "in short, religion places no limit on human passions which reason, which education, which a sound morality cannot do more effectively" (p. 288).

22 As we have noted earlier in this thesis, Galileo Galilei also took a trenchant position, which he erected as a counter-dogma.

23 Wickwar, *op. cit.*, p. 139.

24 We have already alluded to this materialist association of fear with superstition, from Lucretius onwards, in the chapter on Hobbes.

25 Naville, *op. cit.*, p. 346.

26 Joseph-François Lafitau, *Moeurs des sauvages américains*, (Paris, 1983) Volume I, p. 55.

27 Charles Louis de Secondat, Baron de Montesquieu, *The Spirit of the Laws.*

28 The primitive man, according to Rousseau, was fortunate in his solitude and indifference: "The spectacle of nature becomes a matter of indifference to him by dint of becoming familiar to him. It is always the same order, the same succession of changes. He does not have a mind for marvelling at the greatest wonders; and we must now seek in him the philosophy that a man needs in order to know how to observe once what he has seen everyday. His soul, agitated by nothing, is given over to the single feeling of his own present existence, without any idea of the future, however near it may be, and his projects, as limited as his views, hardly extend to the end of the day." *Discourse on the Origins of Inequality* (Indianapolis, 1992), p. 27.

29 According to Naville, "they had a foundation of shared ideas in science, history and morality, tested in the fire of mutual criticism. They shared tasks, on the basis of their individual preferences, aptitudes and material possibilities. Diderot was the visible publisher of the *Encyclopédie*; but as a philosopher he remained clandestine, anonymous. Some of his most wonderful works, such as *Le Rêve de d'Alembert*, remained in manuscript form. Throughout his life, d'Holbach would conserve his anonymity as a philosopher; officially, he was only the noble baron, host of the *Encyclopédistes*, and collaborator in

matters of chemistry, mineralogy and geology; by means of his relations, and credit, he would do everything to cover, to protect the actions of his friends, and he would succeed in doing so. It did not bother him a whit to ask Diderot for help in writing, or advice, just as he would ask Naigeon, Damilaville, Le Roy, Suard and Helvetius. This constant collaboration explains the force, the unity, the power of eighteenth-century materialist philosophy, something which is hard to understand today, given the jockeying for position and prominence which have come to define intellectual strategy." Naville, *op. cit.*, p. 64.

30 Jean-Jacques Rousseau, *Confessions*, translated by W. Conyngham Mallory (New York, 1935). Rousseau denounced the "côterie Holbachique" on numerous occasions in this work, for example on pp. 625, 677, 768, 772, 784 and 799, referring to people in d'Holbach's circle variously as Holbachiens (p. 684) and d'Holbachiens (711).

31 "Grimm, Diderot and d'Holbach were ... in the center of the vortex, lived in the great world, and divided amongst them almost all the spheres of it. The great wits, men of letters, men of long robe, and women, all listened to them when they chose to act in concert. The advantage three men in this situation united must have over a fourth in mine, cannot but already appear. It is true Diderot and d'Holbach were incapable, at least I think so, of forming black conspiracies; one of them was not base enough, nor the other sufficiently able; but it was for this reason that the party was more united. Grimm alone formed his plan in his own mind, and discovered more of it than was necessary to induce his associates to concur in the execution. The ascendancy he had gained over them made this quite easy, and the effect of the whole answered to the superiority of his talents." *Confessions,* p. 779. One wonders whether Rousseau did not suffer from a persecution complex, and possibly paranoia.

32 Quoted in David Seamon and Arthur Zajonc (ed.) *Goethe's Way of Science: a Phenomenology of Nature* (Albany, 1998), p. 18.

33 According to Ronald Hayman, "since reading *Le Système de la Nature* about seven years earlier, Sade had not had the opportunity to re-read it, though it is clear from two letters sent to Renée-Pélagie in November 1783 that he had been thinking about it. 'It is absolutely impossible,' he complained in the first, 'for me to enjoy the refutation of the *Système de la Nature* if you do not send the *Système*.' In the second letter, written at the end of the month, he called it 'truly and quite incontestably the basis of all my philosophy ... I am its devotee to the point of martyrdom if necessary.'" Robert Hayman, *De Sade* (London, 1978), p. 126. D'Holbach would not have recognized his philosophy in Sade's behaviour!

34 La Mettrie's *Machine Man* is less structured, but much more engaging, than *System of Nature*. Even so, La Mettrie's literary merits pale in comparison to several materialists of classical Antiquity, the most compelling of whom was without question Lucretius.

35 G.W.F. Hegel, *Lectures on the History of Philosophy* (London, 1892) vol. III, p. 393.

36 Friedrich A. Lange, *History of Materialism*, 1st Book, 4th Section, p. 93.

37 Ernst Cassirer, *The Philosophy of the Enlightenment*, p. 6.

38 Lange believed, however, that d'Holbach's German origin was a defining, national characteristic: "Paul Heinrich Dietrich von Holbach, a rich German baron, born at Heidelsheim in the Palatinate in 1723, came to Paris early in his youth, and, like his countryman Grimm, whose intimate friend he was, became naturalized into French life. If we consider the influence exercised by these men in their circle, and compare with them the characters of the gay and brilliant society that gathered round Holbach's hospitable hearth, we easily see that we must attribute to these two Germans a decisive part in the philosophical questions that were here discussed. Quiet, inflexible, impassive, like self-absorbed helmsmen, they sit among this whirlpool of eddying talent. With the function of observers they unite, each in his own way, a far-reaching influence that is the more irresistible because it is so imperceptible." *Op cit.*, 1st Book, 4th Section, p. 94.

39 "The science of morals has become an enigma, which it is impossible to unravel, because man has made himself double, has distinguished his mind from his body, supposed it of a nature different from all known beings, with modes of action, with properties distinct from all other bodies; because he has emancipated this mind from physical laws, in order to submit it to capricious laws derived from imaginary regions. Metaphysicians, seized upon these gratuitous suppositions, and by dint of subtilizing them, have rendered them completely unintelligible." *System of Nature,* pp. 159-160.

40 "Whoever contemplates nature without prejudice, will readily acknowledge, that there is no other difference between the man and the beast than that which is to be attributed to the diversity of his organization." *Ibid.*, p. 82.

41 *Ibid.*, p. 300.

[42] *Ibid.*, p. 310.

[43] "Nature cannot be accused of either goodness or malice, since every thing that takes place in it is necessary – is produced by an invariable system, to which every other being, as well as herself, is eternally subjected. The same igneous matter that in man is the principle of life, frequently becomes the principle of his destruction, either by the conflagration of a city, or the explosion of a volcano. The aqueous fluid that circulates through his machine, so essentially necessary to his actual existence, frequently becomes too abundant, and terminates him by suffocation, is the cause of those inundations, which sometimes swallow up both the earth and its inhabitants. The air, without which he is not able to respire, is the cause of those hurricanes, of those tempests, which frequently render useless the labour of mortals."*Ibid.*, p. 173.

[44] "What is the end of nature? We shall reply that it is to act, to exist, to conserve her whole. If it be asked of us, wherefore she exists? We shall reply, that she exists necessarily, and that all her operations, her motions, and her works, are necessary consequences of her necessary existence... In speaking of nature or of the material universe, we shall have fixed and determinate ideas of the cause of which we speak; whilst in speaking of a theological God, we shall never know what he can be, or whether he exists, nor the qualities which we can with justice assign him."*Ibid.*, p. 241.

[45] *Ibid.*, p. 15.

[46] "Man is a sensitive, intelligent, reasonable, sociable being who in every moment during his life seeks without ceasing to conserve himself and to make his existence agreeable ... many moralists have mistakenly created systems of morality, giving us romances and fables in place of the history of humanity; the word Nature was generally for them a vague term to which they did not attach any clear meaning. But since morality is the science of humanity, it is important to start by developing true ideas... In man, we will call Nature that collection of properties and qualities which make him what he is, which are inherent to his species, which distinguish him from other animals..." Baron d'Holbach, *La morale universelle* (Stuttgart, 1970), vol. I, pp. 4-5. Our translation.

[47] Alain Pons (ed.) *Encyclopédie*, p. 135.

[48] Peter Gay, *The Enlightenment: an Interpretation*, vol. I, p. 400.

[49] Naville noted the influence on d'Holbach of Newton and Stahl: "anticipating nineteenth-century English psychologists, he transposed the laws of celestial mechanics on the domain of organic and human behaviour (the moral world); the reciprocal movements of animated beings responded to the same laws as the relative movements of material bodies." Naville, *op. cit.*, p. 239. Moreover, "Newtonian physics, which the baron seeks to ground in the principles which observations are starting to teach scholars in the area of chemistry and the life of organic beings, gives rise to many difficulties and vagueness: but why be surprised to find them in the philosophy of the time? And shouldn't we rather admire the boldness of a synthesis such as we find in the System of Nature? More than two centuries later, can't we agree that d'Holbach had a better idea of the future of science than his detractors?" *Ibid.*, p. 251.

[50] *System of Nature.*, p. 341.

[51] "The more man reflects, the more he will be convinced that the soul, very far from being distinguished from the body, is only the body itself considered relatively to some of its functions, or to some of the modes of existing or acting of which it is susceptibly whilst it enjoys life. Thus, the soul is man considered relatively to the faculty he has of feeling, of thinking, and of acting in a mode resulting from his peculiar nature; that is to say, from his properties, from his particular organization; from the modifications, whether durable or transitory, which the beings who act upon him cause his machine to undergo." *System of Nature*, p. 52.

[52] *Ibid.*, p. 347.

[53] *Ibid.*, p. 139.

[54] *Ibid.*, p. 117.

[55] "Here then is the great macrocosm, the mighty whole, the assemblage of things, adored and deified by the philosophers of antiquity, whilst the uninformed stopped at the emblem under which this nature was depicted, at the symbols under which its various parts, its numerous functions were personified; his narrow mind, his barbarous ignorance, never permitted to mount higher; they alone were deemed worthy of being initiated into the mysteries, who knew the realities masked under these emblems." *Ibid.*, p. 179.

[56] *Ibid.*, p. 92.

[57] *Ibid.* p. 55.

[58] *Ibid.*, p. 68.
[59] *Ibid.*, p. 77.
[60] He responded to the charge that reducing Man's function to a pure mechanism were degrading, shameful and abject: "The philosopher devoid of prejudice, does not understand this language invented by those who are ignorant of what constitutes the true dignity of man." Indeed, the "honest man is a machine, of which the springs are adapted to fulfil its functions in a manner that must gratify the expectation of all his fellows. No, I should not blush to be a machine of this sort; and my heart would leap with joy if I could foresee that the fruit of my reflections would one day be useful and consoling to my fellow man." *Ibid.*, p. 112.
[61] *Ibid.*, p. 119.
[62] Man "contains within himself causes inherent to his existence; he is moved by an interior organ, which has its own peculiar laws, and is itself necessarily determined in consequence of ideas formed from perceptions resulting from sensations which it receives from exterior objects. As the mechanism of these sensations, of these perceptions, and the manner they engrave ideas on the brain of man, are not known to him; because he in unable to unravel all these motions; because he cannot perceive the chain of operations in his soul, the motive principle that acts within him, he supposes himself a free agent; which, literally translated, signifies, that he moves himself by himself; that he determines himself without cause: when he rather ought to say, that he is ignorant how or for why he acts in the manner he does." *Ibid.*, p. 97.
[63] *Ibid.*, p. 323.
[64] *Système Social* (Hildesheim, 1969) vol. I, p. 14.
[65] *Ibid.*, I: 56.
[66] *Ibid.*, I: 64.
[67] *Ibid.*, I: 78.
[68] *Ibid.*, I: 83.
[69] *Ibid.*, I: 146.
[70] Naville gave a fascinating account of clandestine materialist literature in the early eighteenth century. *Op. cit.*, pp. 140-173.
[71] *Ibid.*, p. 180.
[72] Karl Marx and Friederich Engels, *The Holy Family* (Moscow, 1956), pp. 175 and 178.
[73] G.V. Plekhanov, *Essays in the History of Materialism, translated by Ralph Fox* (New York, 1967), pp. 3-75.
[74] *Ibid.*, p. 51.
[75] George H. Sabine, *A History of Political Theory*, pp. 568-569.
[76] *The Philosophy of the Enlightenment*, pp. 55-6.
[77] Wickwar, *op. cit.*, p. 154.
[78] He wrote in *System of Nature* that it is "for want of recurring to the causes that move him; for want of being able to analyze, from not being competent to decompose the complicated motion of his machine, that man believes himself to be a free agent: it is only upon his ignorance that he founds the profound yet deceitful notion of his free agency; that he builds those opinions which he brings forward as a striking proof of his pretended freedom of action." (p. 97)
[79] *Ibid.*, p. 337.
[80] *Ibid.*, p. 101.
[81] Lange, *op. cit.*, 1st Book, 4th Section, p. 123.

KARL MARX (1818-1883)

In this study, there has only been one direct application so far of the metaphor of Man the machine to political ideology, in the seventeenth-century absolutism of Hobbes. Although some materialist and mechanistic aspects of the *Leviathan* are daunting, Hobbes was an ambiguous figure, and cannot be classified simply as a proto-totalitarian. The *Leviathan* gives only a limited advance warning of what nineteenth- and twentieth-century totalitarianism was to become. For La Mettrie and d'Holbach in the eighteenth century, the mechanical metaphor increasingly served the new Enlightenment vision of humanity. They both challenged the age-old belief that Man is in God's image and likeness; they identified reason, atheism and materialist science as keys to man's mastery of himself; and they urged the individual to rely on reason, rather than on the irrational ebb and flow of psychology, which they associated with dysfunctional mechanisms within the human organism. D'Holbach imagined an ideal future society governed by reason, which bears some relation to the totalitarian State, but only indirectly.[1]

With Karl Marx, however, the metaphor of Man the machine undergoes a profound change. Marx drew on some of the sources already identified in this work – the ideal closed society of Plato's *Republic*,[2] the materialism of classical Antiquity[3] and of eighteenth-century France,[4] and the metaphor of Man the machine, as it appeared in the late eighteenth and early nineteenth centuries, in the works of political economists such as Adam Smith (1723-1790)[5], David Ricardo (1772-1823)[6] and the Christian socialist Henri de Saint-Simon (1760-1825).[7] To these diverse sources, some of which he criticized sharply, he added Hegelian idealism,[8] revolutionary fervour,[9] a penchant for historical prophecy,[10] a messianic longing for a new Golden Age,[11] and a very nineteenth-century faith in science.[12] He fashioned these diverse strands into one of the most powerful political ideologies of all time,[13] an ideology that exalted revolutionary violence, since it was based on the dialectical chain of contradictory action-and-reaction that was supposed to govern all social and political change.[14] From this perspective, violence was a normal part of the working-out of historical contradictions, a way of accelerating change, and a way for the working class to conquer total political power.[15]

For Marx, the antagonism between capital and the worker reflected the dialectic working-out of the contradictions just mentioned, was part of an absolute historical law, and was therefore inescapable: "the law which always holds the relative surplus population or industrial reserve army in equilibrium with the extent and energy of accumulation rivets the worker to capital more firmly than the wedges of Hephaestus held Prometheus to the rock. It makes an accumulation of misery a necessary condition, corresponding to the accumulation of wealth. Accumulation of wealth at one pole is, therefore, at the same time accumulation of misery, the torment of labour, slavery, ignorance, brutalisation and moral degradation at the opposite pole, i.e. on the side of the class that produces its own product as capital."[16]

This stark, uncompromising and inescapable antagonism between the "objective" interests of capitalist and worker pervades every page of Marx's writings.

A central feature of Marxist ideology was Man the machine – whether in Marx's theorizing and tactics in the nineteenth century, or in the practical realities of Marxist States in the twentieth century.[17] But Man the machine was interpreted in a completely new way. True, Marx had studied some of the key figures described so far in this study, making periodic references to Hobbes, Descartes and others. In *Capital*, he even added a reference to Aristotle – on instruments that were able, robot-like, to accomplish their own work, obeying or anticipating the will of others.[18] But unlike his predecessors, Marx used the metaphor of Man the machine to support a critique of society, a call to revolution and a rousing prophecy of the perfect "universal" world that was surely coming. Marx's writings are turgid and often obscure. Yet in his attacks on the industrialist's accumulation of capital, and the individual workers' alienation from his labour, he helped to define those social fears of "gigantic" and "demonic" industrial machinery that were growing during his lifetime.

Marx and his close associate Friedrich Engels (1820-1895) focused on the machine, since it symbolized the transformation of economic relations from the onset of the industrial revolution. In the idyllic (and somewhat romanticized) cottage setting of the early eighteenth century, Engels stated that the workers "vegetated throughout a passably comfortable existence, leading a righteous and peaceful life in all piety and probity; and their material position was far better than their successors. They did not overwork; they did no more than they chose to do, and yet earned what they needed." Even so, "they were merely toiling machines in the service of the few aristocrats who had guided history down to that time." But from the mid-eighteenth century onwards, the industrial revolution brought about a profound change, which has made "the workers machines pure and simple, taking from them the last trace of independent activity, and so forcing them to think and demand a position worthy of men. As in France politics, so in England manufacture, and the movement of civil society in general, drew into the whirl of history the last classes which had remained sunk in apathetic indifference to the universal interests of mankind."[19]

The workers had become "machines pure and simple"; the English industrial revolution was as significant for the economy as the French revolution had been for politics. It was clear for Engels that this new situation forced upon the workers a new consciousness, drawing them closer to their historical destiny, and pressing them to serve the universal interests of mankind. The transition from moral commentary to revolutionary agitation to prophecy – all in one short passage – is remarkably compressed.

Marx was above all a theorist, as is clear from a wide range of short works, and larger ones such as *Economic and Philosophical Manuscripts* (first published in 1932), the *Grundrisse* (first published in 1953) and *Capital* (whose three dense volumes appeared in 1867, 1885 and 1894 – the latter posthumously). His energies were primarily devoted to developing the theory of historical materialism (according to which material conditions, such as the relations and mode of production, dictate social existence). He also painstakingly criticized the capitalist economy and articulated the idea of class struggle.

Engels, meanwhile, at least during his early years, was something of a social journalist, denouncing in graphic detail the exploitation of workers and their families, pauperism, famine, and the social degradation resulting from unrestrained capitalism. Since the conditions of unrestrained nineteenth-century capitalism are so different from those in our own day, it is worth quoting from Engels in this respect. In 1844-45, he observed that "Another branch of lace-making, bobbin-lacework, is carried on in the agricultural shires of Northampton, Oxford, and Bedford, chiefly by children and young persons, who complain universally of bad food, and rarely taste meat. The employment itself is most unwholesome. The children work in small, ill-ventilated, damp rooms, sitting always bent over the lace cushion. To support the body in this wearying position, the girls wear stays with a wooden busk, which, at the tender age of most of them, when the bones are still very soft, radically displace the ribs, and make narrow chests universal. They usually die of consumption after suffering the severest forms of digestive disorders, brought on by sedentary work in a bad atmosphere. They are almost wholly without education, least of all do they receive moral training. They love finery, and in consequence of these influences their moral condition is most deplorable, and prostitution is almost epidemic among them.... A great number of operatives are employed in the cotton-printing establishments of Lancashire, Derbyshire, and the west of Scotland. In no branch of English industry has mechanical ingenuity produced such brilliant results as here, but in no other has it so crushed the workers. The application of engraved cylinders driven by steam-power, and the discovery of a method of printing four to six colours at once with such cylinders, has as completely superseded hand-work as did the application of machinery to the spinning and weaving of cotton, and these new arrangements in the printing-works have superseded the hand-workers much more than was the case in the production of the fabrics. One man, with the assistance of one child, now does with a machine the work done formerly by 200 block printers; a single machine yields 28 yards of printed cloth per minute."[20]

In much that Marx and Engels wrote, it is important to note, they blurred the distinction between moralism, appeals to revolution and prophecy. For this reason, moral observations about the effects of capitalism were subtly transformed into arguments for revolution, which themselves were turned into prophecies of imminent revolution.

Marx and Engels denounced the capitalist development and use of technology, and the resulting dehumanizing reduction of man to a machine-like existence, for several reasons. "The machine accommodates itself to man's weakness," wrote Marx in 1844, "in order to turn weak man into a machine."[21] With the onset of the industrial revolution, machinery increasingly replaced human employment, forcing men, women and children into roles subservient to machinery.[22] Technological inventions ensured the victory of machine-work over hand-work.[23] Machinery concentrated capital and national wealth in the hands of capitalists, just as it destroyed all property holding and security of employment for the working class.[24] All-pervasive capitalist machinery brought on a commercial crisis, and created want, wretchedness and crime.[25] Automatic systems of machinery were developed in which workers provided no more than conscious linkages – within the machine, as it were. Machines were demonic mechanical beasts: as Marx wrote in 1857-58 in the *Grundrisse*, "It is the machine which possesses skill and strength in place of the worker, is itself the virtuoso, with a soul of its own in the mechanical laws acting through it; and it consumes coal, oil, etc. (*matières instrumentales*), just as the worker consumes food, to keep up its perpetual motion. The worker's activity, reduced to a mere abstraction of activity, is determined and regulated on all sides by the movement of the machinery, not the opposite. The science which compels the inanimate limbs of the machinery, by their construction, to act purposefully, as an automaton, does not exist in the worker's consciousness, but rather acts upon him through the machine as an alien power, as the power of the machine itself."[26] Not only did machinery have a demonic character – it transformed the collective worker into an "item of machinery" – "the habit of doing only one thing converts him into an organ which operates with the certainty of a force of nature, while his connection with the whole mechanism compels him to work with the regularity of a machine."[27] Marx also noted in *Capital* that "Cyclopean" machines were gradually taking over the construction of other machines.[28] The end result of this concentration of the means of production in the hands of capitalist manufacturers, and the dispossession of the workers themselves was for Marx straight-forward: "factory work exhausts the nervous system to the utmost; at the same time, it does away with the many-sided play of the muscles, and confiscates every atom of freedom, both in bodily and in intellectual activity. Even the lightening of the labour becomes an instrument of torture, since the machine does not free the workers from the work, but deprives the work itself of all content."[29] In fact, technology is used under capitalism to turn the worker's life into a hideous form of slavery: "The life-long specialty of handling the same tool now becomes the lifelong speciality of serving the machine. Machinery is misused in order to transform the worker, from his very childhood, into a part of a specialized machine."[30]

As telling as these observations may be, many of Marx and Engels' contemporaries could have made them. Marx and Engels were not alone in lamenting the negative effects of capitalism and technology on the proletariat during the Industrial Revolution.[31] Nor were they the foremost observers of a wide range of injustices afflicting European and North American society in the 1830s, 1840s, 1850s and 1860s.[32] The difference lay in the remedies proposed. Marx and Engels turned their back on the attempts of leading liberal thinkers to develop a more representative, transparent and stable political system, in which political abuses could be curtailed by periodically dismissing the party in power, and economic abuses could be remedied through public campaigns and reforms.[33] They castigated "philanthropic" socialists, who proposed no concrete remedy and failed to seize the tactical opportunity presented by demoralization, dissolution and corruption – an opportunity that could in their view be converted into revolutionary activity.[34]

Marx was by turns moralist, revolutionary and prophet, which explains why he made three distinct interpretations of the metaphor of Man the machine. By linking these three interpretations (and blurring the distinctions between them), Marx created a vision at once ambiguous and strangely compelling.[35]

First, he used the metaphor to illustrate and condemn the dehumanizing effects of nineteenth-century technology and the exploitation of cog-like proletarians by capitalists. This condemnation gave wide popular appeal to Marx's vision, since it was rooted in direct observations of miserable social conditions affecting millions of people during the most unrestrained phase of European capitalism. Marx's critique of technology was also forceful, and there are passages in his works that demonize the machine and the capitalist factory system.

Second, Marx and Engels used the metaphor in their revolutionary call to arms. For them, the proletarian was "an appendage of the machine":[36] "Modern industry," they wrote in 1848, in *The Communist Manifesto*, "has converted the workshop of the patriarchal master into the great factory of the industrial capitalist. Masses of labourers, crowded into the factory, are organized like soldiers. As privates of the industrial army they are placed under the command of a perfect hierarchy of officers and sergeants. Not only are they slaves of the bourgeois class, and of the bourgeois State; they are daily and hourly enslaved by the machine, by the over-looker, and, above all, by the individual bourgeois manufacturer himself."[37] And the proletarian was trained to act as a machine: "Just as, to the bourgeois, the disappearance of class property is the disappearance of production itself, so the disappearance of class culture is to him identical with the disappearance of all culture. That culture, the loss of which he laments, is, for the enormous majority, a mere training to act as a machine."[38] Finally, "The Communists disdain to conceal their views and aims. They openly declare that their ends can be attained only by the forcible overthrow of all existing social conditions. Let the ruling classes tremble at a Communistic revolution. The proletarians have nothing to lose but their chains. They have a world to win."[39] Chains refer here, of course, to the chains of the capitalist monopoly of control over the means of production, and therefore to the capitalist's abuse of the proletariat by means of dehumanizing technology.

Third, Marx incorporated the metaphor into a prophetic theory of an ideal class-free society rolled up at the end of History. According to Marx, the capitalist factory and technology were dehumanizing because of the very nature of capitalism. There is astonishingly little detail in his works mapping out how factories and technology under communism would be any different. Unlike Plato's *Republic*, not a single one of Marx's many works provided a detailed plan of what the perfect society was to be. Instead, he just affirmed, without offering any evidence, that the communist factory, like communist society in general, would be a happier place. In his ideal future society, all social development would be arrested, the political system would never need reform, and that was that.

It is important to remember the turbulent political and economic conditions under which Marx lived during his formative years: "the restored monarchies and principalities in Germany were only rarely and briefly constitutional; representative institutions, where there were any, were merely consultative bodies subordinate to hereditary or semihereditary rulers, who claimed sole authority for decision making in the state. Unsurprisingly and characteristically they had a strategy for schooling the populace in obedience and resisting encroachments on their powers and the powers of their allies."[40] Moreover, once Marx and Engels began to travel the wider world, once they came into contact with British industrialism in particular, they were exposed to sometimes chaotic economic and political developments: the rapid transformation of England and Scotland into industrial societies; the potato famine of Ireland, the abortive revolutions of 1848 throughout Europe, and subsequently the American Civil War and the Paris Commune of 1871. In this context, Marx considered the proletariat to be a dispossessed class, and imagined that by virtue of its misery and lack of property, it would not be subject to the distortions of history and would thus be the "universal" class ideally suited to take hold of the State, and even do away with it.

Marx sought to create what seemed to him a better world. But his prophetic vision was seriously flawed.[41] It was also a destructive vision. Throughout his writings, he called for the whole-sale abolition of institutions in the name of communism – institutions such as private property,[42] social classes,[43] the rights of man,[44] the individual as a self-sufficient "monad",[45] religion,[46] the family,[47] the State,[48] "bourgeois" law and morality.[49] Total abolition of these institutions was a precondition to creating the perfect communist society. In youth as in middle and old age, he advocated revolutionary violence on a massive scale in order to abolish these institutions.[50] He considered total abolition of inhuman conditions to be his objective.[51] Yet he offered nothing – beyond his own prophetic dreams – to replace the void left in the wake of revolutionary destruction.[52]

Albert Camus wrote that "the future is the only transcendental value of men without God"[53] – and this statement should be applied to Marx. The future lured Marx and Marxists along; they mobilized the future to help forget their failed prophecies and to justify their excesses; the future was fluid and therefore subject to constant re-interpretation, since time kept pushing it further ahead....

The application of Marx's theories in practice resulted in unbelievable suffering – from the Russian Revolution and Civil War, to the establishment of the Soviet system, the creation of the gulags, collectivization, Stalin's organized famine, the Soviet export of the revolution, the Chinese Civil War, the Great Leap Forward, Chinese labour camps and other tragedies.

It was not enough for communism to do violence to the outer life of man; it continued by doing violence to the inner life as well. The individual was denied the freedom to live without fear and the freedom to pursue truth and knowledge for their own sake. It is striking how often this violence to the inner life has been denounced for bringing about a machine-like existence.

According to the Lithuanian-born Nobel laureate Czesław Miłosz, "When one considers the matter logically, it becomes obvious that intellectual terror is a principle that Leninism-Stalinism can never forsake, even if it should achieve victory on a world scale. The enemy, in a potential form, will *always* be there; the only friend will be the man who accepts the doctrine 100 per cent. If he accepts only 99 per cent, he will necessarily have to be considered a foe, for from that remaining 1 per cent a new church can arise."[54] Moreover, Miłosz explicitly pointed to the machine-like existence of the individual under communism: "People who flee from the people's democracies usually give as their chief motive the fact that life in these countries is psychically unbearable. They stammer out their efforts to explain: 'The dreadful sadness of life over there'; 'I felt I was turning into a machine.' It is impossible to communicate to people who have not experienced it the undefinable menace of total rationalism."[55]

An even more poignant allusion to the metaphor of Man the machine, is that of the Russian Nobel laureate Aleksandr Solzhenitsyn, in *The Gulag Archipelago*, where he noted how labour camp administrators in the Soviet Gulag "sought a new stimulus for socially useful labour": "They dug down deeper into the storage chest of history and dragged out what Marx had called 'extraeconomic coercion.' In camp and on collective farms this discovery was presented with bared fangs... All in all, the particular techniques required for this totalled three: (1) *the differentiated ration pot*; (2) *the brigade*; and (3) two sets of bosses. (But the third of these was not absolutely necessary: at Vorkuta, for example, there was only one set of bosses, and things hummed.) And so it was that the Archipelago rested on these three whales, these three pillars. Or if one considers them *the driving belts*, they certainly made the wheels turn."[56] The specific references to Marx and mechanism are worth underlining.

Finally, in the words of Stéphane Courtois, "one of the principal characteristics of Leninism [which he linked directly to Marx] resides in the manipulation of language, in the uncoupling of words and the reality they are supposed to represent, in an abstract vision of society [in which] men have lost all substance and are no more than pieces of a sort of historical and social Meccano [set]. This abstraction, narrowly linked to the ideological impulse, is a fundamental pillar of terror: it is not men who are being exterminated but 'bourgeois', 'capitalists', 'enemies of the people', it is not Nicholas II and his family who are massacred but 'advocates of feudalism', 'bloodsuckers', parasites, lice…"[57]

Even so, once the contradictions of Marxism became glaringly apparent, some observers sought to dissociate Marx from Russian and Chinese Marxism, as if his ideology had been betrayed in practice, and still remained, in all its alluring purity, to be realized sometime in the future.[58] In fact, the violence, slavery, organized terror and appalling human suffering of the Automated State so typical of communism can be traced directly back to Marx.[59] While he attacked the "class tyranny" of the bourgeoisie, he laid the grounds for the far more absolute tyranny of communism. And a key component of his ideology was Man the machine, a key feature of his denunciation, which was turned into a pillar of communism.

If we consider our original point of departure – the Renaissance celebration of man's many dimensions – precious little remains. How can man be in God's image and likeness, if, for Marx, religion is the opium of the masses, and God does not exist?[60] What can be the possible relevance of man-as-microcosm if, for Marx, the universe only contains matter in motion? How can man master himself, how can psychology under capitalism have any relevance, if, for Marx, the individual is the passive product of material conditions and resulting class prejudices? Marx wanted communism to master the individual instead. Psychology is only interesting, to the extent that it provides an illustration of material conditions. But under the future communist system, all individuals, whether proletariats, intellectuals, bourgeois, or any others will be definitively emancipated.[61]

The table below summarizes some influences on Marx's thinking:

Marx's interpretation	Sources	Key features
The body as machine	Classical atomism, La Mettrie, d'Holbach	The body is matter in motion
Man in God's image and likeness	None	Atheism
Man as a microcosm	None	None
Man as self-mastering individual	None	For Marx, man has no chance of mastering himself – because of historical materialism, the individual is the product of material conditions and social class; communism will master the individual (literally)
Man as a psychological being with virtually unlimited dimensions to human personality	None	Psychology under capitalism is basically irrelevant, since the individual is the product of material conditions and resulting class prejudices; violent revolution is needed to alter the consciousness of humanity at a mass level; under the future communist system, all individuals of whatever origin will be definitively emancipated
Man as endowed with reason and devoted to happiness	None	None
Man as a cog within an Automated State	Plato, Hegel (and perhaps indirectly Hobbes)	*"In the capitalist system, man exploits man; but in the communist system, it is the exact opposite!"*

Marx was born in 1818 in the city of Trier in the Rhine province of Prussia, to a genteel family that had converted from Judaism to Christianity. It is possible that some of the messianic and prophetic character of his work found its source in this family setting. While studying law and philosophy at the University of Berlin, in

1836, he was exposed to the works of Hegel, who had enormous influence as the philosopher *par excellence* of Germany. Hegel served as a mentor to Marx in four different respects: Hegel, like Plato, worshipped the State;[62] he revived the dialectic of negativity, a philosophical tradition going back to Heraclitus; he developed a philosophy of history, attributing abstract values to states, peoples and whole categories of citizens, as well as to the direction of historical events themselves; and he held that a single class, in his view, the Prussian bureaucracy, was the ultimate, universal class driving society towards its destiny.

Hegel exalted the role of the German World, which he considered the successor of the previous Oriental, Greek and Roman worlds. For him, the German world had a German spirit, which was "the spirit of the new world. Its aim is the realization of absolute truth as the unlimited self-determination of freedom – *that* freedom which has its own absolute form itself as its purport."[63] Hegel divided the German world into its natural periods – the elements of the Christian German world, the Middle Ages and the modern time. This latter time is "the period of spirit conscious that it is free, inasmuch as it wills the true, the eternal – that which is in and for itself universal."[64] He concluded his vision of the philosophy of history with the remarkable statement that "the history of the world is nothing but the development of the idea of freedom."[65]

Behind this extremely abstract division of History into worlds, the sub-division of worlds into natural periods, and the astonishing idea that a single great idea could quietly be at work over many thousands of years, was Hegel's attempt to interpret the broad patterns of History and to detect a rational process at work. Accordingly he wrote that "The only thought which philosophy brings with it to the contemplation of history, is the simple conception of reason; that reason is the sovereign of the world; that the history of the world, therefore, presents us with a rational process.... It is only an inference from the history of the world, that its development has been a rational process; that the history in question has constituted the rational necessary course of the world-spirit – that spirit whose nature is always one and the same, but which unfolds this its one nature in the phenomena of the world's existence. This must, as before stated, present itself as the ultimate result of history."[66]

Marx was a Young Hegelian for a time, and while he found Hegel's positions infuriating, he did, broadly speaking, accept the idea that a rational process was at work in History, a process to which could be assigned abstract values.

In 1841, Marx entitled his doctoral thesis *The Difference between the Democritean and Epicurean Philosophy of Nature*. This work outlined opinions on the relationship between Democritean and Epicurean physics, difficulties concerning the identity of the Democritean and Epicurean philosophy of nature, with further short chapters (mainly strings of quotes) being devoted to the declination of the atom from the straight line, the qualities of the atom, time and meteors. It is a remarkably thin piece of work, and often obscure, yet there is one passage in the preface, which is often cited as proof of Marx's early personal defiance, of his determination to make a difference: "As long as a single drop of blood pulses in her world-conquering and totally free heart philosophy will continually shout at her opponents the cry of Epicurus: 'The profane man is not the one who destroys the gods of the multitude but the one who foists the multitude's doctrines on the gods.' Philosophy makes no secret of it. The proclamation of Prometheus: 'in a word, I detest all the Gods' is her own slogan against all the gods of heaven and earth who do not recognise man's self-consciousness as the highest divinity. There shall be none other beside it."[67] According to David McLellan, Marx came out in favour of Epicurus, since his "emphasis on the absolute autonomy of the human spirit has freed men from all superstitions of transcendent objects; secondly, the emphasis on 'free individual self-consciousness' shows one way of going beyond the system of a 'total philosophy.'"[68]

Marx then gravitated towards the materialism and humanistic theologizing of Ludwig Feuerbach (1804-1872). And he increasingly subjected the philosophy of Hegel to criticism. In 1843, for example, Marx wrote in his *Critique of Hegel's Doctrine of the State* that "If Hegel [in his Doctrine of the State] had begun by positing real subjects as the basis of the state he would not have found it necessary to subjectivize the state in a mystical way. 'The truth of subjectivity,' Hegel claims, 'is attained only in a subject, and the truth of personality only in a person.' This too is a mystification. Subjectivity is a characteristic of the subject, personality is a characteristic of the person. Instead of viewing them as the predicates of their subjects Hegel makes the predicates into autonomous beings and then causes them to become transformed into their subjects by means of a mystical process."[69]

Marx subjected his former *maître à penser* to rigorous criticism. He wanted to enquire into the nature of political institutions, and uncover the secret of change – the "riddle", as he put it, of History itself.[70] In this respect, he reacted to Hegel, the apologist of such a stagnant, backward society as Prussia, while simultaneously accepting the abstract framework that Hegel had developed, and filling it with a new content. "The importance of Hegel's *Phenomenology* and its final result," he wrote, "the dialectic of negativity as the moving and productive principle – lies in the fact that Hegel conceives the self-creation of man as a process, objectification as loss of object [*Entgegenständlichung*], as alienation and as supersession of this alienation; that he therefore grasps the nature of *labour* and conceives objective man, true, because real man, as the result of his *own labour*."[71] In his early writings, Marx's style of analysis was marked by paradoxes, catchy phrases and polarizations, since he was already putting into practice the dialectic he had learned from Hegel.[72]

Marx insisted on the importance of rapid change; he believed that contradictions consisted of thesis and antithesis, which would produce an eventual synthesis (this latter containing, in germ, both thesis and antithesis); he wanted positions for and against to be resolved and harmonized into a new whole. The dialectical view was all the more attractive to young radicals like him, in that it seemed to offer analytical and practical tools that could be used to conceptualize and plan change in Germany, a society whose ruling class lived under a continuing fear of revolution. Hegel had portrayed the existing Prussian State and social institutions as "rational" in an attempt to preserve the ancien regime – something Marx attacked as "mystification" in 1843. The dialectic became a pillar of Marx's philosophical thought, and a tool of analysis, which, as he became increasingly radical, he applied to a wide variety of situations.

For example, in *On the Jewish Question*, the short work he wrote in 1843 (it is best known for the statement that "religion is the opium of the people"), Marx maintained that the best way to resolve the opposition between Jew and Christian was to abolish religion altogether: "We must emancipate ourselves before we can emancipate others. The most rigid form of opposition between Jew and Christian is the religious opposition. How does one resolve an opposition? By making it impossible. How does one resolve a religious opposition? By abolishing religion. Once Jew and Christian recognize their respective religions as nothing more than different stages in the development of the human spirit, as snake-skins cast off by history, and man as the snake which wore them, they will no longer be in religious opposition, but in a purely critical and scientific, a human relationship. Science itself will be their unity. But oppositions in science are resolved by science itself."[73]

This practice of applying the dialectic in an attempt to resolve conflict not only accentuated contradictions and heightened conflicts, but also supported Marx's habit (derived from Hegel) of attributing abstract values to particular categories of citizens, and of borrowing rhetorical (and messianic)[74] language from the domain of religion. For example, where Hegel extolled the methodical, loyal Prussian bureaucracy as the universal class, Marx held up to the world a new universal class – the dispossessed proletariat. He sharpened the contradictions and conflicts affecting the working class, by interpreting them in a dialectical fashion, and then placed them in a messianic setting of total loss and total redemption.

This peculiar fusion of dialectics, abstractions and messianism is apparent in Marx's ground-breaking *Contribution to the Critique of Hegel's Philosophy of Right, Introduction*, which he wrote in 1843-4. This work, although short, is important since it is an early statement of the program of total revolutionary activity that Marx set for himself: "So where is the positive possibility of German emancipation? This is our answer. In the formation of a class with radical chains, a class of civil society which is not a class of civil society, a class which is the dissolution of all classes, a sphere which has a universal character because of its universal suffering and which lays claim to no particular right because the wrong it suffers is not a particular wrong but wrong in general; a sphere of society which can no longer lay claim to a historical title, but merely to a human one, which does not stand in one-sided opposition to the consequences but in all-sided opposition to the premises of the German political system; and finally a sphere which cannot emancipate itself without emancipating itself from – and thereby emancipating – all the other spheres of society, which is, in a word, the total loss of humanity and which can therefore redeem itself only through the total redemption of humanity. This dissolution of society as a particular class is the proletariat."[75]

Total loss and total redemption were invoked in this short work. Marx called for the breaking not of a *single* form of bondage, but of *all* forms of bondage, by means of a thorough revolution: "In Germany no form of bondage can be broken without breaking all forms of bondage. Germany, which is renowned for its thoroughness, cannot make a revolution unless it is a thorough one. The emancipation of the German is the emancipation of man. The head of this emancipation is philosophy, its heart the proletariat. Philosophy cannot realize itself without the transcendence of the proletariat, and the proletariat cannot transcend itself without the realization of philosophy."[76] The following year, this view was reiterated in *The Holy Family*, a work he drafted with Engels.[77]

While writing *Economic and Philosophical Manuscripts*, Marx continued to develop this total program of revolutionary activity. He wrote that "Communism [that is, Marx's conception of communism, which he was contrasting with the "crude communism" of Cabet and others] is the positive supersession of private property as human self-estrangement, and hence the true appropriation of the human essence through and for man; it is the complete restoration of man to himself as a social, i.e.

human being, a restoration which has become conscious and which takes place within the entire wealth of previous periods of development. This communism, as fully developed naturalism, equals humanism, and as fully developed humanism equals naturalism; it is the genuine resolution of the conflict between man and nature, and between man and man, the true resolution of the conflict between existence and being, between objectification and self-affirmation, between freedom and necessity, between individual and species. It is the solution of the riddle of history and knows itself to be the solution. The entire movement of history is therefore both the actual act of creation of communism – the birth of its empirical existence…"[78]

In other words, where for Hegel, "the history of the world is nothing but the development of the idea of freedom", for Marx communism was the culmination of the dialectical process; it was the synthesis in which all economic, political and social contradictions would be resolved; it was the goal of History; it alone was capable of truly resolving conflicts between highly abstract categories, such as existence and being, objectification and self-affirmation, etc. The rhetorical advantage of this line of analysis is obvious: Marx could interpret History in his own fashion, assigning abstract values to events past, present (and future!), as well as to categories of citizens, in a way that seemed always to point to the ultimate resolution of contradictions in communism. And communism was not just a body of ideas – it was a plan of revolutionary activity.[79]

According to Marx, proletarian violence, when channeled by communist revolutionaries, had several features: it was the inevitable consequence of the degrading effects of capitalism; it was needed to bring about the alteration of men on a mass scale; and it was an education which would qualify the proletariat for the exercise of political power.

In the first volume of *Capital*, Marx wrote that the violent overthrow of capitalism was inevitable: "Along with the constant decrease in the number of capitalist magnates, who usurp and monopolize all the advantages in the process of transformation, the mass of misery, oppression, slavery, degradation, and exploitation grows; but with this there also grows the revolt of the working class, a class constantly increasing in numbers, and trained, united and organized by the very mechanism of the capitalist process of production. The monopoly of capital becomes a fetter upon the mode of production which has flourished alongside and under it. The centralization of the means of production and the socialization of labour reach a point at which they become incompatible with their capitalist integument. This integument is burst asunder. The knell of capitalist private property sounds. The expropriators are expropriated."[80]

And what if the proletariat only resorted to sporadic violence, and did not follow the audacious lead of communist intellectuals in bringing about total revolution? The chilling answer drawn up by Marx and Engels in 1845-46 is contained in *The German Ideology*: "Both for the production on a mass scale of this communist consciousness, and for the success of the cause itself, the alteration of men on a mass scale is necessary, an alteration which can only take place in a practical movement, a revolution; the revolution is necessary, therefore, not only because the ruling class cannot be overthrown by any other way, but also because the class overthrowing it can only in a revolution succeed in ridding itself of all the muck of ages and become fitted to found society anew."[81] In other words, the massive alteration of humanity needed to develop an appropriate communist consciousness could only be brought about through revolution – as if the violent overthrow of the existing social order were an enlightening experience, opening the way to an exalting new reality. This sounds very much like the mechanical reprogramming or brainwashing, through violence, of the entire human species. This view was reiterated two years after the collapse of the revolutions of 1848: Marx wrote of revolutionaries who substitute idealism for materialism and regard pure will as the motive power of revolution instead of actual conditions: "A national German approach has replaced the universal conception of the Manifesto, flattering the national sentiments of German artisans. The *will*, rather than the actual conditions, was stressed as the chief factor in the revolution. We tell the workers: 'if you want to change conditions and make yourselves capable of government, you will have to undergo fifteen, twenty or fifty years of civil war.'"[82] Proletarian violence was not just a means to an end, but was an education in itself.

If one takes Marx at face value during these early years, one has the impression that he was dealing only with philosophical abstractions. Actually, he was approaching the conditions of the working class from the theoretical perspective, positioning and repositioning abstract values as he went along. Friedrich Engels, the son of a manufacturer, who had moved from Germany to Manchester, provided a far more vivid picture of the practical conditions of the working class, in *The Conditions of the Working Class in England*, published in 1844. We may note here some of Engels' primary observations.

In an obvious allusion to the nightmarish Hobbesian vision of the *Leviathan*, Engels wrote that under English capitalism, "however much one may be aware that this isolation of the individual, this narrow self-seeking, is the fundamental principle of our society everywhere, it is nowhere so shamelessly barefaced, so self-conscious as just here in the crowding of the great city. The dissolution of mankind into monads, of which each one has a separate essence, and a separate purpose, the world of atoms, is here carried out to its utmost extreme. Hence it comes, too, that the social war, the war of each against all, is here openly declared."[83] For Engels, the industrial revolution had only made "this war of each against all" more intense.[84]

In this social commentary, Engels denounced the makeshift hovels and shacks within British industrial towns; the epidemics that inevitably raged there because of the filth and raw sewage dumped into the streets; the promiscuity, vice and prostitution forced onto the workers, especially women; the destructive effects of new technologies, of unrestrained competition and of the lack of legislation protecting men, women and child workers and the unemployed; the indifference of the bourgeoisie to the disastrous effects of some of their business practices. Engels singled out the capitalist's fascination with technological innovation, in his insatiable desire for ever greater profits: "In all directions machinery is being introduced, and the last trace of the working man's independence thus destroyed. In all directions the family is being dissolved by the labour of wife and children, or inverted by the husband's being thrown out of employment and made dependent upon them for bread; everywhere the inevitable machinery bestows upon the great capitalist command of trade and of the workers with it. The concentration of capital strides forward without interruption, the division of society into great capitalists and non-possessing workers is sharper every day, the industrial development of the nation advances with giant strides towards the inevitable crisis."[85]

Marx's three roles as moralist, revolutionary and prophet have so far been outlined and his three interpretations of the metaphor of Man the machine have been considered. An enormous gap has been detected between his position, and that of the Renaissance thinkers at the beginning of this work. And the link has been established between his political theory and later revolutionary practice, between his call for the wholesale abolition of many institutions and the unrestrained violence that was needed to make that happen – on a world scale.

After the collapse of European revolutions of 1848, Marx settled down in London, where he devoted himself for several decades to theoretical work as well as to some agitation. We will here consider Marx's critique of technology, since it is at once his strong point (we can gain some insights from his study of the relationship of human employment to technology) and his weak point (contrary to his prophecy, his own critique of technology applies even more to communism than it did to the unrestrained capitalism of the nineteenth century).

In the *Grundrisse* and again in *Capital*, Marx surveyed the historical process of technological development. The Roman Empire had handed down elementary technology such as the water-wheel; the handicraft period brought about inventions such as the compass, gunpowder, type printing and the automatic clock; seventeenth century machines provided great mathematicians with the practical means on which to base modern mechanics. Marx agreed with the judgment of Engels, according to whom the division of labour, the application of water and especially steam, and the application of machinery constituted three great levers of manufacturing – levers which had been used since the middle of the eighteenth century "to put the world out of joint."[86]

For Marx, a key development during the eighteenth century industrial revolution was the emergence of the "collective worker" – an organic group of individual workers, all performing specialized, integrated functions within a technological system: "The collective worker now possesses all the qualities necessary for production in an equal degree of excellence, and expands them in the most economical way by exclusively employing all his organs, individualized in particular workers or groups of workers, in performing their special functions. The one-sidedness and even the deficiencies of the specialized individual worker become perfections when he is part of the collective worker. The habit of doing only one thing converts him into an organ which operates with the certainty of a force of nature, while his connection with the whole mechanism compels him to work with the regularity of a machine."[87]

But just what is a machine? For Marx, it was neither the organic machine of Leonardo and Harvey, nor the metaphysical machine of Descartes and Leibniz. "All fully developed machinery," he wrote in the first volume of *Capital*, "consists of three essentially different parts, the motor mechanism, the transmitting mechanism and finally the tool or working machine. The motor mechanism acts as the driving force of the mechanism as a whole. It either generates its own motive power, like the steam-engine, the caloric-engine, the electro-magnetic engine, etc., or it receives its impulse from some already existing natural force, like the water-wheel from the descent of water down an incline, the windmill from the wind, and so on. The transmitting mechanism, composed of fly-wheels, shafting, toothed wheels, pulleys, straps, ropes, bands, pinions and gearing of the most varied kinds, regulates the motion, changes its form where necessary, as for instance from linear to circular, and divides and distributes it among the working machines. It is this last part of the machinery, the tool or working machine, with which the industrial revolution of the eighteenth century began. And to this day it constantly serves as the starting-point whenever a handicraft or a manufacture is turned into an industry carried on by machinery."[88]

The introduction of this machinery meant that the dehumanized individual worker was no longer the focus of the process of production, but had become merely an appendage, an accessory, whose task was to make sure, from within the machine, that it was operating properly: "The machine, which is the starting-point of the industrial revolution, replaces the worker, who handles a single tool, by a mechanism operating with a number of similar tools and set in motion by a single motive power, whatever the form of that power. Here we have the machine, but in its first role as a simple element in production by machinery. An increase in the size of the machine and the number of its working tools calls for a more massive mechanism to drive it; and this mechanism, in order to overcome its own inertia, requires a mightier moving power than that of man, quite apart from the fact that man is a very imperfect instrument for producing uniform and continuous motion."[89] In fact, the task of operating nineteenth-century machinery required none of the attributes of male workers of the past, such as skill, brute strength and so forth. On the contrary, it required that workers be weak, slim, and capable of executing repetitive tasks without thinking: "In so far as machinery dispenses with muscular power, it becomes a means for employing workers of slight muscular strength, or whose bodily development is incomplete, but whose limbs are all the more supple. The labour of women and children was therefore the first result of the capitalist application of machinery! That mighty substitute for labour and for workers, the machine, was immediately transformed into a means for increasing the number of wage-labourers by enrolling, under the direct sway of capital, every member of the worker's family, without distinction of age or sex."[90]

According to Marx, the diminutive and degrading status of the human worker next to the machine was a key feature of capitalism. But there is nothing in the above passages, which is the *necessary consequence* of capitalism. In fact, all of Marx's observations apply to manufacturing, the concentration of work in factories, the elaboration of the factory system and automated processes, including the creation of machines by other machines. And these features, being typical of manufacturing, could be just as much a part of communist manufacturing as capitalist manufacturing. Except that Marx predicted this was not to be the case, without ever explaining how or why. Experience in communist countries has proven Marx wrong in this respect!

One has the sense, in Marx, that the machine is invested with a personal identity, with mechanical intelligence. Since the machinery was constantly in motion, there had to be a prime mover, and this prime mover was an automaton. In the *Grundrisse*, for example, he noted that "...once adopted into the production process of capital, the means of labour passes through different metamorphoses, whose culmination is the machine, or rather, an automatic system of machinery (system of machinery: the automatic one is merely its most complete, most adequate form, and alone transforms machinery into a system), set in motion by an automaton, a moving power that moves itself; this automaton consisting of numerous mechanical and intellectual organs, so that the workers themselves are cast merely as its conscious linkages."[91]

The automaton of Marx's rather frightening observation resembles Hobbes' *Leviathan* in some respects – particularly in the sense that it had a sort of metallic life, had mechanical and intellectual organs, and served as a framework or network in which the workers played subservient roles, running back and forth. The power of this automaton was to regulate the movement of machinery: "The worker's activity, reduced to a mere abstraction of activity, is determined and regulated on all sides by the movement of the machinery, and not the opposite. The science which compels the inanimate limbs of the machinery, by their construction, to act purposefully, as an automaton, does not exist in the worker's consciousness, but rather acts upon him through the machine as an alien power, as the power of the machine itself. The appropriation of living labor by objectified labour – of the power or activity which creates values by value existing for-itself – which lies in the concept of capital, is posited, in production resting on machinery, as the character of the production process itself, including its material elements and its material motion. The production process has ceased to be a labour process in the sense of a process dominated by labour as its governing entity. Labour appears, rather, merely as a conscious organ, scattered among the individual living workers at numerous points of the mechanical system; subsumed under the total process of the machinery itself, as itself only a link of the system, whose unity exists not in the living workers, but rather in the living (active) machinery, which confronts his individual, insignificant doings as a mighty organism."[92]

It was in *Capital* that Marx depicted the monstrous, demonic, gigantic, feverish and whirling character of machinery and large-scale industry: "An organized system of machines to which motion is communicated by the transmitting mechanism from an automatic center is the most developed form of production by machinery. Here we have, in place of the isolated machine, a mechanical monster whose body fills whole factories, and whose demonic power, at first hidden by the slow and measured motions of its gigantic members, finally burst forth in the fast and feverish whirl of its countless organs."[93]

Since nineteenth-century machines were being used to construct other machines, Marx feared that they would make the worker even more redundant than before, a development he used mythical language to denounce: "At the same time as machine production was becoming more general, in the first decades of the nineteenth century, it gradually took over the construction of the machines themselves. But it is only during the last few decades that the construction of railways and ocean steamers on a vast scale has called into existence the Cyclopean machines now employed in the construction of prime movers."[94]

The fact that machines could produce other machines was a devastating development for Marx. He resented the way superior technology inevitably drove old handicrafts and manufacture into the ground, giving industrial capitalism the ferocious power to extend itself indefinitely: "...as soon as the factory system has attained a reasonable space to exist in, and reached a definite degree of maturity, and in particular as soon as the technical basis peculiar to it, machinery, in itself produced by machinery, as soon as coal-mining and iron-mining, the metallurgical industries, and the means of transport have been revolutionized; in short, as soon as the general conditions of production appropriate to large-scale industry have been established, this mode of production acquires an elasticity, a capacity for sudden extension by leaps and bounds, which comes up against no barriers but those presented by the availability of raw materials and the extent of sales markets."[95]

For the individual worker, meanwhile, factory work was exhausting, deadening, a form of mental and physical torture; it was devoid of content and therefore meaningless.[96] This drudgery was made all the more odious, since the worker had no recourse but to work ever-longer days in ever-more intense conditions; he or she was subject to arbitrary punishments, fines, deductions and other abusive treatment, and had no economic choice (and therefore no freedom) but to accept the insecure conditions of factory employment.[97]

As Marx wrote in the second volume of *Capital*, published in 1885, capitalist commodity production led to the "gigantic extension of technique" which dehumanized the worker even further: "All pursuit of commodity production becomes at the same time pursuit of the exploitation of labour-power; but only capitalist commodity production is an epoch-making mode of exploitation, which in the course of its historical development revolutionizes the entire economic structure of society by its organization of the labour process and its gigantic extension of technique, and towers incomparably above all earlier epochs."[98]

While he slammed nineteenth-century capitalism for its excesses, he relegated to a mere footnote (!) the comment that the communist factory system would be completely different: "Since the division of the day's labour into necessary labour and surplus labour differs in different countries, and even in the same country at different periods, or in different branches of industry; and further, since the actual wage of the worker sometimes sinks below the value of his labour-power, and sometimes rises above it, it is possible for the difference between the price of the machinery and the price of the labour-power replaced by that machinery to undergo great variations, while the difference between the quantity of labour replaced by it remains constant. --- footnote: The field of application for machinery would therefore be entirely different in a communist society from what it is in bourgeois society."[99]

Marx was trying to establish something important: *that the machine was becoming the measure of all things.* This development came as a shock in the nineteenth century. Ever since the time of Protagoras, there had existed at least a current of thought, taken up by Renaissance humanists, according to which *man was the measure of all things.* If the machine was becoming the measure instead, that could only mean that it was displacing, pushing aside, replacing man himself, forcing man to live and work within the vast new mechanical framework of technology. In this apprehension, Marx was doubtless right. But he was dead wrong in asserting that this new development was a *necessary* feature of capitalism, while it would be *unknown* under communism. If anything, the machine became even more powerful under communism.

It may be objected that Marx was attacking the alienation and dehumanization of machine-like man under nineteenth-century capitalism, rather than proposing a new machine-like existence for man under communism. However, capitalism was being reformed in his own day, whereas for Marx the process of transition to communism was irreversible and could not be appealed. He condemned the *circumstantial* machine-like wage slaves of capitalism to become *perpetual* machine-like slaves in the communist future.

Moreover, his dismissal of the Declaration of the Rights of Man and the Citizen as "bourgeois" and "egoistical" meant that life under communism would necessarily exclude the most elementary individual rights: being born and remaining free and equal in rights, and enjoying natural and imprescriptible rights to Liberty, Property, Safety and Resistance to Oppression. Instead, communism would create social proletarian machine-like beings, subject to the dictates of an abstract, faceless dictatorship – theoretically the dictatorship of the proletariat, but practically a dictatorship of communist intellectuals.

Underlying Marx's vision was a string of perverse equations – a habit of mind that may have found its origin in Hegel's philosophy of identity.[100] His equation of the ruling communist clique with the ruling political party ended up concentrating total power in the hands of the few. His equation of the ruling political party with the State made it practically impossible, once communists came into power, to dismiss the party or to reform the political system itself. His equation of control over the means of production (by the ruling communist clique) with control over society as a whole ensured that the individual, whether proletarian, intellectual or otherwise, was more of a cog than ever before. Indeed, under communism, the individual was doomed to be virtually a slave in the monolithic mechanism of a vast Automated State, which wielded total power over the means of production, and therefore over technology.

Marx believed that he was solving the "riddle" of history. He cast this solution in supposedly scientific terms, by undertaking a painstaking economic analysis of material conditions. During the nineteenth century, when science in Europe seemed poised to overthrow revealed religion, Marx's repeated references to science gave his theories an aura of intellectual permanence and legitimacy. At the same time, he saw reality through the distorted lens of Hegel, who had pictured history as a rational process consisting of abstracted rational patterns leading to a non-historical abstraction located in a prophesied future. This appeal to historicism meant that Marx's critique was invested with historical evidence crammed into broad patterns, while his prophecy – the beatific future end that justified the revolutionary means – could be presented as the inescapable culmination of all history. Since it lay in the future, no evidence could be offered to support it, and for faithful Marxians, Marxists and anyone else who followed in his footsteps, none was needed.

He criticized Europe's unrestrained nineteenth century capitalism in every respect, to the point of demonizing it. He launched shrill, abusive and sarcastic attacks on any variety of socialism outside of the narrow parameters of communism. He singled out the growth of technology as one of the key features and problems of capitalism, since it so often displaced human employment, and ended up dehumanizing man, turning him into a machine-like instrument. At the same time, Marx affirmed that communism would be superior to capitalism, basing this affirmation on anecdotes and abstract theories. This assumption is all the more surprising, in our eyes, since Marx believed that once ownership of the means of production was transferred from concrete capitalist individuals to the more abstract universal communist society, a qualitative change for the better would come about – a change of which proletarians would be the leading beneficiaries.

But the fulfillment of this destructive vision depended on propaganda, agitation, revolutionary opportunism and violence. This explains why Marx devoted considerable energies to expose and exacerbate tensions, to inflame passions and exploit frustration, to propagate class hatred and perpetrate exasperation – particularly during the Paris Commune of 1871, but in varying degrees up to his death in London in 1883. Instead of seeking to reform the more oppressive aspects of unrestrained capitalism, he rejected them outright, simply because rejection would fuel the fire of the coming revolution. This explains why he relied on violent revolution itself to break any link between the working class and its previous historical experience.

Yet Marx's purely materialist view of history, focusing on economic relations, is an inappropriate framework for understanding history. People do not always necessarily act according to their material class interests. The proletariat has class interests as well as a national identity, and is no more likely to disappear into a faceless, "universal" existence than any other group of society. Besides, Marx never explained how the communist system, if it was to be the fulfillment of history, could ever be reformed, reversed, changed or abandoned. He never envisaged what would come *after* communism.

A final obvious question raised by Marx's works is whether the violent overthrow, through revolution, of an entire existing social order is *worth it?*

Judging by the example of the French Revolution, which resulted in between 600,000 and 800,000 deaths,[101] one would have to say that violent revolution is not worth it. Even if the French Revolution had not taken place, Alexis de Tocqueville (1805-1859) noted, "The old social structure would nonetheless have been shattered everywhere sooner or later. The only difference would have been that instead of collapsing with such brutal suddenness it would have crumbled bit by bit. At one fell swoop, without warning, without transition, and without compunction, the Revolution effected what in any case was bound to happen, if by slow degrees."[102] Besides, the French Revolution left a vacuum, which was filled by an unstable succession of failed monarchs, revolutions and republics. Yet, from Marx's point of view, the French Revolution did not go far enough, since it "abolished feudal property in favour of bourgeois property."[103] In any case, he found a convenient way of dismissing revolutions not his own: they were turned to the past, not the future.[104]

There remains the question of long-term consequences of Marx's ideology. The total number of deaths attributable to Russian communism from the October Revolution to the end of Stalinism has been estimated at between 42 and 60 million.[105] The total number of deaths attributable to Chinese communism between 1949 and 1987 has been officially set at 80 million, while dissidents place the figure at 160 million.[106] Another estimate of the deaths attributable to communism (including Viet Nam, North Korea, Cambodia, Eastern Europe, Latin America, Africa and Afghanistan) puts the total number at close to 100 million.[107]

This grim litany of death is only one aspect of the destructive character of Marx's ideology. He enshrined communism as the culmination of History, and for this reason, once communists achieved total power, they made life unliveable for hundreds of millions of people: the State became a prison, like the Soviet Union, a slave-colony, like Poland, or it became a hermetically sealed world-unto-itself, like China or Albania in the 1960s. Revolutionary violence within the communist State was renewed; deviations from Marx's prophecy were condemned as "bourgeois" or "reactionary", since the future course of history had already been determined; property was expropriated; communist economies smothered innovation, stifled individual initiative, failed to satisfy normal demand for practical products, and flooded the market with products nobody wanted. Many features of twentieth-century communist regimes – from violence and terror to mind control and the wholesale destruction of social institutions – can be traced directly back to Karl Marx – the moralizing, revolutionary prophet of Trier.

Marx denounced the negative effects of capitalism and technology, because they turned *some members of society into dispossessed machine-like cogs in the automated factory.* But he sought only to redirect these negative effects, by creating the theoretical basis for a system that transferred abstract ownership of the means of production to the proletariat. In reality, this guaranteed, in turn, that *all members of society would be equally dispossessed machine-like cogs under an Automated State.* By a curious series of equations, the proletariat's abstract ownership of the means of production supported the concentration of total State power in the hands of a group of intellectuals, like Marx, who would tightly hold the reins of the Communist Party.[108] Marx defined political and economic relations, couching in pseudo-scientific language his claim that communism was the inevitable and ultimate fulfillment of every historical process since the dawn of time.

While he was right in objecting that the machine in his day was becoming the measure of all things, he was wrong in assuming that he had solved the "riddle" of History: in fact, Marx inspired an absolute form of class tyranny, dominated by communists themselves, a tyranny that is still with us, in various parts of the globe.

[1] According to G.V. Plekhanov, d'Holbach was an absolutist in matters of politics, a republican in religious affairs, and someone who held the contradictory belief that man was the product of social environment, which was, in turn the product of public opinion. *Essays in the History of Materialism*, pp. 3-75.

[2] Writing during the Second World War, Sir Karl Popper traced many of the most pernicious aspects of Marxism to Plato and Hegel in *The Open Society and its Enemies* (Princeton, 1966). One puzzling aspect of the work is that Popper wrote it as a way of exposing the dangers of Marxism, yet he was far more muted in his condemnation of Marx than of either Plato or Hegel.

[3] This influence on Marx is perhaps most evident in his *Notebooks on Epicurean Philosophy* and in his 1841 doctoral dissertation, *The Difference between the Democritean and the Epicurean Philosophy of Nature.*

[4] Marx and Engels wrote of the importance of French materialism in *The Holy Family* (Moscow, 1956) and *The German Ideology* (New York, 1998), hereafter referred to as *HF* and *GI* respectively. In the first of these works, written in 1844, they explicitly linked La Mettrie and d'Holbach to communism: "In Lamettrie's works we find a combination of Descartes' system and English materialism. He makes use of Descartes' physics in detail. His *Man Machine* is a treatise after the model of Descartes' beast-machine. The physical part of Holbach's *Système de la Nature, ou des lois du monde physique et du monde moral* is also a result of the combination of French and English materialism.... As Cartesian materialism merges into natural science proper, the other branch of French materialism leads direct to socialism and communism. There is no need of any great penetration to see from the teaching of materialism on the original goodness and equal intellectual endowment of men, the omnipotence of experience, habit and education, and the influence of environment on man, the great significance of industry, the justification of enjoyment, etc., how necessarily materialism is connected with communism and socialism." *HF*, p. 175.

[5] For example, Adam Smith wrote "When any expensive machine is erected, the extraordinary work to be performed by it before it is worn out, it must be expected, will replace the capital laid out upon it, with at least the ordinary profits. A man educated at the expense of much labour and time to any of those employments which require extraordinary dexterity and skill, may be compared to one of those expensive machines. The work which he learns to perform, it must be expected, over and above the usual wages of common labour, will replace to him the whole expense of his education, with at least the ordinary profits of an equally valuable capital." Adam Smith, *The Wealth of Nations* (Chicago, London & Toronto, 1952), Ch. X, Pt. 1, pp. 42-43.

[6] According to Marx, "Ricardo in his book [*On the Principles of Political Economy, and Taxation*] (rent of land): Nations are merely workshops for production, and man is a machine for consuming and producing." *Economic and Philosophic Manuscripts* in Karl Marx, *Early Writings*, translated by Rodney Livingstone and Gregor Benton (Harmondsworth, 1975), p. 306. *Early Writings* hereafter referred to as *EW*.

[7] In *La physiologie sociale*, Saint-Simon wrote that "France has become a great factory, and the French nation a great workshop. This general factory must be run in the same manner as individual factories. The primary task of these latter factories is first of all to establish manufacturing processes, and then to combine the interests of owners and workers, on the one hand and on the other with those of consumers." Moreover, "Society is not a simple agglomeration of living beings whose independent actions have no finality other than the arbitrary character of individual desires, and no result other than ephemeral accidents of no importance. Society, on the contrary, is above all a true and well-organized machine, whose parts all contribute in a distinct manner to the working of the whole." Henri de Saint-Simon, *La physiologie sociale: oeuvres choisies*, edited by Georges Gurvitch (Paris, 1965), pp. 139 and 57. Our translation.

[8] Where Hegel singled out the Prussian bureaucracy as the universal class directing the future course of the State, Marx singled out the proletariat as the universal class. In many respects, Marx adopted Hegel's speculative philosophy of history, which detected broad patterns in the rise, development and fall of civilizations, and a belief in the arrow-like future direction of progress. In this latter respect, Marx was heir to a venerable tradition starting with Polybius, continuing through St. Augustine, Joachim de Fiore and Ibn Khaldun, and resurfacing in more recent times in the works of Giambattista Vico and the marquis de Condorcet. In the twentieth century, Oswald Spengler and Arnold Toynbee revived this tradition. The speculative philosophy of history invests heavily in the symbolic value of historical events, and in so doing it commits anachronisms. It oversimplifies events in the interest of

identifying parallels between utterly different types of societies (or civilizations), which are telescoped together, even though they may have existed several thousand years apart.

[9] His works contain many references to the French Revolution, as well as to the proponents of "crude communism" such as Étienne Cabet and Pierre Joseph Proudhon.

[10] Two interesting contemporary sources on the role of prophecy in Marx are: Bernard Cazes, *Histoire des futurs: les figures de l'avenir de saint Augustin au XXIe siècle* (Paris, 1986), and Jean Delumeau, *Une histoire du paradis*, vol. II : *Mille ans de bonheur* (Paris, 1995).

[11] According to Mircea Eliade, Marx's view that a classless society would bring an end to all historic tensions found a parallel in the myth of the Golden Age at the cosmic beginning and end of History: "Marx enriches this age-old myth with a whole Judeo-Christian messianic ideology; on the one hand, the prophetic role and soteriological function it conferred on the proletariat; on the other the final struggle between Good and Evil, which can easily be likened to the apocalyptic conflict between Christ and the Antichrist, leading to the definitive victory of Christ." *Mythes, rêves et mystères* (Paris, 1957), p. 24. Our translation.

[12] Marx's scientism can be likened to that of Comte and Renan. Tom Sorrell defined scientism as the idea that "science, natural science, is much the most valuable part of human learning – much the most valuable part because it is much the most authoritative, or serious, or beneficial." Tom Sorrell, *Scientism: Philosophy and the Infatuation with Science* (London and New York, 1991), p. 1.

[13] It has often been compared, both in its intensity and absolute terror, to its mirror ideology, fascism. For example, Ernst Nolte wrote "Fascism is anti-Marxism which seeks to destroy the enemy by the evolvement of a radically opposed and yet related ideology and by the use of almost identical and yet typically modified methods, always, however, within the unyielding framework of national self-assertion and autonomy. This definition implies that without Marxism there is no fascism, that fascism is at the same time closer to and further from communism than is liberal anti-communism, that it necessarily shows at least an inclination toward a racial ideology, that fascism should never be said to exist in the absence of at least the rudiments of an organization and propaganda comparable to those of Marxism." Ernst Nolte, *Three Faces of Fascism* (New York, 1969), p. 40.

[14] There is an interesting discussion of the influence of Heraclitus on Plato and Hegel in Popper, *op. cit.*, vol. I, pp. 11-17 & 203.

[15] As Marx and Engels wrote in 1845-6 in *The German Ideology*: "Further, it follows that every class which is aiming at domination, even when its domination, as in the case of the proletariat, leads to the abolition of the old form of society in its entirety and of domination in general, must first conquer political power in order to represent its interest in turn as the general interest, which is the first moment it is forced to do so." *GI*, p. 52-53.

[16] Marx, *Capital*, translated by Benjamin Fowkes and David Fernbach (Harmondsworth, 1977-1981), vol. I, p. 799

[17] As will be obvious from the tone of this chapter, it is not based on a reading of Marx and Engels alone, but also on the author's first-hand observations in many Communist countries, where the theories of Marx and Engels were applied, such as the former Yugoslavia, the former Soviet Union, the former Czechoslovakia, Poland, the former East Germany and China.

[18] *Capital*, vol. I, p. 532, quoting from Aristotle, *Politics*, Book I, Chapter 4, p. 447. But Marx seems to have taken this quote out of context, applying it not to the instrumentality, i.e. the uses of various features of the economy, as Aristotle had done, but to the capitalist's exploitation of capital.

[19] Friedrich Engels, *Condition of the Working Class in England* (Harmondsworth, 1987), pp. 52-53. Hereafter referred to as *CWCE*.

[20] *CWCE*, p. 207.

[21] "The simplification of machinery and of labour is used to make workers out of human beings who are still growing, who are completely immature, out of children, while the worker himself becomes a neglected child. The machine accommodates itself to man's weakness, in order to turn weak man into a machine. The fact that the multiplication of needs and of the means of fulfilling them gives rise to a lack of needs and of means is proved by the political economist (and by the capitalist – we invariably mean empirical businessmen when we refer to political economists, who are the scientific exposition and existence of the former) in the following ways: (1) By reducing the workers' needs to the paltriest minimum necessary to maintain his physical existence and by reducing his activity to the most abstract mechanical movement. In so doing, the political economist declares that man has no other needs,

either in the sphere of activity or in that of consumption. For even this life he calls human life and human existence. (2) By taking as his standard – his universal standard, in the sense that it applies to the mass of men – the worst possible state of privation which life (existence) can know. He turns the worker into a being with neither needs nor senses and turns the worker's activity into a pure abstraction from all activity. Hence any luxury that the worker might enjoy is reprehensible, and anything that goes beyond the most abstract need – either in the form of passive enjoyment or active expression – appears to him as a luxury. Political economy, this science of wealth, is therefore at the same time the science of denial, of starvation, of saving, and it actually goes so far as to save man the need for fresh air or physical exercise."
Economic and Philosophical Manuscripts in *EW*, p. 360.
22 *Ibid.*, p. 360.
23According to Engels, "With these inventions, since improved from year to year, the victory of machine-work over hand-work in the chief branches of English industry was won; and the history of the latter from that time forward simply relates how the hand-workers have been driven by machinery from one position after another. The consequences of this were, on the one hand, a rapid fall in price of all manufactured commodities, prosperity of commerce and manufacture, the conquest of nearly all the unprotected foreign markets, the sudden multiplication of capital and national wealth; on the other hand, a still more rapid multiplication of the proletariat, the destruction of all property-holding and of all security of employment for the working class, demoralization, political excitement, and all those facts so highly repugnant to Englishmen in comfortable circumstances, which we shall have to consider in the following pages. Having already seen what a transformation in the social condition of the lower classes a single jenny had wrought, there is no cause for surprise as to that which a complete and interdependent system of finely adjusted machinery has brought about, machinery which receives raw material and turns out woven goods." *CWCE*, p. 54-55
24 *Ibid.*, p. 54.
25 *Ibid.*, pp. 159-160.
26 Karl Marx, *Grundrisse (Foundation of the Critique of Political Economy – Rough Draft),* translated by Martin Nicolaus (Harmondsworth, 1973), p. 693.
27 Marx pursued this subject further in *Capital*, vol. I, pp. 468-469.
28 *Ibid.*, p. 506.
29 *Ibid.*, p. 548.
30 *Ibid.*, p. 547.
31 His works contain countless references to contemporary sources, whether parliamentary debates, public health reports, government reports, newspaper articles, sermons by ministers or the works of other economists, exposing the deplorable conditions of the working class. Most of these sources favoured reform, rather than revolution. It is ironic that Marx's authority was partly derived from the published evidence he quoted, about the flaws of capitalism. Publication of this sort of evidence would be prohibited under communism.
32 One has only to consider Gustave de Beaumont's *Marie: or Slavery in the United States* (1835), Beaumont and Alèxis de Tocqueville's *On the Penitentiary System in the United States* (1833), Tocqueville's *Democracy in America and his Journeys to England and Ireland*, (1835 and 1833-35) and English working class novels by Charles Dickens such as *Oliver Twist* (1837-39). Neither Marx nor Marxists participated in some of the great emancipations of oppressed peoples in the mid-nineteenth century, emancipations which have had long-lasting effects: the abolition of slavery throughout the British Empire; the war against slavery in the United States; the campaign against white slavery; the evangelical movement in Britain to educate the poor; the movement to reform European and North American prisons in order to improve living conditions for those incaracerated; the movement to remove property qualifications for voters; the movement to increase individual liberties within the framework of a stable State which was subject to reform; the movement to allow periodic, peaceful changes of government by means of representative parliamentary institutions.
33 Benjamin Constant and John Stuart Mill are examples of early nineteenth-century liberal thinkers who proposed to resolve problems through parliamentary institutions and reform, whereas Marx promoted fiery revolutionary violence.
34 For example, Engels wrote in *Conditions of the Working Class in England*: "While bemoaning the demoralization of the lower classes, they [the English Socialists] are blind to the element of progress in this dissolution of the old social order, and refuse to acknowledge that the corruption wrought by

private interests and hypocrisy in the property-holding class is much greater. They acknowledge no historic development, and wish to place the nation in a state of Communism at once, overnight, instead of continuing political action until the goal is won and the movement can dissolve. They understand, it is true, why the working man is resentful against the bourgeoisie, but regard as unfruitful this class hatred, which is, after all, the only moral incentive by which the worker can be brought nearer the goal. They preach instead a philanthropy and universal love far more unfruitful for the present state of England. They acknowledge only a psychological development, a development of man in the abstract, out of all relation to the past, whereas the whole world rests upon that past, the individual man included. Hence they are too abstract, too metaphysical, and accomplish little." *CWCE*, p. 243.

[35] This ambiguity has often been noted. Whereas we see Marx as moralist, revolutionary and prophet, George Sabine referred to Marx's double role: "This union in Marx of a program of revolutionary action with a philosophical theory of the necessary course of social development has been a standing puzzle to commentators. Unsympathetic critics have usually divided the two and described, first, Marx the social philosopher and, second, Marx the founder of party-socialism.... It seems certain that Marx himself had no consciousness of playing a double role. The necessity that he attributed to history was like Hegel's in that it invited cooperation and participation; a theory of party tactics was its natural supplement. For both Hegel and Marx the secret of this union was believed to lie in the dialectic." George Sabine, *A History of Political Theory*, p. 684. Likewise, Frederick Copleston noted, "Marxism is indeed a living philosophy in the sense that it inspired and gave impetus and coherence to a force which, for good or ill, exercises a vast influence in the modern world. It is accepted, doubtless, with varying degrees of conviction, by a great many people today. At the same time it is arguable that its continued life as a more or less unified system is primarily due to its association with an extra-philosophical factor, a powerful social-political movement, the contemporary importance of which nobody would deny." Frederick Copleston, *A History of Philosophy*, vol. VII, p. 305.

[36] *The Communist Manifesto*, p. 87. Hereafter referred to as *CM*.

[37] *CM*, pp. 87-8.

[38] *Ibid.*, p. 99.

[39] *Ibid.*, pp. 120-121.

[40] Terrell Carver, "Reading Marx: Life and works" in Terrell Carver (ed.) *The Cambridge Companion to Marx* (Cambridge, 1991), p. 5.

[41] As examples of flawed prophecy, we may note here Marx's prophecies that: communism will succeed capitalism; communism will be an obviously superior stage of historical development compared to capitalism; the revolution is coming to nineteenth-century England; the revolution is coming to nineteenth-century Germany; under capitalism, the worker will never profit from his products, from which he is alienated; workers will necessarily be happier and more productive under communism; the proletariat will necessarily want to put an end to private property, social classes, the rights of man, the individual "as a self-sufficient monad", religion, the family, the State, law and morality; communism will enshrine the dictatorship of the proletariat; communism will succeed in being a universal society of equality, happiness and a balanced economy, in which the proletariat will find fulfillment; under communism, the relationship of man to machine will be fundamentally improved; man will be a social being under communism, and will no longer know exploitation, oppression, social vices, and will no longer be subject to higher classes concentrating wealth, power and opportunity in their hands; the mass destruction of human lives, material wealth and social institutions through violent revolution will have no consequences for society *worth mentioning*; the despotic police state is the true model for capitalism, not communism. One of the most obviously fallacious communist prophecies is contained in Engels' *Conditions of the Working Class in England*: "Prophecy is nowhere so easy as in England, where all the component elements of society are clearly defined and sharply separated. The revolution must come; it is already too late to bring about a peaceful solution; but it can be made more gentle than that prophesied in the foregoing pages. This depends, however, more upon the development of the proletariat than upon that of the bourgeoisie. In proportion as the proletariat absorbs socialistic and communistic elements, will the revolution diminish in bloodshed, revenge and savagery. Communism stands, in principle, above the breach between bourgeoisie and proletariat, recognizes only its historic significance for the present, but not its justification for the future: wishes, indeed, to bridge over this chasm, to do away with all class antagonisms. Hence it recognizes as justified, so long as the struggle exists, the exasperation of the

proletariat towards its oppressors as a necessity, as the most important lever for a labour movement just beginning; but it goes beyond this exasperation, because Communism is a question of humanity and not of the workers alone." *CWCE*, p. 291

[42] *CM*, p. 104.

[43] *Ibid.*, p. 105.

[44] There is a long discussion of the *Declaration of the Rights of Man and the Citizen* in *On the Jewish Question*, which Marx wrote in 1843. [*EW*, p. 227]: "Let us consider for one moment these so-called rights of man. Let us consider them in their most authentic form – the form they have among those who discovered them, the North Americans and the French! These rights of man are partly political rights, rights which are only exercised in community with others. What constitutes their content is participation in the community, in the political community or state. They come under the category of political freedom, of civil rights, which as we have seen by no means presupposes the consistent and positive abolition of [*EW*, p. 228] religion and therefore of Judaism... The incompatibility of religion with the rights of man is so alien to the concept of the rights of man that the right to be religious – to be religious in whatever way one chooses and to practise one's chosen religion – is expressly enumerated among the rights of man. The privilege of faith is a universal right of man. The rights of man as such are distinguished from the rights of the citizen. Who is this man who is distinct from the citizen? None other than the member of civil society. Why is the member of civil society simply called 'man' and why are his rights called [*EW*, p. 229] the rights of man? How can we explain this fact? By the relationship of the political state to civil society, by the nature of political emancipation. The first point we should note is that the so-called rights of man, as distinct from the rights of the citizen, are quite simply the rights of the member of civil society, i.e. of egoistic man, of man separated from other men and from the community.... Liberty is therefore the right to do and perform everything, which does not harm others. The limits within which each individual can move without harming others are determined by law, just as the boundary between two fields is determined by a stake. The liberty we are here dealing with is that of man as an isolated monad who is withdrawn into himself.... But the right of man to freedom is not based on the association of man with man but rather on the separation of man from man. It is the right of this separation, the right of the restricted individual, restricted to himself. The practical application of the right of man to freedom is the right of man to private property.... The right to private property is therefore the right to enjoy and dispose of one's resources as one wills, without regard for other men and independently of society: the right of self-interest. The individual freedom mentioned above, together with this application [*EW*, p. 230] of it, forms the foundation of civil society. It leads each man to see in other men not the realization but the limitation of his own freedom. But above all, it proclaims the right of man 'to enjoy and dispose at will of all his goods, his revenues and the fruit of his industry.' There remain the other rights of man, equality and security. Equality, here in its non-political sense, simply means equal access to liberty as described above, namely that each man is equally considered to be a self-sufficient monad.... The concept of security does not enable civil society to rise above its egoism. On the contrary, security is the guarantee of its egoism. Therefore not one of the so-called rights of man goes beyond egoistic man, man as a member of civil society, namely an individual withdrawn into himself, his private interest and his private desires and separated from the community... It is a curious thing that a people which is just beginning to free itself, to tear down all the barriers between the different sections of the people and to found a political community, that such a people should solemnly proclaim the rights of egoistic man, separated from his fellow men and from the community..."

[45] *Ibid.*, p. 229. See preceding footnote for the exact quote from Marx.

[46] For example, in 1843-4, Marx wrote in his *Contribution to the Critique of Hegel's Philosophy of Right, Introduction*: "Religious suffering is at one and the same time the expression of real suffering and a protest against real suffering. Religion is the sigh of the oppressed creature, the heart of a heartless world and the soul of soulless conditions. It is the opium of the people. The abolition of religion as the illusory happiness of the people is the demand for their real happiness. To call on them to give up their illusions about their conditions is to call on them to give up a condition that requires illusions." *EW*, p. 244.

[47] In 1844, Marx wrote in the *Economic and Philosophical Manuscripts*: "It is easy to see how necessary it is for the whole revolutionary movement to find both its empirical and its theoretical basis in the movement of private property or, to be more exact, of the economy. This material, immediately sensuous private property is the material, sensuous expression of estranged human life. Its movement

– production and consumption – is the sensuous revelation of the movement of all previous production, i.e. the realization or reality of man. Religion, the family, the state, law, morality, science, art, etc. are only particular modes of production and therefore come under its general law. The positive supersession of private property, as the appropriation of human life, is therefore the positive supersession of all estrangement, and the return of man from religion, the family, the state, etc. to his human, i.e. social existence. Religious estrangement as such takes place only in the sphere of consciousness, of man's inner life, but economic estrangement is that of real life – its supersession therefore embraces both aspects." *EW*, p. 348-349.

[48] In 1845-6, Marx and Engels wrote in *The German Ideology*, "… the proletarians, if they are to assert themselves as individuals, have to abolish the hitherto prevailing condition of their existence (which has, moreover, been that of all society up to then), namely, labour. Thus they find themselves directly opposed to the form in which, hitherto, the individuals, of which society consists, have given themselves collective expression, that is, the state; in order, therefore, to assert themselves as individuals, they must overthrow the state." *GI*, p. 88.

[49] Marx and Engels wrote in *The Communist Manifesto* that "in bourgeois society capital is independent and has individuality, while the living person is dependent and has no individuality. And the abolition of this state of things is called by the bourgeois, abolition of individuality and freedom! And rightly so. The abolition of bourgeois individuality, bourgeois independence and bourgeois freedom, is undoubtedly aimed at." *CM*, p. 98.

[50] His early works contain many appeals to violence, for example in his repeated call to arms, in his contention that the highly destructive French Revolution did not go far enough, and in such observations as the following, made on the defeat of June 1848: "Finally, with the victories of the Holy Alliance Europe has assumed a form in which any new proletarian uprising in France will immediately coincide with a *world war*. The new French revolution will be forced to leave its natural soil immediately and to *conquer the European* terrain, on which alone the social revolution of the nineteenth century can be carried out." *Political Writings*, edited by David Fernbach (New York, 1974), vol. II: *Surveys from Exile*, pp. 61-61. In 1871, Marx was still predicting (and justifying) violent revolution, as the following interview of July 18th 1871 in *World* indicates. "Reporter: It would seem that in this country [England] the hoped-for solution, whatever it may be, will be attained without the violent means of revolution. The English system of agitating by platform and press until minorities become converted into majorities is a hopeful sign. Dr. Marx: I am not so sanguine on that point as you. The English middle class has always shown itself willing enough to accept the verdict of the majority so long as it enjoyed the monopoly of the voting power. But mark me, as soon as it finds itself outvoted on what it considers vital questions we shall see here a new slave-owners war." This latter reference is the American civil war. See *Political Writings*, vol. III: *The First International and After*, p. 400. In the third volume of *Capital*, published after Marx's death, he predicted rather weakly that increasing automation of productive forces would lead to socialist revolution: "A development in the productive forces that would reduce the absolute number of workers, and actually enable the whole nation to accomplish its entire production in a shorter period of time, would produce a revolution, since it would put the majority of the population out of action. Here we have once again the characteristic barrier to capitalist production, and we see how this is in no way an absolute form for the development of the productive forces and the creation of wealth, but rather comes into conflict with this at a certain point in its development." (p. 372) Marx then went on to show how the resulting contradictions and crisis in capitalism would be accompanied by the development of conditions appropriate for revolution.

[51] In 1845-6, Marx and Engels wrote: "In history up to the present it is … an empirical fact that separate individuals have, with the broadening of their activity into world-historical activity, become more and more enslaved under a power alien to them (a pressure which they have conceived as a dirty trick on the part of the so-called world spirit, etc.), a power which has become more and more enormous and, in the last instance, turns out to be the world market. But it is just as empirically established that, by the overthrow of the existing state of society by the communist revolution … and the abolition of private property, which is identical with it, this power, which so baffles the German theoreticians, will be dissolved; and that then the liberation of each single individual will be accomplished in the measure in which history becomes wholly transformed into world history." *GI*, p. 59.

[52] In 1859, Marx offered an unconvincing defence of revolutionary destruction, claiming that the material conditions for the new epoch of society would already have ripened within the previous (corrupt) epoch: "No social order is ever destroyed before all the productive forces for which it is sufficient have been developed, and new superior relations of production never replace older ones before the material conditions for their existence have matured within the framework of the old society. Mankind thus inevitably sets itself only such tasks as it is able to solve, since closer examination will always show that the problem itself arises only when the material conditions for its solution are already present or at least in the course of formation. In broad outline, the Asiatic, ancient, feudal and modern bourgeois modes of production may be designated as epochs marking progress in the economic development of society." *Preface to A Contribution to the Critique of Political Economy* in *EW*, p. 426.

[53] Albert Camus, *The Rebel*, translated by Anthony Bower (New York, 1967), p. 166.

[54] Czesław Miłosz, *The Captive Mind*, translated by Jane Zielonko (New York, 1981), p. 214.

[55] *Ibid.*, p. 215.

[56] Aleksandr Solzhenitsyn, *The Gulag Archipelago*, translated by Thomas P. Whitney and Harry Willetts (New York, 1973-1976), vol. II, pp. 154-155.

[57] Stéphane Courtois et al., *Le livre noir du communisme: crimes terreur et repression* (Paris, 1997), p. 808.

[58] For example, in his 1972 foreword to the Penguin Classic edition of the *Grundrisse*, Martin Nicolaus wrote: "If Marx is right about the course of development then there will be a time in the far-distant future when materialist dialectics will be so universal an acquisition of the human race that its study and mastery will require no special effort, and its application in life will be as unremarkable as breathing." *Grundrisse*, p. 44.

[59] The communist attitude that "the end justifies the means" – in this case, the use of violence, terror and mind control – cannot lead to the formation of a perfect society, since what begins as corrupt and builds on this beginning will always remain corrupt. The key element in communist revolutions in the twentieth century was the overthrow of the old regime or liberation from it, rather than any true emancipation in a new State. The hope that in communist society there would be great material abundance was not confirmed by experience, and the belief that communist man was a new man perfecting himself turned out to be a vain dream – rather than contributing to the inner life of man, communism denies it.

As Machiavelli made clear in *The Prince*, once a régime comes to power through violence, it will always be easier and more natural for that regime to maintain power through violence – no other means is so effective. This is a problem with revolutionary regimes. Another, related problem is that where a regime feels it is the culmination of thousands of years of human and social development, one might almost say the fruit of toil and tumult, then it feels justified in controlling the minds and consciences of its citizens to that end, as well as the work of scholars, scientists and artists. So it does violence to the inner life as well as the outer life.

The bare fact of the communist revolution justifies whatever the revolutionary may do afterwards, and excuses him from having to be consistent in his political position and alliances. Since the seizure of power is the revolutionary's goal (and however he phrases his intentions, if he is in the elite group of revolutionaries, he hopes to exercise that power afterwards), this power is seen as good in itself, the more so if the revolutionary has a messianic view of himself. There are grave dangers inherent in such a way of looking at things, and people: often power by the people, for them and of them, becomes transformed into power over them, through them and against them.

Most people would like to feel they are good, and are in some way vital to society; thus leaders of commerce and industry say leaders are necessary, the educated middle-class feels that without its own existence the tide would not roll in, workers and farmers say that without them everything would grind to a halt. In the case of the revolutionary, he sees himself as fulfilling a very special role: if he is a communist, he is bringing his people that much closer to perfection. The personality cults of Lenin, Stalin, Mao, Kim Il-Sung and others is a logical extension of such a view. It is not only Big Brother who is watching you, but the Father of Modern Man who is guiding your human and social development. This worship of the hero, so prevalent in the twentieth century, goes against the original statement of Marx that "The proletarian movement is the self-conscious, independent movement of the immense majority, in the interests of the immense majority" – it goes against such an idea because the revolutionary hero is not simply a figure around which the forces of progress rally: he is saint, judge and Great Mover rolled into one.

[60] For Denys Turner, what Marx said on religion "means that there is no God; there is no room for God in the world and nothing at all outside of it. Religious belief claims are false." "Religion: illusions and liberation" in Terrell Carver (ed.), *The Cambridge Companion to Marx*, p. 323. Turner also quoted from Marx and Engels to the effect that: "The only service which can be rendered to God today is to declare atheism a compulsory article of faith and to ... prohibit ... religion generally." *Ibid.*, p. 322.

[61] It is peculiar to see Marx buttressing his totalitarian vision with quotations from some of the great humanist poets of the Christian and classical tradition, such as Dante, Shakespeare and Goethe. Such quotations had a rhetorical value, since they created the illusion that Marx was somehow in touch with the imaginative world of artistic creation, whereas the ideology he developed restricted creative liberty and sought to control the inner life of man.

[62] According to Popper, "Hegel's radical collectivism depends as much on Plato as it depends on Frederick William III, King of Prussia in the critical period during and after the French Revolution. Their doctrine is that the state is everything, and the individual nothing; for he owes everything to the state, his physical as well as his spiritual existence. This is the message of Plato, of Frederick William's Prussianism, and of Hegel. 'The Universal is to be found in the State,' Hegel writes. 'The State is the Divine Idea as it exists on earth... We must therefore worship the State as the manifestation of the Divine on earth, and consider that, if it is difficult to comprehend Nature, it is infinitely harder to grasp the Essence of the State... The State is the march of God through the world... The State must be comprehended as an organism.' This selection of utterances may suffice to show Hegel's Platonism and his insistence upon the absolute moral authority of the state, which overrules all personal morality, all conscience. It is, of course, a bombastic and hysterical Platonism, but this only makes more obvious the fact that it links Platonism with modern totalitarianism." *Op. cit.*, vol. II, p. 31.

[63] Hegel, *The Philosophy of History*, (New York, 1952), p. 315.

[64] *Ibid.*, p. 348.

[65] *Ibid.*, p. 369.

[66] *Ibid.*, pp. 156-157.

[67] *Karl Marx: Early Texts*, translated by David McLennan (Oxford, 1972), p. 13.

[68] David McLennan, *Marx Before Marxism* (New York, 1970), p. 60.

[69] *Critique of Hegel's Doctrine of the State*, *EW*, p. 80.

[70] *Economic and Philosophical Manuscripts, EW*, p. 348.

[71] *Economic and Philosophical Manuscripts, EW*, p. 385-386.

[72] In 1843, for example, Marx wrote in *Letters from the Franco-German Notebooks*: "The principle on which monarchy in general is based is that of man as despised and despicable, of dehumanized man; and when Montesquieu declares that its principle is honour he is quite in error. He attempts to make this plausible by distinguishing between monarchy, despotism and tyranny. But these names refer to a single concept denoting at best different modes of the same principle. Where the monarchical principle is in the majority, human beings are in the minority; where it is not called in question, human beings do not even exist." *EW*, p. 202-203.

[73] *On the Jewish Question, EW*, p. 213.

[74] It is striking how many times Hegel, in *The Philosophy of History*, referred to "destiny" and to "God" as natural features of historical processes.

[75] *EW*, p. 256.

[76] *Ibid.*, p. 257.

[77] "When socialist writers ascribe this historic role to the proletariat, it is not, as Critical Criticism pretends to think, because they consider the proletarians as gods. Rather the contrary. Since the abstraction of all humanity, even of the semblance of humanity, is practically complete in the full-grown proletariat; since the conditions of life of the proletariat sum up all the conditions of life of society today in their inhuman acuity; since man has lost himself in the proletariat, yet at the same time has not only gained theoretical consciousness of that loss, but through urgent, no longer disguisable, absolutely imperative need – that practical expression of necessity – is driven directly to revolt against that inhumanity; it follows that the proletariat can and must free itself. It cannot abolish the conditions of its life without abolishing all the inhuman conditions of life of society today which are summed up in its situation." *HF*, p. 52. The appeal to "abolish all the inhuman conditions of life of society today" is an open-ended appeal to total violence. Of course, this violence might not necessarily succeed in abolishing inhuman conditions, but would only create other inhuman conditions.

[78] *Ibid.*, p. 348.

[79] "In order to supersede the idea of property, the idea of communism is enough. In order to supersede property as it actually exists, real communist activity is necessary. History will give rise to such activity, and the movement which we already know in thought to be a self-superseding movement will in reality undergo a very difficult and protracted process. But we must look upon it as a real advance that we have gained at the outset an awareness of the limits as well as the goal of this historical movement and are in a position to see beyond it. When communist workmen gather together, their immediate aim is instruction, propaganda, etc. But at the same time they acquire a new need – the need for society – and what appears as a means has become an end. This practical development can be most strikingly observed in the gatherings of French socialist workers. Smoking, eating and drinking, etc., are no longer means of creating links between people. Company, association, conversation, which in turn has society as its goal, is enough for them. The brotherhood of man is not a hollow phrase, it is a reality, and the nobility of man is not a hollow phrase, it is a reality, and the nobility of man shines forth upon us from their work-worn figures." *Economic and Philosophical Manuscripts*, *EW*, p. 365.

[80] *Capital*, vol. I, p. 929

[81] *GI*, p. 60.

[82] Karl Marx, *Political Writings*, vol. I, *The Revolutions of 1848*, p. 341.

[83] *CWCE*, p. 69.

[84] "Hand-work is superseded by machine-work almost universally, nearly all operations are conducted by the aid of steam or water, and every year is bringing further improvements. In a well-ordered state of society, such improvements could only be a source of rejoicing; in a war of all against all, individuals seize the benefit for themselves, and so deprive the majority of the means of subsistence. Every improvement in machinery throws workers out of employment, and the greater the advance, the more numerous the unemployed; each great improvement produces, therefore, upon a number of workers the effect of a commercial crisis, creates want, wretchedness, and crime. Take a few examples. The very first invention, the jenny, worked by one man, produced at least sixfold what the spinning-wheel had yielded at the same time; thus every new jenny threw five spinners out of employment. The throstle, which, in turn, produced much more than the jenny, and like it, was worked by one man, threw still more people out of employment. The mule, which required yet fewer hands in proportion to the product, had the same effect, and every improvement in the mule, every multiplication of its spindles, diminished still further the number of workers employed. But this increase of the number of spindles in the mule is so great that whole armies of workers have been thrown out of employment." *CWCE*, pp. 159-160.

[85] *Ibid.*, pp. 218-219.

[86] "It has been already suggested that manufacture centralizes property in the hands of the few. It requires large capital with which to erect the colossal establishments that ruin the petty trading bourgeoisie, and with which to press into its service the forces of Nature, so driving the hand-labour of the independent workman out of the market. The division of labour, the application of water and especially steam, and the application of machinery, are the three great levers with which manufacture, since the middle of the last century, has been busy putting the world out of joint." *CWCE*, pp. 65-66.

[87] *Capital*, vol. I, pp. 468-469.

[88] *Ibid., Capital*, vol. I, p. 494.

[89] *Ibid.*, p. 497.

[90] *Ibid.*, p. 517.

[91] *Grundrisse*, p. 692.

[92] *Ibid.*, p. 693.

[93] *Capital*, vol. I, p. 503

[94] *Ibid.*, p. 506.

[95] *Ibid.*, p. 578.

[96] "Factory work exhausts the nervous system to the utmost; at the same time, it does away with the many-sided play of the muscles, and confiscates every atom of freedom, both in bodily and in intellectual activity. Even the lightening of the labour becomes an instrument of torture, since the machine does not free the worker from the work, but deprives the work itself of all content." *Ibid.*, 548.

[97] "Even at the present day, when the system is perfectly organized and its labour lightened to the utmost, it is found nearly impossible to convert persons past the age of puberty into useful factory hands. In the factory code, the capitalist formulates his autocratic power over his workers like a private legislator, and purely as an emanation of his own will, unaccompanied by either that division of responsibility otherwise so much approved of by the bourgeoisie, or the still more approved representative system. This code is merely the capitalist caricature of the social regulation of the labour process which becomes necessary in co-operation on a large scale and in the employment in common of instruments of labour, and especially of machinery. The overseer's book of penalties replaces the slave-driver's lash. All punishments naturally resolve themselves into fines and deductions from wages...." *Ibid.*, pp. 549-550.

[98] *Capital*, vol. II, p. 120.

[99] *Ibid.*, vol. I, p. 515.

[100] Popper wrote extensively on this subject: op. cit., vol. II, pp. 308-9, 393 & 395.

[101] *Quid*, p. 653.

[102] Alexis de Tocqueveille, *The Old Regime and the French Revolution*, translated by Stuart Gilbert (New York, 1955), p. 20.

[103] *CM*, p. 96.

[104] For example, in *The Eighteenth Brumaire of Louis Bonaparte*, Marx wrote that "an entire people thought it had provided itself with a more powerful motive force by means of a revolution; instead it suddenly found itself plunged back into an already dead epoch.... The social revolution of the nineteenth century can only create its poetry from the future, not from the past. It cannot begin its own work until it has sloughed off all its superstitious regard for the past. Earlier revolutions have needed world-historical reminiscences to deaden their awareness of their own content. In order to arrive at its own content the revolution of the nineteenth century must let the dead bury the dead." In *Political Writings*, vol. II, *Surveys from Exile*, pp. 148-149.

[105] *Ibid.*, p. 1240.

[106] *Ibid.*, p. 1031.

[107] Stéphane Courtois et al., *op. cit., Le livre noir du communisme: crimes terreur et repression*, p. 14.

[108] In *The German Ideology*, for example, Marx and Engel claimed "modern universal intercourse will be controlled by all": "All earlier revolutionary appropriations were restricted; individuals, whose self-activity was restricted by a crude instrument of production and a limited intercourse, and hence merely achieved a new state of limitation. Their instrument of production became their property, but they themselves remained subordinate to the division of labour and their own instrument of production. In all appropriations up to now, a mass of individuals remained subservient to a single instrument of production; in the appropriation by the proletarians, a mass of instruments of production must be made subject to each individual, and property to all. Modern universal intercourse cannot be controlled by individuals, unless it is controlled by all." *GI*, p. 97. But this statement is a living contradiction: one is left wondering how this collectivism would itself be controlled, unless by new individuals chosen by the Communist Party.

H. G. WELLS (1866-1945)

In his scientific romances, early prophecies, novels, wartime speculations and encyclopaedic works,[1] Herbert George Wells brought together many unique attributes. He was a technocrat, who could foresee the disturbing impact of new technologies (after all, he foresaw the advent of air battles, tank warfare and the atom bomb, well before their time); yet he maintained almost to his dying breath an undiminished faith in systems engineering, whether technical, social or political.[2] He was a socialist/collectivist (although an "evolutionary" one), who longed for the secular New Jerusalem. He disliked physical coercion (although he advocated intellectual coercion), was temperamentally closer in his non-violence to Plato than to Marx, held Britain's aristocratic class in contempt, and yet fantasized extensively about becoming an *intellectual* aristocrat of his own. Wells would have liked to be a Platonic guardian, or in his words, a "Samurai", in a futuristic and highly regimented ideal State.[3] He was a visionary, someone who could take a scientific fact, and then extrapolate whole scenarios of consequences derived from this fact, over the space of hundreds, if not hundreds of thousands of years.[4] He was also a dreamer for the pleasure of dreaming alone. He was an evolutionist, who sought to conceptualize and live out a new personal ethics that was, in his opinion, better suited to Evolution than revealed religion.[5] He was a man of many passions, greedy for sex with multiple female partners, wordy, self-involved, a man who felt compelled to publicize and fictionalize his many love affairs, in an attempt to define and redefine his inconclusive, wandering personality, which was ever seeking to escape the stifling confines of Victorian morality.[6] He was a powerful journalist and communicator. If he played the role of social prophet and sage – a man of the people who interviewed Lenin, Roosevelt and Stalin – it was in a commercial setting, where he sought to sell the most copies of his prophecies, in serialized form and in cheap mass-market editions, to support himself and to influence the world. He was a great believer in public education, whose life experience, as a sickly Cockney who had nevertheless succeeded in pulling himself up by his bootstraps, persuaded him that the general population needed access to popularized knowledge of history, economics, political institutions, and above all science – he devoted enormous energy to the task of popularizing knowledge.[7] He was a masterful synthesizer who wrote voluminously, but was sometimes completely out of his depth, for example when writing about philosophy and religion. He was an advocate of world government, of what was to become the League of Nations and finally the United Nations, as well as charters of human rights and other international legal instruments.[8] Despite his flaws, most of which he acknowledged in writing at some point in his life, Wells was a *universal man*, whose role models included Roger Bacon, the medieval magus of Oxford, and Leonardo da Vinci.[9] Although George Orwell grew up reading Wells, he wrote rather unsympathically that Wells lost his creative impulse after 1920, or so.[10] But Wells was not only a scientific romancer; he was also the author of prodigious encyclopedic works, which "fleshed out" the earlier vision of his fiction.

Wells brought together some of the sources we have met so far: his interpretation of Man the machine was derived from early Greek materialists, Plato, Aristotle and Hero (but not Vitruvius and Galen); he did original work in biology, like Vesalius and Harvey; he was a political philosopher of sorts, after the pattern of

Hobbes and Marx – with obvious reservations, an iconoclast like La Mettrie, and an Encyclopedist after the manner of d'Holbach.

Given this uniquely powerful mix of intellectual attributes and sources, it is not surprising that Wells should have been poorly served by his biographers, few of whom have had much knowledge of science.[11] Among his encyclopaedic works is the two-volume *Experiment in Biography*, which explores in great detail the defective *mechanism* of Wells' brain, and all the things that came to pass as a result of this defect. Although it is self-serving at times, it is still the best source revealing Wells, as he truly was.

If we examine Wells within the framework we have been using throughout this work, some of the seven dimensions of humanity from the Renaissance are missing, but Wells nevertheless constitutes a substantial improvement on Marx. The body is a machine, certainly, but for Wells it is impossible to accept that man is in God's image and likeness or to state directly that he is a microcosm. Like Marx, Wells sought to master himself, at a personal level, while he sketched out utopian political systems that would master other individuals. The Wellsian corpus of fiction is testimony of a sort to his belief that man is a psychological being with virtually unlimited dimensions to human personality, although many of H.G. Wells' novels are didactic works of social criticism, novels spelling out a program of political and social change.[12] When it comes to the Enlightenment faith in reason and man's capacity for happiness, Wells was a frustrated and pessimistic believer, hoping against hope in reason, but daily confronted with what he considered to be the disastrously unreasonable course followed by England, Europe and the world in general. This made him an unhappy, although driven man. There was, even so, a strain of narcissism in his appeals to reason – as if he were always asking: "Why can't people just listen to *me*?"[13]

Wells promoted the idea of a secular, well-educated aristocracy (of which he would doubtless be a part), the kind of exclusive social group that would keep future society highly regimented; and with this idea he deliberately promoted a policy of eugenics, the artificial programmed selection of the best progeny for society. In *The New Machiavelli*, a novel published in 1911, his hero states, "I have explained how the ideas of a trained aristocracy and a universal education grew to paramount importance in my political scheme. It is but a short step from this to the question of the quantity and quality of births in the community, and from that again to these forbidden and fear-beset topics of marriage, divorce and the family organization A sporadic discussion of these aspects has been going on for years, a Eugenic society existed, and articles on the Falling birth Rate, and Rapid Multiplication of the Unfit were staples of the monthly magazines. But beyond an intermittent scolding of prosperous childless people in general – one never addressed them in particular – nothing was done towards arresting these adverse processes."[14] Such chunks of scarcely disguised Wellsian editorial comment are to be found throughout his fiction.

In the somber years immediately following the First World War, he wrote in *Outline of History*, "Human history becomes more and more a race between education and catastrophe. Against the unifying effort of Christendom and against the unifying influence of the mechanical revolution, catastrophe won."[15] Throughout his lifetime, Wells often depicted this catastrophe against the backdrop of man's ambivalent relationship with technology.

Wells' prodigious literary output leaves the historian with a dilemma: how is it possible to "cover" so much material, and still give coherence to the whole? Fortunately, in our case, Wells returned again and again, in many different literary genres, to the metaphor of Man the machine. Among the thinkers considered in this work, Wells is the one whose vision of Man the machine has the most facets, contours, depth, whose use of the metaphor comes closest to the range of uses made today, in twenty-first-century fields where technocratic views are common, such as genomics, biomedical science and artificial intelligence. He expressed this vision in manuals of social pedagogy, in bold prophecies, and in the myths and gripping imagery of science fiction.

According to Christophe Canto and Odile Faliu, "he had no illusions about the benefits of progress, but steered clear of pessimism. He was more daring in his novels than in his formal futurological studies, which tend to be serious and moralistic. Wells had a voluntarist attitude towards the future."[16]

Many of Wells' prophecies came true, and the causes he advocated proved to be of enduring public benefit. This is surprising, considering the poor rate of success achieved by his predecessor, Karl Marx.

Yet Wells was also an opportunist. It is not at all to his credit that he admired the technocratic Automated State, in which the individual would be little more than a cog. Marx was surely dishonest, in laying the ground for a political ideology that enslaved the cog-like individual, while claiming to emancipate him. Wells was more honest than Marx in this respect, since his utopias were explicitly based on rigid social controls. About collectivism, he was ambivalent, even to the point of crass opportunism, as his highly publicized and uncritical encounter with Stalin shows.

The purges, collectivization and famine of the 1930s were common knowledge at the time, even in the West. But meeting Stalin made good publicity for Wells' attempt to address problems at a world scale, before a world audience.

In Wells, we find, on the one hand, *a profound admiration for the mechanical structure and processes of the human body and indeed of all Nature*. And we find, on the other hand, *a naked technocratic impulse, bordering on the totalitarian, which consists in holding up the machine as the measure of all things*, as a powerful and yet fearful model for man to imitate, within an "ideal" re-engineered society. And in between these two images – of machine-like man and man-like machines, we find Wells, the tireless emissary, seeking always to renegotiate the relationship, on his own terms.[17]

The table below summarizes some influences on Marx's thinking:

Wells' interpretation	Sources	Key features
The body as machine	Classical atomism, Spinoza,[18] Thomas Huxley, nineteenth-century biology and biomedical science in general	The body is an intricate series of mechanical structures and processes, which can be directly compared to mechanical inventions
Man in God's image and likeness	None – Descartes' dualism is explicitly rejected[19]	Disinterest in God – his "religion" was world government
Man as a microcosm	None	References liable to be interpreted as the microcosm were probably accidental[20]
Man as self-mastering individual	None	Wells wanted to master himself – why else would he have devoted thousands of pages to exploring his foibles in print? – but he wanted a machine-like State, under his own style of evolutionary collectivism, ruled by Platonic guardians, who would master the individual
Man as a psychological being with virtually unlimited dimensions to human personality	Wide range of authors; his self-consciousness	Psychology is endlessly fascinating
Man as endowed with reason and devoted to happiness	Enlightenment faith in reason	He was unhappy with the unreasonable behaviour of civilization
Man as a cog within an Automated State	Plato and Utopian socialism	Society should operate as smoothly as a linotype machine

H.G. Wells was born in Bromley, Kent in 1866, to a Cockney family of domestic servants. From an early age, he had a keen sense of what it meant to suffer from financial insecurity, to be deprived of educational and professional opportunities, and to flinch from snobbish remarks directed his way by "his betters" – people higher up the social ladder. This gave the young H.G. a chip on the shoulder, from which he never recovered. His father suffered a cricket accident rendering him incapable of work, while his mother worked for various elderly matrons, in the late Victorian setting of tight-lipped evangelical moralizing and working class fear of economic freefall.

It is an extraordinary admission to make, but in his autobiography, published in 1934, Wells noted that at the age of thirteen he went through a pro-Aryan phase, much like Hitler would in the 1920s and 1930s. Wells was writing before the full extent of Hitler's evil was widely known. In the 1930s, Hitler was more popular among the British upper and chattering classes than is commonly accepted; Wells showed candour in owning up to this proto-fascist vice.[21]

At an early age, H.G. Wells developed a passion for reading, and as he was often a sickly child, one can picture him in his bed devouring such books as Plato's *Republic*, which conjured up ideal worlds, rich in myth and colour, where the evils of the world would be finally set right by harmonious, orderly patterns and regimentation, and where bright boys like himself would have an equally bright future, something his Cockney circumstances seemed to deny him.[22]

Readings from Plato were a release from his dreary draper's apprenticeship at the age of fourteen. He then served as usher in a grammar school, before getting a scholarship to study at the Normal School of Science, in South Kensington, under T.H. Huxley. This experience was to prove a revelation. Through Huxley, Wells developed a passion for science, as well as the ambition to make a difference as a scientist.

"In those days," he remembered, many years later, "both sides of descriptive biology, botany and zoology, were in a parallel phase; they were passing on from mere classification to morphology and phylogeny. Comparative physiology and genetics had still to come within the scope of the ordinary biological student. It was perhaps inevitable that they should wait upon the establishment and confirmation of the phylogenetic tree, the family tree of life, before they in their turn could take the center of the stage.... The mechanism of evolution remained therefore a field for almost irresponsible speculation. Weismann and his denial of the inheritance of acquired characteristics was in the ascendant. Our chief discipline was the determination of the relationship of groups by the acutest possible criticism of structure.... The study of zoology in this phase was an acute, delicate, rigorous and sweepingly magnificent series of exercises. It was a grammar of form and a criticism of fact. That year I spent in Huxley's class was, beyond all question, the most educational year of my life. It left me under that urgency for coherence and consistency, that repugnance from haphazard assumptions and arbitrary statements, which is the essential distinction of the educated from the uneducated mind."[23]

Huxley was one of the most vigorous defenders of the "mechanism" of evolution, defending it at Oxford in 1860, in the presence of Bishop Samuel Wilberforce. In addition, Huxley wrote extensively on the relations of man to the lower animals, and, from the agnostic perspective, on the way in which evolution challenged human ethics – a subject dear to Wells' heart.

In 1870, Huxley had got embroiled in a public controversy over the idea of Man the machine. Speaking before the Cambridge Young Men's Christian Association, he said, "I hold, with the Materialist, that the human body, like all living bodies, is a machine, all the operations of which will sooner or later be explained on physical principles. I believe that we shall, sooner or later, arrive at a mechanical equivalent of consciousness, just as we have arrived at a mechanical equivalent of heat."[24] At the same time, Huxley defended the view that science and philosophy are extra-Christian, outside of the purview of religion itself: scientists, such as he, had therefore to suspend judgment on matters outside of their discipline. This view of Man the machine was attacked on moral and social grounds in *The Spectator*. The commentator wrote, "Professor Huxley as a thinking machine, even if he could strike the answer to ten thousand questions on which now he can only exhort us to suspend our judgments, if he could sweep away from the lives of his fellow-citizens a thousand evils which he can now only help them to bear, would be, we think we may venture to say, comparatively a social and moral failure."[25]

It is interesting to note that Huxley's metaphor was close to part of Wells' later metaphor – as stated in *The Science of Life*, a work he co-authored with his son G.P. Wells, and Thomas Huxley's grandson, Julian Huxley.

During the formative years of his normal school education, Wells also had the chance to refine some of his ideas about socialism. He felt every bit a socialist, and had nothing but contempt for the upper-class types who had made his mother's life insecure and miserable, but he did not care for Marx, whom he considered cheap, base, enfeebling, spiteful and a parasite.[26] This is an interesting opinion from an English working class Cockney – just the type of person Marx claimed to be leading to a brighter "universal" future. But the Cockney had a mind of his own!

It was at this time that Wells began to be conscious of losing what little religious faith he had, and of turning towards the future – something he associated with the evolutionary theory of Darwin and Huxley. If the theory of evolution had revealed the slow progress of all that the human species had become, for Wells it necessarily pointed to a future, towards which evolution would naturally extend.[27] "I should probably romance about it, fill in gaps and simplify unduly," he wrote, "if I tried to give an orderly account of how preoccupation with the future became dominant in my conscious life. But I think my contact with evolutionary speculation at my most receptive age played a large part in the matter. I cannot judge, I do not know how to judge, whether the accident of writing those two early pieces about the remote future and mankind and time-travelling [*The Man of the Year Million* & *The Chronic Argonauts*, in 1887 & 1888] gave me a bias in this matter, and whether, having once made a little success in forecasting, it seemed natural to give the public more from the same tap, or whether on the other hand there was an innate disposition to approach things in general from an unusual side. The idea of treating time as a fourth dimension was, I think, due to an original impulse; I do not remember picking that up. But I may have picked it up, because it was in the air. If I did not then the bias was innate. The future depicted in the *Time Machine* (1894) was a mere fantasy based on the idea of the human species developing along divergent lines, but the future in *When the Sleeper Awakes* (1898) was essentially an exaggeration of contemporary tendencies: higher buildings, bigger towns, wickeder capitalists and labour more downtrodden than ever and more desperate. Everything was bigger, quicker and more crowded; there was more and more flying and the wildest financial speculation. It was our contemporary world in a state of highly inflamed distension."[28]

The scientific romances are the most successful of Marx's works, and the most enduring. They are open-ended, fast-paced narratives of "highly inflamed distension" – tautly crafted like a foreign correspondent's dispatches, with minimal dialogue. They recount time traveling that enables the hero to visit a forbidden future in the 8,028th century and there discover the secrets that lie in store for him and humanity; an evil doctor on a remote island who creates and pacifies monstrous chimeras which eventually turn around and destroy him; encounters with destructive Martian automata that are finally wiped out by earthly bacteria; a man who falls asleep for a few centuries and awakes to find himself the object of a strange cult in a world gone mad; and a space voyage to the Moon, where the Selenites, peculiar and highly intelligent creatures living underground, who seem to have organized their society along Platonic lines.

Several points are worth mentioning in this respect. All of these scientific romances deal in allegorical language with real-life situations of the nineteenth century;[29] all point to the advantages and disadvantages of planned societies, whether of humans, transgenic beasts or extraterrestrials;[30] all contain some reference to the powerful natural forces at work in evolution;[31] and all point to the fearful onset of the animate machine, of the terrifying mechanism now coming alive and challenging humanity.[32] This animate machine, like the metallic, gleaming, green-eyed automaton of *War of the Worlds*, was also intent on devouring man.[33]

But these are not merely scientific romances. They are also secular prophecies with a decidedly apocalyptic element: Wells evoked violent epic struggles between softhearted aborigines and evil monsters; the murderous uprising of animals against humans; the end-of-the-world scenario of a Martian invasion; the ultimate confrontation between good and evil in a future world, and the revulsion that a master race of highly organized and socialized Selenites felt for humans. In a previous work,[34] we noted some of the main features of the apocalyptic genre – most of these features can be found in Wells' scientific romances. The apocalyptic genre can be:

- a literal statement of what is yet to come;
- disguised commentary on one's own times;
- a dramatized projection of anxieties and the fear of death;
- a mythical framework setting a beginning and ending which serve as limits to time;
- a search for meaning in the moving incoherent jumble of events;
- a longing for future release from present suffering;
- a final resolution of the world's problems;
- a mythical reversal of the injustices in today's world, by conjuring up a vision of the justice-to-come, which will comfort the elect;
- a justification for bludgeoning all those who do not fit the inspired description of the Elect;
- several of the above simultaneously.

That Wells should have resorted to the apocalyptic genre is not surprising, when one remembers that he was a socialist longing for a godless New Jerusalem, which he understood to be the World City of Mankind.[35] He was very different in this respect from Marx, who gave brutal descriptions of the here and now, but never bothered to provide a glimpse of the future communist State.

Once Wells had published his hugely successful scientific romances, he turned to non-fiction works of secular prophecy that were intended for a wide readership. In 1901 appeared *Anticipations of the Reaction of Mechanical and Scientific*

Progress Upon Human Life and Thought. This work translated into prose the vision Wells had been nurturing in fiction, of a future world, dominated by superior, high-minded and well-educated technocrats who would use science and technology for the greater good of humanity.

The world of *Anticipations* had several features. It was a world containing four main social elements: "(I.) the element of irresponsible property; (II.) the helpless superseded poor, that broad base of mere toilers now no longer essential; (III.) a great inchoate mass of more or less capable people engaged more or less consciously in applying the growing body of scientific knowledge to the general needs, a great mass that will inevitably tend to organize itself in a system of interdependent educated classes with a common consciousness and aim, but which may or may not succeed in doing so; and (IV.) a possibly equal number of non-productive persons living in and by the social confusion."[36]

Wells detested the element of irresponsible property (the unproductive aristocracy and upper middle class), and had both pity and contempt for the superseded poor, whose "drowning existences ... crude hardship ... individual doom" he considered to be "an integral part of this physiological process of mechanical progress, as inevitable in the social body as are waste matters and disintegrating cells in the body of an active and healthy man."[37]

For Wells, meanwhile, the most productive and creative element of society in the future would be the technocrats, whose understanding of science and technology positioned them at the forefront of humanity, and whose knowledge and methodical mental habits would be translated into political and economic power: "The practical people, the engineering and medical and scientific people, will become more and more distinctly aware of a common 'general reason' in things, and of a common difference from the less functional masses and from any sort of people in the past. They will have in their positive science a common ground for understanding the real pride of life, the real reason for the incidental nastiness of vice, and so they will be a sanely reproductive class, and, above all, an educating class. Just how much they will have kept or changed of the deliquescent morality of to-day, when in a hundred years or so they do distinctively and powerfully emerge, I cannot speculate now. They will certainly be a moral people. They will have developed the literature of their needs, they will have discussed and tested and thrashed out many things, they will be clear where we are confused, resolved where we are undecided and weak. In the districts of industrial possibility, in the healthier quarters of the town regions, away from the swamps and away from the glare of the midnight lights, these people will be gathered together. They will be linked in processions through the agency of great and sober papers – in England the *Lancet*, the *British Medical Journal*, and the already great periodicals of the engineering trades, foreshadow something, but only a very little, of what these papers may be."[38]

The dominant role to be played by this technocratic class can be explained in several ways. The industrial and scientific revolutions had changed the structure and nature of society, placing the accent on knowledge, technological innovation and competent planning, where previously it had been placed on social hierarchy, traditional prejudices and the chaotic, undirected and wasteful growth of social institutions.[39] Wells revived the Platonic ideal of the guardians of the *Republic*, of those "specially trained and capable people – doctors, engineers, scientific men of all sorts" who would consciously become *the* State, dominating the other three classes of society.[40] These technocrats would moreover be neutral where technology was concerned, entering into a symbiotic relationship with the machine: "The sort of people who will work the machine are people with 'faith', as the popular preachers say, meaning, in fact, people who do not analyse, people who will take the machine as it is, unquestioningly, shape their ambitions to it, and – saving their vanity – work it as it wants to go."[41]

One senses in *Anticipations* that Wells' literary success with the scientific romances had gone to his head, because he was now speaking of *definitive laws* governing the future course of society, laws which he (alone) was able to articulate. For instance, the growth of scientific knowledge and technique provided a country's capable technocrats with the key to power and military victory, just as it condemned the poor and uneducated to the unenviable, subhuman status of the "People of the Abyss". In Wells' view, if these latter people could not be educated or reformed, then they would be sterilized, exported or poisoned.[42]

Such attitudes shock us today, in their apparent approval of eugenics and euthanasia[43] on a massive scale. Wells believed that technology itself had wrought a fundamental change in society, had become a part of Evolution itself, and had altered the evolutionary concept of the "fittest", who were now not the most brutal or wily, but the most knowledgeable about science, technology and competent planning. This fundamental change, this "essential process arising out of the growth of science and mechanism," pointed to a new existence for humanity, which would finally overcome its limitations, prejudices, misunderstandings and pointless bloodshed, to establish one world State in which national particularities would disappear.[44] Naturally, such a fundamental change called for an entirely new system of ethics, "reconstructed in the light of modern science" – "The ethical system of these men of the New Republic, the ethical system which will dominate the world-State, will be shaped primarily to favour the procreation of what is fine and efficient and beautiful in humanity – beautiful and strong bodies, clear and powerful minds, and a growing body of knowledge – and to check the procreation of base and servile types, of fear-driven and cowardly souls, of all that is mean and ugly and bestial in the souls, bodies, or habits of men."[45]

Wells followed *Anticipations* up in 1905 with a further book of secular prophecy, *A Modern Utopia,* which did not sell well but which he still considered three decades later one the "most vital and successful" of his books, marking his debt to Plato's ideal *Republic,* and Thomas More's *Utopia.*[46] We have noted in a previous work some typically utopian features, all of which appear in one way or another in Wells' work. More's *Utopia* was:

- a closed insular system, remote from and in marked contrast to contemporary Europe, with its selfish greed and power struggles;
- an idealized State, existing outside of time and in no particular place ("Utopia" means no place), where serious political projects could be envisaged without being too offensive to the powers that be;
- a place knowing neither the bitter ashes of war nor the extravagance of superfluous, unshared wealth;
- a State governed by reason in which the causes of social conflict (private property, vice, disorder, self-interest etc.) were systematically isolated and removed so that collective life was marvelously well regulated;

- an island republic, which severely limited individual liberties in the name of collective cohesion and prosperity;
- the subject of an entertaining imaginary travelogue, in which it is never quite clear what should be taken seriously and what lightly.

For Wells, Utopia was a place "where men and women are happy and laws are wise, and where all that is tangled and confused in human affairs has been unraveled and made right."[47]

Once again, he maintained that the "almost cataclysmal development of new machinery, the discovery of new materials, and the appearance of new social possibilities through the organized pursuit of material science, has given enormous and unprecedented facilities to the spirit of innovation."

This revolutionary change had left the old order in a deliquescent, wrecked, flooded State, where the old social hierarchy, prejudices, conventions and rituals had been smashed, scattered and "mixed discordantly together."[48] In the Wellsian Utopia, meanwhile, the technocrats would process scientific data, seated at their "glowing desks" (in our eyes today, this sounds like an early anticipation of computer screens, although it may have been nothing of the sort): Francis "Bacon's visionary House of Salomon will be a thing realized, and it will be humming with this business. Every university in the world will be urgently working for priority in this aspect of the problem or that. Reports of experiments, as full and as prompt as the telegraphic reports of cricket in our more sportive atmosphere, will go about the world.... The literature of the subject will be growing and developing with the easy swiftness of an eagle's swoop as we come down the hillside; unseen in that twilight, unthought of by us until this moment, a thousand men at a thousand glowing desks, a busy specialist press, will be perpetually sifting, criticizing, condensing, and clearing the ground for further speculation."[49]

It should be noted that Wells' technocratic vision was in sharp contrast with the futuristic novels of two literary contemporaries, who accorded far less importance to machinery, and far more to personal liberty. Samuel Bulter (1835-1902) wrote *Erewhon*, the satirical account of a horseman accidentally coming across a lost world in the Rangitoto mountains of New Zealand. This quasi-utopian lost world had come to understand the dangers of technology. Some four hundred years previously, humanity had discovered that machines were developing a superior sort of vitality, and would ultimately supplant man. The entire country "made a clean sweep of all machinery that had not been in use for more than two hundred seventy-one years (which period was arrived at after a series of compromises), and strictly forbade all further improvements and inventions under pain of being considered in the eye of the law to be laboring under typhus fever, which they regard as one of the worst of all crimes."[50] A museum of old machines, containing a heap of rusting wreckage, served as a reminder of human folly.

In *Erewhon*, Butler maintained that machines had consciousness of a sort. Since human faculties could be understood in mechanistic terms and found wanting, then man was now becoming the servant of the machine. If all machines were annihilated, and if all knowledge of mechanical inventions were taken from man, Butler did not see how humanity could survive more than a few weeks. "The servant glides imperceptibly into the master; and we have come to such a pass that, even now, man must suffer terribly on ceasing to benefit the machines.... Even now the machines will only serve on condition of being served, and that too upon their own terms; the moment their terms are not compiled with, they jib, and either smash both themselves and all whom they can reach, or turn churlish and refuse to work at all."[51]

In *The Crystal Age*, W.H. Hudson (1841-1922) portrayed a lost world regulated by rationalism and brotherly solidarity. The hero, inexplicably finding himself in the dense forest of a lost world, feels out of place at first, but little by little comes to be accepted by the highly rational tribal society around him, whose customs, sanctions and ultimate motivations remain a mystery to him. They speak English, yet have no knowledge of England; they know labour but have no money; they have some elementary tools like the axe and plough, but no appreciable technology; their morality and behaviour are based on a severely rational code. In this highly regimented lost world, even horses know their place: they can read the hero's thoughts, and know when to start and stop ploughing on their own. The hero falls in love with a lovely young woman, hoping that she will love him in return. But when he discovers she is an utterly passionless, rational creature without any capacity for emotional intimacy and sexual love, he plunges into a crisis. Since he cannot leave this lost world and return home, he commits suicide instead. In Hudson's writings, from *The Purple Land* to *Green Mansions* and *Idle Days in Patagonia*, one has the sense that a powerful spiritual force animates Nature and therefore all of life. *The Crystal Age* exposes the cold crystal-like existence of a highly regimented and purely rational society, out of touch with its procreative, emotional and spiritual nature.

Butler and Hudson found significant dangers in both technology and rationalism. Yet Wells felt that the machine should be a key feature of any utopian vision. He was part of quite a different literary tradition, extending from *Icarie* by Etienne Cabet (1788-1856) through *Looking Backward* by Edward Bellamy (1850-

1898), according to which the rational machine was at the center of speculation about a highly regimented future society, and served to combat capitalist exploitation, financial speculation and superstitious fear.[52]

Wells set up the machine as a norm, while explicitly deprecating human beings: "The plain message physical science has for the world at large is this, that were our political and social and moral devices only as well contrived to their ends as a linotype machine, an antiseptic operating plant, or an electric tram-car, there need now at the present moment be no appreciable toil in the world, and only the smallest fraction of the pain, the fear, and the anxiety that now makes human life so doubtful in its value. There is more than enough for everyone alive. Science stands, a too competent servant, behind her wrangling underbred masters, holding out resources, devices, and remedies they are too stupid to use."[53]

But in Wells' modern Utopia, the machine had an additional, highly distinctive aspect: it would provide the technocratic class with the means to collect, process, catalogue, analyse and transmit private information about the individual.[54] This amounted to exerting total social control over the individual, in the interests of competent, rational planning guided by scientific and technical knowledge.

We have it on good authority that this vision of a utopian future was totalitarian. Wells said so himself, in his autobiography: "The experience of the thirty years that have passed since I launched this scheme [*A Modern Utopia*], and particularly the appearance of such successful organizations as the Communist Party and the Italian Fascists has greatly strengthened my belief in the essential soundness of this conception of the governing order of the future. A Samurai Order educated in such an ideology as I have since tried to shape out, is inevitable if the modern world-State is ever to be fully realized. We want the world ruled, not by everybody, but by a politically-minded organization open, with proper safeguards, to everybody. The problem of world revolution and world civilization becomes the problem of crystallizing, as soon as possible, as many as possible of the right sort of individuals from the social magma, and getting them into effective, conscious co-operation."[55]

Although Wells admired "successful organizations" such as the Communist Party and the Italian Party, there was an important difference, a difference which came out strongly in his 1920 encounter with Vladimir Lenin (1870-1925) – Wells renounced revolutionary violence, he believed in the capacity of humanity to *evolve* in the direction of collectivism, by means of education. This was essentially an Enlightenment view, and would have appealed to such figures as d'Holbach or Condorcet in the late eighteenth century.

"In Lenin," Wells wrote in *Russia in the Shadows*, "I realized that Communism could after all, in spite of Marx, be enormously creative. After the tiresome class-war fanatics I had been encountering among the Communists, men of formulae as sterile as flints, after numerous experiences of the trained and empty conceit of the common Marxist devotee, this amazing little man, with his frank admission of the immensity and complication of the project of Communism and his simple concentration upon its realization, was very refreshing. He at least has a vision of a world changed over and planned and built afresh."[56]

Moreover, Wells wrote, the essential difference between himself and Lenin was "the difference of the Evolutionary Collectivist and Marxist, the question whether the social revolution is, in its extremity, necessary, whether it is necessary to overthrow one economic system completely before the new one can begin. I believe that through a vast sustained educational system the existing Capitalist system can be *civilized* into a Collectivist world system; Lenin on the other hand tied himself years ago to the Marxist dogmas of the inevitable class war, the downfall of capitalist order as a prelude to reconstruction, the proletarian dictatorship, and so forth. He had to argue, therefore, that modern Capitalism is incurably predatory, wasteful, and unteachable, and that until it is destroyed it will continue to exploit the human heritage stupidly and aimlessly, that it will fight against and prevent any administration of natural resources for the general good, and that, because essentially it is a scramble, it will inevitably make wars."[57]

We are left wondering what happened to Wells' utopian vision. Had he been merely a wishful thinker in believing that society could be "civilized", made collectivist, by voluntary means? Was he trying to have it both ways, boldly transforming the world order, yet preserving the peaceful, evolutionary process of organic growth? Or were there particular experiences that had demonstrated to him the "other side" of technology, showing that it was not just a norm, a model for human society to follow, but also hugely destructive when placed in the wrong hands?

The First World War had been a traumatic experience for him.[58] Not only had it confirmed his worst suspicions about the idiocy and incompetence of the old aristocratic leadership (the British Army had refused his prophetic advice about tank warfare, for example); it had given a new impetus to his millenarian desire to create a revival, a new collective world identity for mankind, a new federal world State, and an era of planetary peace. This desire found expression in the *Outline of History*, likely the first universal history based on evolutionary principles, which told the story of the world from the emergence of biological life to the most recent times. The vision of this work was not that different from his previous scientific romances. There was the same mythology of future happiness, the expectation that problems would be resolved and hatred and destruction would dissolve, the fervent hope that a new Golden Age of scientific discoveries, technological innovation and competent planning would provide peace and security. "Life begins perpetually. Gathered together at last under the leadership of man, the student-teacher of the universe, unified, disciplined, armed with the secret powers of the atom and with knowledge as yet beyond dreaming, Life, for ever dying to be born afresh, for ever young and eager, will presently stand upon this earth as upon a footstool, and stretch out its realm amidst the stars."[59]

According to Wells, several important developments seemed to "move commandingly" towards an adequate world control at the present time." The developments included the increasing destructiveness and intolerableness of war waged with the new powers of science; the inevitable fusion of the world's economic affairs into one system; the need, because of the increasing mobility of peoples, of effectual controls of health everywhere; the urgent need of some equalization of labour conditions, and of the minimum standard of life throughout the world; and the impossibility of developing the enormous benefits of flying without a world control of the air-ways.[60]

In the light of these developments, Wells decided to "ape Roger Bacon in his prophetic mood, and set down what we believe will be the broad fundamentals of the coming world state." These fundamentals were eight-fold. Wells foresaw a common world religion; universal education both in the home and in institutions of learning employing ten per cent of the world's population; "no armies, no navies and no classes of unemployed people, wealthy or poor"; scientific research and record organized on a planetary scale; a vast free literature of criticism and discussion; a democratic world political organization, in immediate touch with and responsive to the general thought of the educated whole population; economic activity organized and guided by science and undertaken for the common good; and finally electoral methods and a stable currency.[61]

While this wish list seems even less realistic than *A Modern Utopia* had been, the *Outline of History* was a remarkable bestseller, coming as it did shortly after "the war to end of all wars." Wells never abandoned his view that a highly educated elite, knowledgeable about science and its application through technology, would play a commanding role in society. This elite was made up of disinterested, self-abnegating, devoted individuals who transcended their private interests by placing their knowledge at the service of the State.[62]

We have noted that Wells' collectivism was grounded in the theory of Evolution, which, in his view, called for a new system of ethics, to be enshrined in a New Republic. Ideally, Wells hoped that the utopian society of the future would be as well organized as "a linotype machine, an antiseptic operating plant, or an electric tram-car." This view, on the face of it, does not make a lot of sense. How could a theory of organic evolution be interpreted along mechanical lines? How could "things" such as printing presses be held up as models for organic humans to emulate? Why did Wells, in many respects a humanitarian, promote the machine as the measure of all things? But this is to forget that for Huxley and Wells alike, the slow unfolding of Evolution over time was a mechanical process. Wells saw man as a mechanism, a potentially valuable machine: but man's chaotic and uneducated behaviour, his blind prejudices and obscure rituals, his destructive impulses and haphazard reproductive practices meant he was far less rational and therefore less useful than "a linotype machine, an antiseptic operating plant or an electric tram-car."

In the *Science of Life*, Wells and his co-authors exposed in rich and fascinating detail their view of the human mechanism. Indeed this work ranks as one of the finest examples of popularized science ever published, in its simple and accurate description of scientific detail, and in its use of metaphors, many of them mechanical, to explain the inner workings of Nature. Some of the biological details in this three-volume work are now out of date, but the underlying message about Man the organic machine is identical to that heard in the twenty-first century in fields such as genomics and biomedical science. In this respect, Wells, while surely not a biological innovator, was a key popularizer of the idea of Man the organic machine.

Man is pictured in *The Science of Life* as part of the vast, unbroken stream of life: "That same stream in the dawn of life on earth manifested itself in the form of single microscopic cells; hundreds of millions of years later, after transformation through forms we dimly guess at – forms of polyps, of worm-like creatures, of headless things like lancelets, it flowed through thousands of generations in the form of fish; it emerged on land, it learnt to be a reptile, it covered itself with hair and warmed its blood, and fed its young with milk. Still without any break in continuity, it transformed itself to become fully mammalian, its young to grow as parasites upon its life. Four-footed, tailed and hairy, it took to the Eocene forests; it grew into lemur, into monkey, into ape, and finally ape turned man-ape, and man-ape grew to man. If that self-same stream of life that flows through our human generations and that we call man was once fish, and if those fishy ancestors could be transformed into our present selves in three-hundred million years, without the aid of conscious purpose in any of the prehuman forbears, who shall prophesy what our race may not achieve and into what it may not transform itself before another such period in the history of life on earth has passed? To grasp the full implications of this estimate of available time is to realize that we are still only in the dawn of consciousness and thought, and that all human will and wisdom has ever done is no more than an augury of what it may yet achieve. Evolution presents itself as an accelerating process, gathering momentum and hardly yet beyond the beginning of its revelations."[63]

Natural Selection can be compared to a sifting machine and "the mutations are the raw proposals that come to it for consideration, rejection, or justification. Undesirable variations are sifted out and thrown aside; successful ones get through and continue in the germ-plasm of the race."[64] Moreover, "there is a machinery underlying Evolution as there is a machinery behind chemical combination or the laws of gaseous pressure."[65]

Life originally arose in the sea, and while biology has made great strides in understanding the mechanisms of life, the possibility that life could be artificially created seems extremely remote.[66]

Moreover, "the human body is fundamentally a machine. ... [but] it is not a simple machine. It is a great mechanical system made up of an almost infinite multitude of smaller machines."[67]

The three co-authors described the complex body-machine and how it works, explaining cells, blood, the course of the blood, breathing, kidneys and other exhaust organs, how food is transformed into blood, and the continual struggle against infection and chill. In *The Science of Life*, they acknowledged that this idea of the human machine might be controversial. They therefore faced objections squarely: "Is a living man fundamentally a machine? That is a question capable of experimental decision. We can measure the amount of food that a man or an animal consumes over a given period of time, and we can measure the energy yielded during the same period. If we burn an equal weight of similar food in a suitable apparatus and find out how much energy its combustion yields, and if this value is equal to the energy yielded by the experimental subject, then evidently the living organism, so far as its energy-output is concerned, is really and precisely a combustion engine. Naturally, we do not suggest that this demonstration of our fundamental mechanical nature explains everything; as we have already pointed out, the living body has certain obvious properties that distinguish it from any man-made machine. It grows and reproduces its kind, and it is conscious.... There is no observable life-process which is independent of a supply of physical energy. When that ceases, growth, movement, and all signs of consciousness cease also – so that in studying the physical mechanism of the body, even if we are not studying development and mind themselves, we are studying conditions upon which they rest and from which they are apparently inseparable."[68]

After getting the basic principles of Evolution and Natural Selection out of the way, as well as some initial objections to the idea of the human machine, the co-authors then went into the mechanical subsystems of the complex mechanism in considerable detail. They explained, for example, that the brain and spinal cord send commands and respond to the copious stream of information flowing towards them from all parts of the body;[69] they noted the chemical processes within cell-machines, which they later likened to internal combustion engines;[70] the chief mechanisms of heat-regulation by means of skin-capillaries and perspiration;[71] and they alluded in passing to the implicit order of God.[72] This was a puzzling reference indeed, since they also noted that Evolution had replaced the authority of Genesis as an account of the origins and development of life on Earth.[73]

In one of the most graphic uses of the mechanical metaphor, the co-authors compared the central nervous system to a telephone system: "The telephone wires of the body, then, are living threads of astounding delicacy, finer than the finest gossamer. They are about one-tenth the thickness of a human hair and may be several feet long. The messages which flash along these protoplasmic wires are called 'nervous impulses'; they are physical changes which travel at about four hundred feet per second in man. Our bodies are permeated by a network of such fibres, centring in the brain and spinal cord."[74]

There are passages in *The Science of Life* that resemble the writings of Leonardo or Vesalius: "the ear is an ingenious device for touching different cells when notes of different pitch are sounded. The nerve-fibres run from the ear to the brain, and here the impulses are interpreted as notes of varying pitch according to the particular fibres along which they arrive ... The structure of an eye is very like that of a photographic camera. We may distinguish two essential parts: a sensitive screen at the back, the *retina*, and an optical system that projects an image of the outside world on to that screen."[75] The brain itself is a piece of machinery, whose "construction of living threads and cells far outdoes in complication any machine of metal or rubber or glass ever constructed by men. The cerebrum, the organ of the mind, is superposed upon this system of automatic, machine-like responses, and it is capable of interfering with and modifying the activity of the reflex centers."[76] Where the nervous system is concerned, Wells and his co-authors noted ever greater complexity as a species ascended the tree of life – an idea that is not as current today as it was in their time.[77] This idea of ascension related to the hierarchy of species, but also cropped up in yet another reference to eugenics, which was needed to disqualify and sterilize stupid, shiftless slum dwellers who could not be taught to avoid reproducing themselves.[78] As was the case in many of Wells' other works, *The Science of Life* also featured an appeal to education and to the application of knowledge to make humanity's dreams come true.[79]

Once *The Science of Life* was published, in 1931, Wells had finally brought about, at least in print, a fusion of the biggest intellectual discoveries he had made during his early years: Evolution and Plato's collectivist Republic. His motto could well have been "the survival of the fittest *minds*."

Yet there is, below the surface of many of Wells' works, an all-engulfing sense of emptiness, of metaphysical despair even, as he cast Man as a machine, but also sought to recover all that humanity had lost since the Enlightenment and the onset of the Industrial Revolution.

He tried to replace God with an idealized transcendent future, and the old sense of local community with a world globalized and made secure; he tried to replace the unifying medieval Christian Church with a United Nations, and convince his readers that technocrats were modern heirs to the disinterested monastic tradition of learning. He also devoted the greater part of his life to praising the machine as the measure of all things, felt anxious and disenchanted, and then tried as he might to negotiate a truce between machine and man that would restore some lost dignity to man.

But how could this truce ever hold, if man's inner life – not the intricate workings of his biological mechanism, but his very spirit – was simply ignored, written off as a jumble (and often a confused jumble) of biochemical messages and processes? How could the truce hold if God was dead, if Genesis had been replaced by a secular vision of Evolution, and there was nothing beyond our fleeting mortal existence? Wells could conjure up a vision of Utopia, but he could not ensure that people would be inspired by it to reform their destructive, self-serving ways, and make of the world a better and more beautiful place.

Throughout his life, he marvelled at machine-like man, but was also fascinated by the man-like machine. This sense of marvel and fascination ended in the depressing work of his final weeks, *Mind at the End of its Tether*. In this work, written towards the end of the Second World War, Wells made his final prophecy: "The writer finds very considerable reason for believing that, within a period to be estimated by weeks and months rather than by aeons, there has been a fundamental change in the conditions under which life, not simply human life but all self-conscious existence, has been going on since its beginning. This is a very startling persuasion to find establishing itself in one's mind, and he puts forward his conclusions in the certainty that they will be entirely inacceptable to the ordinary rational man. If his thinking has been sound, then this world is at the end of its tether. The end of everything we call life is close at hand and cannot be evaded. He is telling you the conclusions to which reality has driven his own mind, and he thinks you may be interested enough to consider them, but he is not attempting to impose them upon you." [80]

In this short last work, marked by immense sadness and metaphysical gloom, Wells wrote of the possible extinction of the human species. Such a desperate emotion may have foreshadowed his approaching death. But it also indicates that his lifelong vision of future utopias, where rational, regimented men would cohabit with machines, had completely and utterly collapsed.[81]

He now foresaw, in *Mind at the End of its Tether*, nothing but a reality glaring at once coldly and harshly upon humanity, delusions, a frightful queerness, an impasse, the end of all existence on Earth.[82] He also lost all faith in prophecy, his own or anyone else's: "The limit to the orderly secular development of life had seemed to be a definitely fixed one, so that it was possible to sketch out the pattern of things to come. But that limit was reached and passed into a hitherto incredible chaos. The more he scrutinized the realities around us, the more difficult it became to sketch out any Pattern of Things to Come. Distance had been abolished, events had become practically simultaneous throughout the planet, life had to adapt itself to that or perish, and with the presentation of that ultimatum, the Pattern of Things to Come faded away. Events now follow one another in an entirely untrustworthy sequence. No one knows what tomorrow will bring forth…"[83]

In this final work, written towards the Second World War, when he was spent and lay dying, he wondered whether humanity was not moving swiftly into the vortex of extinction, whether there some implacable but unknown antagonist (life itself?) was now turning against the human race to wipe it out.[84]

In the end, Wells called into question the inexorable progress of Evolution, the ascent of man up the hierarchy of the tree of life. He called prophecy into question, the real capacity of man to build on his utopian visions. How could he believe any longer that one day there would be a closed insular society within an idealized collectivist State, a place knowing neither the bitter ashes of war nor the extravagance of superfluous, unshared wealth? He had just lived through the second of two world wars, in the space of a mere quarter century, which was insignificant in the context of evolutionary time. He no longer believed in the existence of a future – and this was a devastating admission for people without God whose only transcendent value, as Camus had put it, had been the future itself. Wells had penetrated through to the other, darker side of humanity's relationship with technology. He had traveled to the very limits of a metaphor that pervades his many scientific romances, early prophecies, novels, wartime speculations and encyclopaedic works: *Man the machine.* It was like a blinding apocalypse, without any hope of future redemption.

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[1] We have studied the following Wellsian works for study, in the course of our researches: *Text-Book of Biology*, 2 vols. (1892), *The Time Machine* (1895), *The Island of Doctor Moreau* (1896), *The Invisible Man* (1897), *The War of the Worlds* (1898), *A Story of Days to Come* (1899), *When the Sleeper Awakes* (1899), *The First Men on the Moon* (1901), *Anticipations of the Reaction of Mechanical and Scientific Progress Upon Human Life and Thought* (1901), *A Modern Utopia* (1905), *The War in the Air* (1908), *First and Last Things* (1908), *The New Machiavelli* (1911), *God the Invisible King* (1917), *The Outline of History*, 2 vols. (1920), *Russia in the Shadows* (1920), *A Short History of the World* (1924), *The Undying Fire* (1925), *The Science of Life*, 3 vols. (1931), *The Work, Wealth and Happiness of Mankind* (1932), *Experiment in Autobiography*, 2 vols. (1934), the film script *Things to Come* (1935), *The Happy Turning* (1945), *Mind at the End of its Tether* (1945), and various short stories.

[2] This fascination with the perfectly ordered, technocratic society is particularly noticeable in *A Modern Utopia* (Lincoln, 1967), p. 102, where Wells wished that political and social and moral devices could be "as well contrived to their ends as a linotype machine, an antiseptic operating plant, or an electric tram-car."

[3] Wells admired Plato's *Republic* at an early date, described in *A Modern Utopia* how guardian-like Samurai would maintain order in his perfect future State, and ultimately never gave up this vision of disciplined militaristic leaders guiding all the operations of the State.

[4] The most colourful scenario that Wells devised may well have been in *The Time Machine*, which actually contains several alternative, parallel scenarios, since the time traveller can adjust his machine, and go backwards and forwards in time at will. In *Three Prophetic Science Fiction Novels of H.G. Wells* (New York, 1960).

[5] He frequently wrote about religion, for example in *First and Last Things* (London, 1908), p. 269: "All these religions are true for me as Canterbury Cathedral is a true thing and as a Swiss chalet is a true thing. There they are, and they have served a purpose, they have worked. Men and women have lived in and by them. Men and women still do. Only they are not true for me to live in them. I have, I believe, to live in a new edifice of my own discovery. They do not work for me. These schemes are true, and also these schemes are false! in the sense that new things, new phrasings, have to replace them." "Why do people go on pretending about this Christianity?" he wrote in *Experiment in Autobiography* (London, 1934, 2 vols., hereafter referred to as *EA*) "At the test of war, disease, social injustice and every real human distress, it fails – and leaves a cheated victim, as it abandoned my mother. Jesus was some fine sort of man perhaps, the Jewish Messiah was a promise of leadership, but Our Saviour of the Trinity is a dressed-up inconsistent effigy of amiability, a monstrous hybrid of man and infinity, making vague promises of helpful miracles for the cheating of simple souls, an ever absent help in times of trouble." *EA* I, p. 68. One possible explanation for Wells' conscientious and highly intellectualized infidelities and numerous offspring with different women, is that he was looking for a new kind of morality which put the accent on pleasure, and treated the family as something elastic and extended, with many overlaps, such as is sometimes found in the animal kingdom.

[6] At least one masterful book came out of this experience: the secret diary Wells had kept over the years, and which was edited and published by his son G.P. Wells in London in 1984: *H.G. Wells in Love*. Perhaps because H.G. had nothing to prove to anyone, he was far franker in this book, and some of the descriptions of personality are incredibly funny. Wells may have been in favour of incest; he was certainly convinced that intensive inbreeding of the best type of individuals was a good thing, as he wrote in *The Work, Wealth and Happiness of Mankind*: "Who among us cannot recall the half-handsome children of the beautiful, the not very brilliant offspring of the genius? Now and then, of course, there may be a run of luck, but our best chance of getting any quality repeated, say the biologists, is to inbreed closely, which at once brings us up against the restrictions of current morality. We should turn back towards the primary social sin, incest.... When, therefore, biological workers seek to evolve and fix a new variety of some plant or animal, they resort to expedients quite outside our present liberties with human material. The first thing is to discover the recessives by the freest promiscuous breeding and interbreeding. Every undesirable recessive thus brought to light is then thrown out of reproduction; every individual known to carry a recessive is also cast out. When at last a 'pure' strain is achieved, all the rest are destroyed, sterilized, isolated, or otherwise put beyond the possibility of re-entering the reproductive stream...." *The Work, Wealth and Happiness of Mankind* (London, 1932), p. 679. (Hereafter referred to as *WWHM*.)

[7] Strictly speaking, the encyclopaedic works are: *The Outline of History* (London, 1920, 2 vols.), hereafter referred to as *OH*, *The Science of Life* (London, 1931, 3 vols.), hereafter referred to as *SL*, *The Work, Wealth and Happiness of Mankind* (*WWHM*), and *Experiment in Autobiography*. These works deal with world history, the biological sciences, economics and his own life.

[8] *EA* II, p. 752: "The particular brain whose ups and downs and beatings about in the world you have been following in this autobiography, has arrived at the establishment of the socialist world-State as its directive purpose and has made that its religion and end."

[9] "Let us ape Roger Bacon in his prophetic mood," Wells wrote in *OH* II, pp. 586-587, fulfilling what may well have been a dream of his youth, "and set down what we believe will be the broad fundamentals of the coming world state." Likewise, in *SL* I, pp. 14-15, he wrote, "The student, turning over the notebooks of Leonardo da Vinci, finds there the artist and scientific man inextricably mingled. From the studio and private investigations of dissatisfied medical men, far more than from the bookish study, did the modern science of life arise. Modern science owes more to art and natural curiosity and less to/literature and philosophy than is commonly understood." Leonardo was one of his heroes.

[10] George Orwell, *The Collected Essays, Journalism and Letters of George Orwell* (Harmondsworth, 1984), vol. IV, p. 293.

[11] The best biography is that of Anthony West, the natural son of H.G. Wells and Rebecca West. It does have a pathetic side to it, however, since West spent much of the book trying to establish some sort of stable, caring relationship with his father, several decades after the latter's death – as if to state emphatically that West deserved his father's love, although he never really got it.

[12] A good example of the pedagogical social novel was *The New Machiavelli*, (London, 1911, hereafter referred to as *NM*) which reads something like a school manual. Wells was aware of his own literary limitations. In *Experiment in Autobiography*, he wrote, "The majority of the Dickens novels were novels with a purpose, but they never deal with any inner confusion, any conflicts of opinion within the individual characters, any subjective essential change. A much closer approximation to the spread-out novel I was advocating is the propaganda novel. But I have always resented my novels being called propaganda novels, because it seems it me the word propaganda should be confined to the definite service of some organized party, church or doctrine. It implies direction from outside. If at times I have been inclined to thrust views upon my readers, they were at any rate my own views and put forward without any strategic aim." *EA* II, pp. 496.

[13] One can read into many passages this narcissistic identification of Wells' person with larger events, and in particular with the resolution of huge national and international problems, The following example is taken from *The New Machiavelli*: "And a hundred times when I thought of England as our country might be, with no wretched poor, no wretched rich, a nation armed and ordered, trained and purposeful amidst its vales and rivers, that emotion of collective ends and collective purposes has returned to me. I felt as great as humanity. For a brief moment I was humanity, looking at the world I had made and had still to make…" *NM* pp. 147.

[14] Wells' hero character then went on to reflect, "Almost against my natural inclination, I found myself forced to go into these things. I came to the conclusion that under modern conditions the isolated private family, based on the existing marriage contract, was failing in its work. *NM* p. 407.

[15] *OH* II, pp. 594.

[16] Christophe Canto and Odile Faliu, *The History of the Future*, translated by Francis Cowper (Paris, 1993), pp. 12-13.

[17] This interpretation is markedly different from that of Simon Wells, great-grandson of H.G. Wells, and director of the Dreamworks film *The Time Machine* (2002), for whom H.G. Wells had a fundamentally scientific outlook, and imagined future political systems where intelligence would be a criterion for holding power. Interview conducted by author, September 2002, Dreamworks Animation, Los Angeles, USA.

[18] We do not intend to explore Wells' relationship with Spinoza. Suffice it to say that Wells wrote "This conception of the body in space among objective things and consciousness which apprehends space but does not seem to occupy it, as being merely two distinct and infusible aspects of one substance, one mind-body, is called and has been called since the time of Spinoza, Monism. Spinoza's monism is the flat opposite of the extreme dualism of Descartes. It is the conception most prevalent among biological workers, and it dominates the thought of the three-fold author of this present work." *SL*, p. 853.

[19] "The soul, thought Descartes, communicated with the body through that central and unpaired organ of the brain, the pineal gland; the soul operated in the pineal gland like a captain in a conning-tower, in some way it directed the activities of the animal and automatic machine constituted by the rest of the body. Apparently Descartes was unaware that other vertebrata also possess pineal glands." *SL*, p. 850.

[20] For example, in describing the human body, Wells wrote, "A kidney consists of a multitude of cooling tubes. It is built up of tubes of two kinds. Firstly, the arteries, the veins and the capillaries which connect them together, and secondly, the *kidney-tubules*, end-branches of the ureters, in the walls of which the separating processes take place. There are roughly a million of these tubules in each kidney of a grown man. (The number of stars that a good eye can distinguish on a winter night is between two and three thousand.)" This is no more than an implicit reference to the microcosm, and may only be accidental. *SL*, p. 44

[21] "In those days I had ideas about Aryans extraordinarily like Mr. Hitler's. The more I hear of him the more I am convinced that his mind is almost the twin of my thirteen year old mind in 1879; but heard through a megaphone and – implemented. [Did not make much fuss about Jews] I had reveries

– I indulged a great deal in reverie until I was fifteen or sixteen, because my active imagination was not sufficiently employed – and I liked especially to dream that I was a great military dictator like Cromwell, a great republican like George Washington or like Napoleon in his earlier phases... And I entered conquered, or rescued, towns riding at the head of my troops, with my cousins and my schoolfellows recognizing me with surprise from the windows. And kings and presidents, and the great of the earth, came to salute my saving wisdom. I was simple even in victory. I made wise and firm decisions, about morals and customs and particularly about the Civil Service Stores which had done so much to bankrupt my father. With inveterate enemies, monarchists, Roman Catholics, non-Aryans and the like I was grimly just. Stern work – but my duty..." *EA* I, pp. 100-101. "So much for the Hitlerite stage of my development, when I was a sentimentalist, a moralist, a patriot, a racist, a great general in dreamland, a member of a secret society, an immortal figure in history, an impulsive fork thrower and a bawling self-righteous kicker of domestic shins. I will now go on to tell as well as I can how this pasty-faced little English Nazi escaped his manifest destiny of mean and hopeless employment, and got to that broader view of life and those opportunities that have at last made this autobiography possible." *EA* I, p. 107.

22 Recalling the years 1880-1881, when he had been fourteen or fifteen, he wrote, 1880-1881: "... I found Plato's *Republic*. That last was a very releasing book indeed for my mind." *EA* I, p. 138.

23 *EA* I, pp. 200-201.

24 T.H. Huxley, "On Descartes' 'Discourse Touching the Method of Using one's Reason Rightly and of Seeking Scientific Truth," in *MacMillan's Magazine*, vol. XXII, May to October, 1870.

25 R.H.Hutton, "Professor Huxley as Machine" in *The Spectator*, April 30, 1870.

26 "Marx offered to the cheapest and basest impulses the poses of a pretentious philosophy, and the active minds amidst the distressed masses fell to him very readily. Marxism is in no sense creative or curative. Its relation to the inevitable reconstruction of human society which is now in progress, is parasitic. It is an enfeebling mental epidemic of spite which mankind has encountered in its difficult and intricate struggle out of outworn social conditions towards a new world order. It is the malaria of the Russian effort to this day. There would have been a creative revolution, and possibly creative revolution of a far finer type if Karl Marx had never lived." *EA* I, p. 180.

27 This is the thesis of *The Time Machine*.

28 *EA* II, pp. 644-645.

29 "So the magnificent dream of the nineteenth century," Wells wrote in *When the Sleeper Awakes*, " the noble project of universal individual liberty and universal happiness, touched by a disease of honour, crippled by a superstition of absolute property, crippled by the religious feuds that had robbed the common citizens of education, robbed men of standards of conduct, and brought the sanctions of morality to utter contempt, had worked itself out in the face of invention and ignoble enterprise, first to a warring plutocracy, and finally to the rule of a supreme plutocrat. His Council at last ceased even to trouble to have its decrees endorsed by the constitutional authorities, and he a motionless, sunken, yellow-skinned figure had lain, neither dead nor living, recognizably and immediately Master of the Earth. And awoke at last to find himself – Master of that inheritance! Awoke to stand under the cloudless empty sky and gaze down upon the greatness of his dominion." *When the Sleeper Awakes*, in *Three Prophetic Science Fiction Novels of H.G. Wells* (New York, 1960) p. 101.

30 In this respect, the Wellsian scholar Leon Strover has undertaken an interesting analysis of the ideological origins of Wells' scientific romances, and the influences of Henri de Saint-Simon, Jules Verne and others. Introduction to Leon Strover (ed.) *H.G. Wells: The First Men in the Moon: a Critical Text of the 1901 Edition* (Jefferson, N. Carolina, 1998).

31 The most notable reference by Wells to evolution is contained in *The Island of Dr. Moreau.*

32 In *War of the Worlds*, we read, "They were described as 'vast spider-like machines, nearly a hundred feet high, capable of the speed of an express train, and able to shoot out a beam of intense heat.' Masked batteries, chiefly of field guns, had been planted in the country about Horsell Common, and especially between the Woking district and London. Five of the machines had been seen moving toward the Thames, and one, by a happy chance, had been destroyed." *War of the Worlds*, p. 76. "When I looked again, the busy handling machine had already put together several of the pieces of apparatus it had taken out of the cylinder into a shape having an unmistakable likeness to its own. And down on the left a busy little digging mechanism had come into view, emitting jets of green vapor and working its way around the pit, excavating and embanking in a methodical and discriminating manner. This it was which had caused the regular beating noise and the rhythmic shocks that had kept our ruinous

refuge quivering. It pied and whistled as it worked. As far as I could see, the thing was without a directing Martian at all." *Ibid.*, p. 130.

[33] "I crouched, watching this fighting machine closely, satisfying myself now for the first time that the hood did indeed contain a Martian. As the green flames lifted I could see the oily gleam of his integument and the brightness of his eyes. And suddenly I heard a yell, and saw a long tentacle reaching over the shoulder of the machine to the little cage that hunched upon its back. Then something – something struggling violently – was lifted high against the sky, a black, vague enigma against the starlight. As this black object came down again I saw by the green brightness that it was a *man*. For an instant he was clearly visible. He was a stout ruddy middle-aged man, well dressed. Three days before he must have been walking the world, a man of considerable consequence. I could see his staring eyes and gleams of light on his studs and watch chain. He vanished behind the mound and for a moment there was silence. And then began a shrieking and a sustained and cheerful hooting from the Martians." *Ibid.*, p. 134.

[34] George Tombs, *Paradise, the Apocalypse and Science: the Myth of an Imminent Technological Eden*, M.A. dissertation, McGill University, 1997, p. 76.

[35] "The Socialism of my beliefs rests on a profounder faith and a broader proposition. It looks over and beyond the warring purposes of to-day as a general may look over and beyond a crowd of sullen, excited and confused recruits, to the day when they will be disciplined, exercised, trained, willing and convergent to a common end. It holds persistently to the idea of men increasingly working in agreement, doing things that are sane to do, on a basis of mutual helpfulness, temperance and toleration. It sees the great masses of humanity rising out of base and immediate anxieties, out of dwarfing pressures and cramped surroundings, to understanding and participation and fine effort. It sees the resources of the earth husbanded and harvested, economized and used with scientific skill for the maximum of result. It sees towns and cities finely built, a race of beings finely bred and taught and trained, open ways and peace and freedom from end to end of the earth. It sees beauty increasing in humanity, about humanity and through humanity. Through this great body of mankind goes evermore an increasing understanding, an intensifying brotherhood. As Christians have dreamt of the New Jerusalem so does Socialism, growing ever more temperate, patient, forgiving and resolute, set its face to the World City of Mankind." *First and Last Things*, pp. 284-285.

[36] *Anticipations* (New York, 1999), p. 56.

[37] *Ibid.*, pp. 46-47.

[38] *Ibid.*, pp. 79-80.

[39] In this respect, Wells owed an intellectual debt to Saint-Simon, the Christian socialist, who "reversed" the Golden Age, placing in not in the past, as Hesiod and Ovid had done, but in the future instead. Jean Delumeau has made an interesting analysis of this reversal in *L'histoire du paradis*, vol. II. Saint-Simon used age-old metaphors such as the body politic, and newer ones, such as the pyramid, which he used to illustrate a perfect political hierarchy, with the monarch on the top. Since for Saint-Simon the State was a machine, the place of the governing class would be taken by a new class of administrators drawn from the ranks of science and other modern disciplines. This prefigured the utopian technocracy advocated by Wells.

[40] *Ibid.*, p. 86.

[41] *Ibid.*, p. 89.

[42] "The law that dominates the future is glaringly plain. A people must develop and consolidate its educated efficient classes or be beaten in war and give way upon all points where its interests conflict with the interest of more capable people.... The war of the coming time will really be won in schools and colleges and universities, wherever men write and read and talk together. The nation that produces in the near future the largest proportional development of educated and intelligent engineers and agriculturists, of doctors, schoolmasters, professional soldiers, and intellectually active people of all sorts; the nation that resolutely picks over, educates, sterilizes, exports, or poisons its People of the Abyss; the nation that succeeds most subtly in checking gambling and the moral decay of women and homes that gambling inevitably entails; the nation that by wise interventions, death-duties and the like, contrives to expropriate and extinguish incompetent rich families while leaving individual ambitions free; the nation, in a word, that turns the greatest proportion of its irresponsible adiposity into social muscle, will certainly be the nation that will be the most powerful in warfare as in peace, will certainly be the ascendant or dominant nation before the year 2000." *Ibid.*, p. 120.

[43] "Consider what it will mean to have perhaps half the population in the world, in every generation, restrained from or tempted to evade reproduction! This thing, this euthanasia of the weak and sensual, is possible. On the principles that will probably animate the predominant classes of the new time, it will be permissible, and I have little or no doubt that in the future it will be planned and achieved." *Ibid.*, p. 173.
[44] *Ibid.*, p. 138.
[45] *Ibid.*, pp. 167-168
[46] "Although it has never had any great popular sale," he wrote in his autobiography, "*A Modern Utopia* remains to this day one of the most vital and successful of my books. It is as alive to-day as *Mankind in the Making* is dead. It was the first approach I made to the dialogue form, and I am almost satisfied with its literary quality as I am with that of *The Undying Fire.* The trend towards dialogue like the basal notion of the Samurai, marks my debt to Plato. *A Modern Utopia*, quite as much as that of More, derives frankly from the *Republic.*" *EA* II.658.
[47] *A Modern Utopia*, p. 30.
[48] *Ibid.*, pp. 39-40.
[49] *Ibid.*, pp. 60-61.
[50] *Erewhon*, p. 87.
[51] *Ibid.*, pp. 246 & 248.
[52] According to Bellamy, utopian functionaries at Washington would be men of no more than fair ability, whose power resided in their ability to manipulate the machine of government: "The machine which they direct is indeed a vast one, but so logical in its principles and direct and simple in its workings, that it all but runs itself; and nobody but a fool could derange it, as I think you will agree after a few words of explanation." Edward Bellamy, *Looking Backward: 2000-1887* (Harmondsworth, 1986), p. 140.
[53] *A Modern Utopia*, p. 102.
[54] For example, Wells conceived a system of transparent index cards, containing private information about every citizen. "These index cards might conceivably be transparent and so contrived as to give a photographic copy promptly whenever it was needed, and they could have an attachment into which would slip a ticket bearing the name of the locality in which the individual was last reported. A little army of attendants would be at work upon this index day and night. From sub-stations constantly engaged in checking back thumb-marks and numbers, an incessant stream of information would come, of births, of deaths, of arrivals at inns, of applications to post-offices for letters, of tickets taken for long journeys, of criminal convictions, marriages, application for public doles and the like. A filter of offices would sort the stream, and all day and all night for ever a swarm of clerks would go to and fro correcting this central register, and photographing copies of its entries for transmission to the subordinate local stations, in response to their inquiries. So the inventory of the State would watch its every man and the wide world write its history as the fabric of its destiny flowed on. At last, when the citizen died, would come the last entry of all, his age and the cause of death and the date and place of his cremation, and his card would be taken out and passed on to the universal pedigree, to a place of greater quiet, to the ever-growing galleries of the records of the dead. Such a record is inevitable if a Modern Utopia is to be achieved." *Ibid.*, pp. 164-165. *A Modern Utopia* resembles *The Prisoner*, which we alluded to in the Introduction, in that the Village's constant gathering of personal information about the individual provides the very basis for social control. But whereas Wells was in favour of state surveillance, Number 6 in *The Prisoner* always managed to conceal his thoughts from the authorities of the mysterious Village. His cunning defiance opened up a small space of freedom for him, making life in his prison community liveable.
[55] *EA* II, pp. 659-660.
[56] *Russia in the Shadows s*(London, 1920), pp. 137-138.
[57] *Ibid.*, pp.138-139.
[58] "The terrible experiences of the Great War have made very many men who once took political things lightly take them now very gravely. To a certain small number of men and women the attainment of a world peace has become the supreme work of life, has become a religious self-devotion. To a much greater number it has become at least a ruling motive. Many such people are seeking ways of working for this great end, or they are already working for this great end, by pen and persuasion, in schools and colleges and books, and in the highways and byways of public life." *OH* II, p. 581.

[59] *OH* II, p. 595.
[60] *OH* II, p. 585.
[61] *OH* II, pp. 586-587.
[62] *WWHM*, pp. 311-312.
[63] *SL*, p. 274.
[64] *Ibid.*, p. 395.
[65] *Ibid.*, p. 425.
[66] In his opinion, "based on a general weighing of alternatives, that, as a matter of history, life on this planet originated from not-life, that it originated at one phase and at one phase only, that it probably originated in the surface waters of the warm early globe, and that sunlight, that 'only begetter' of all terrestrial activities, played a necessary part in its origin. [The hints we have come up with so far] also hold out a hope that we shall one day be able to make living matter artificially. But that, if ever it arrive, may be a long time coming. To be impatient with the biochemists because they are not producing artificial microbes is to reveal no small ignorance of the problems involved. Living matter is matter: but it is quite appallingly complicated matter, many times more complex in its construction than any other substance known anywhere in the universe. It has been evolved through billions of generations under the filtering action of Natural Selection which has rejected every false try and unsuccessful experiment. We rightly praise the skill of the chemists who build up dyes and drugs to order, but to build up living matter, substances as complicated as their highest achievements in synthesis would have to be used as the basic bricks. In any attempt at making living matter, we begin about where the modern organic chemist leaves off, and we begin more than a thousand million years of evolution behind contemporary living cells." *Ibid.*, pp. 434-435
[67] *Ibid.*, p. 25.
[68] *Ibid.*, p. 21.
[69] *Ibid.*, p. 24.
[70] *Ibid.*, pp. 32 & 42.
[71] *Ibid.*, 60.
[72] *Ibid.*, p. 61.
[73] *Ibid.*, p. 764.
[74] *Ibid.*, p. 68.
[75] *Ibid.*, p. 77.
[76] *Ibid.*, p. 83.
[77] *Ibid.*, pp. 750-751.
[78] "All those who have had experience of birth-control work in the slums seem to be convinced that there is a residuum, above the level of the definable 'defective', which is too stupid or shiftless or both to profit by existing birth-control methods. These 'unteachables' constitute pockets of evil germ-plasm responsible for a large amount of vice, disease, defect, and pauperism. But the problem of their elimination is a very subtle one, and there must be no suspicion of harshness or brutality in its solution. Many of these low types might be bribed or otherwise persuaded to accept voluntary sterilization." *Ibid.*, p. 968.
[79] *Ibid.*, p. 685
[80] *Mind at the End of its Tether*, p. 67.
[81] This view is shared, for example, by Jean Delumeau, author of the remarkable three-volume work, *Histoire du paradis*. According to Prof. Delumeau, the hope that Wells had placed in a bright new future, dominated by the mythology of machines, simply "collapsed" in his declining years. Interview conducted by author, July 2002, Collège de France, Paris.
[82] *Mind at the End of its Tether*, p. 69
[83] *Ibid.*, pp. 69-70.
[84] *Ibid.*, pp. 71 & 73.

CONCLUSION

In this work, we have traced the metaphor of Man the machine back to its roots in Greek Antiquity, noted its appearance during the Italian Renaissance, and then followed its subsequent development during the following five centuries. The metaphor is important, given what seems to be the growing convergence nowadays of man and machine, in areas such as artificial intelligence, genetic engineering, genomics and medical science.

As we have seen, historical interpretations of man the machine have gone through four distinct phases from the late fifteenth to the mid-twentieth century. First came the Renaissance portrayal of bodily mechanisms in the artistic and anatomical works of Leonardo, Vesalius and Harvey, among others.

That man should be a machine had philosophical implications, which were duly investigated first by Descartes and Hobbes as they articulated *la philosophie mécanique* and cast man as a mechanical machine, and then by Leibniz, who sought to spiritualize Nature by portraying man as a metaphysical machine.

During the radical Enlightenment, La Mettrie and d'Holbach developed a highly reductionist materialism, which cut man loose from religion, exalted the purely physical description of the natural universe and represented man as a rationalistic machine. Marx acknowledged the importance of French materialism in the development of his own system – communism. While he denounced capitalism for treating man as a mere manufacturing sub-unit, his ideology paradoxically ended up relegating man to the slave-like existence of a collectivist cog.

Finally, Wells articulated a synthetic vision grounded in Evolution, intellectual elitism and scientific prophecy, culminating in the utopian ideal of the technocracy. According to this ideal, man was an information machine, to be kept under surveillance and to be directed by other machine-like technocrats seated at their "glowing desks".

The table below summarizes some of the main features of interpretations considered in our work:

Author	**Interpretation of Man the machine**
Leonardo	Man is an organic machine (comparable to springs, joints, cables & pulleys), with mechanical processes (such as clutching, raising, swimming, seeing, smelling & feeling); man can be compared to an automaton, and can serve as a model for machines (owing to mathematical predictability, harmony & rationality); man is God's mechanical masterwork - a universal machine
Vesalius	The human body is perfectly coherent (i.e. well-planned by the wise Creator, the divine Author of the human fabric); it is a complex series of intricate mechanisms which should be observed and experimented upon in the dissection of human cadavers, to bolster the science of anatomy and serve as a foundation for the practice of medicine
Harvey	God, Nature, or the Soul of the Universe (however the Creator is designated) has fashioned the heart as a mechanical pump, in which the expansion and contraction of ventricles and auricles allows the continuous circulation of a finite amount of blood throughout the body – this mechanical model is admirable in its symmetry
Descartes	God's thought produced both the great machine of the universe (which is indefinitely extended, in constant motion, harmonious and well ordered) and the self-moving machine of Man (which can be likened to automata, clocks, artificial fountains, mills and other man-made, self-moving machines); Descartes moved from metaphor to equation by likening man to machine – the finest example of the human mechanism is the circulation of the blood
Hobbes	The universe is a machine, and all that it contains is matter in motion; since the body is in the universe, the body is also matter in motion, and therefore a clocklike machine; the human body and the State are compared prescriptively to highly perfected automata

Leibniz	All particular natural phenomena can be explained mathematically or mechanically by those who understand them – but the general principles of corporeal nature and mechanics are metaphysical; spiritual automata contain everything that is beautiful in mechanism – but by virtue of preformation, of mirroring from all time in their monad-like parts the entire universe, as well as the perfections of God, they go well beyond mechanism; each created substance mirrors the whole; a sentient or thinking being is not a mechanical thing like a watch or a mill; nevertheless, the human soul can be conceived as a most exact immaterial automaton
La Mettrie	Man is a purely material machine, whose thoughts and actions depend on how the human machine is variously constructed; *a priori* speculative philosophy about the nature of man, is less valid than *a posteriori* reasoning, based on direct anatomical observation of man's organs; man is a clock-like machine, in that every organ functions as a cog or spring, contributing to the orderly movement of the whole; it is in this functional movement that we detect both the mechanical nature of man and the complexity of that mechanism, since countless cogs and springs operate independently of one another; while the artistry of this clocklike mechanism is admirable, there is no divine clockmaker
d'Holbach	Man is matter in motion, the work of Nature, and subject to her laws, from which he cannot free himself; motion is the motive principle of all existence, connecting our organs to external and internal objects; man, like a clock, is an organized whole of matter in motion, and thus has none of the spiritual, immaterial attributes (a soul joined to his body) the existence of which speculative philosophers and theologians have long assumed; Nature is a machine, of which the human species makes a part; the metaphor of Man the machine provides (a) a rational model for the proper organization and functioning of matter, (b) a reductionist image which can be used to explain any human thought or feeling, whether it be the product of an orderly mechanism or of confusion in his machine, and (c) a utilitarian justification for the determinist view that universal necessity is only a consequence of the nature of things, in virtue of which the whole acts by immutable laws
Marx	Man is a purely material being in a godless material universe; capitalism condemns the individual worker to an insecure, alienated existence as a mere mechanism within vast manufacturing systems invested with identity and mechanical intelligence; manufacturing technology is monstrous, demonic, gigantic, feverish and whirling – according to

	Marx's theory, under communism everything would be different – but in practice, as experience showed, man became even more of a faceless cog, within the communist Automated State
Wells	Man is not God's creation, he is the outcome of Evolution, of life issuing from non-life; the human body is an intricate series of mechanical structures and processes, which can be directly compared to mechanical inventions (like the central telephone exchange and the camera); this machine metaphor often relates to the generation and transmission of information within the human body; the State should be collectivist and fully automated (like a linotype machine, an antiseptic operating plant or an electric tramcar), and be subject to the benevolent rule of technocrats, who will keep it running just as smoothly as they would any other complex mechanical device

As this summary suggests, it is undeniable that the metaphor of Man the machine has offered considerable advantages. It has given wings to thought. At first, it was associated with a new and overtly mechanical framework of the fifteenth century, sometimes called the "Paduan methodology", which consisted in taking apart a subject, such as human nature, as if it were a clock, and analysing its contents in a systematic fashion. In many respects, this methodology provided the foundation for the development of early modern science, from the fifteenth to the eighteenth centuries.

Man seemed to gain powerful attributes when compared to the machine – attributes such as order, symmetry and beauty. The metaphor also emphasized the value of rationality, the organization of society and the heightened potential of humans themselves.

The admirable design of the human body has been explored continuously from the late fifteenth century onwards. There has been, nonetheless, an important transition in the significance given to the notion of "design": the inspired teleology of God's Renaissance workshop and the Baroque clockwork universe gave way, from the eighteenth century onwards, to a masterful biological design that nevertheless had developed without any personified designer. It is interesting to note that both the Judaeo-Christian and instrumental-naturalist world-views maintain that life on Earth proceeded from non-life, although the two world-views account for this in vastly different ways.

But the metaphor also proved, over time, to have significant disadvantages. With the growing sophistication of technology and the instrumental approach supporting it, the metaphor became loaded in favour of the machine. It was transformed from a simple metaphor into an equation (Descartes), a prescription (Hobbes), and finally a substitute (Marx/Wells). Since the Enlightenment, this transformation has strengthened the emergence of the instrumental-naturalist world-view. The effect of this view has been to situate man in a flat, dehumanized, one-dimensional world, and to make it more difficult, at least in Western industrialized countries, to sustain a spiritual view of the world. The resulting loss of human identity has been accompanied by a series of rising temptations: to manipulate and engineer humans beings; to exercise means of absolute social and political control, thus limiting individual liberty; to make man subservient to one of his creations – the machine.[1]

In this work, we have knowingly used a historical frame of reference, as a way of showing the particular aspects of human identity that have been challenged and in some cases lost since the Renaissance. Few people today "believe" in the microcosm. We have nevertheless included it in our frame of reference, as a way of underlining the fact that a person has many dimensions – biological, psychological, moral and spiritual. A person has many resources: the ability to master himself or herself, the ability to reason and to know happiness and to have a sense of wonder. Of course, a person has the capacity to love and procreate, to experience, to act according to conscience and to show compassion towards others. According to the spiritual perspective, a person has the potential to draw close to God. These are all things a machine will never do.

We have sought to show that the relationship of man and machine needs to be constantly renegotiated. Humanity's relationship with science, and its many applications through technology, will continue to unfold during the twenty-first and future centuries. Technological innovations amaze and bewilder us, because they are so novel, and their consequences, in artificial intelligence, genetic engineering and genomics, to cite just three examples, offer such promise.

Technology is a "hot" topic nowadays, because the technologies of today and tomorrow are far more powerful – and potentially more threatening – than fifteenth century pulleys, seventeenth century clocks, artificial fountains and mills, or nineteenth century manufacturing systems and electric tramcars. Today's smart machines sometimes make us feel stupid: they are derived from algorithms and logic-based systems that mimic the mechanisms of our own actions and thoughts, so that artificial mechanisms can become more structured, efficient and productive than we ourselves. Western popular culture is increasingly fascinated with the individualized virtual utopia of cyberspace, where computer software seems to fulfill and even anticipate our innermost fantasies.[2]

The intention behind artificial intelligence may not always be to surpass humanity, but the idea that "everything going on within us" can be reduced to some sort of engineered code is derived from a fantasy of total power, that offers commercial profits but only the illusion of personal satisfaction. In any case, it would have been better to call artificial intelligence by a less ambiguous name. Expert systems, as a tool in the hands of medical professionals, have proven useful, however.

Some commentaries about artificial intelligence narrowly focus on novelty, instrumentality and efficiency, as well as the superior processing power of computers as compared to humans, without considering the human context in which machines are developed and used. Moreover, the claim by Raymond Kurzweil that computers can actually be "spiritual" is an abuse of language, and one designed to sell books as much as to hype technology. The idea of artificial spirituality is nonsense. Spirituality is something reserved for humans, but derived from God. We are not artificial beings dreamed up at the "glowing desk" of a technocrat. Kurzweil has put a new spin on things, by describing the machine as a quasi-person.

The Human Genome Project has set out to catalogue all the genes in the human body, and eventually to trace the mechanisms by which specific genes are associated with health and disease – frequently by making comparisons with "homologues" in the genomes of other species, such as worms, beer yeast and mice. This is an impressive undertaking, in its own way as wide-ranging as the *Fabrica* of Vesalius, and as likely to revolutionize medical knowledge. By definition, the Human Genome Project is technology on a human scale – it seeks to discover the true measure of man, at least in genomic terms. It has been undertaken for the public benefit of humanity, and is expected to lead to bold new diagnostic and therapeutic applications. The scientific ambitions of the project are immense, but John Sulston has characterized them in modest terms: "The complexity of control, overlaid by the unique experience of each individual, means that we must treat every human as unique and special, and not imagine that we can predict the course of a human life other than in broad statistical terms."[3]

Advocates of high tech's power to utterly transform humans and the face of the planet would do well to show the same motivations and modesty. This is not to say that Sulston's words amount to a defence of metaphysics or spirituality, in the face of instrumental-naturalism or potentially invasive technologies.[4] On the contrary, science is now secular, i.e. kept at a respectful and, one might add, a safe distance from religion.

The Human Genome Project offers an interesting position in the new negotiation opening up between man and machine. According to Sulston, the project has from the beginning promoted the values of information sharing among scientists, public access to information, and management of new knowledge in an equitable way, with benefits shared broadly across the human community.

Sulston's writings, most notably in *The Common Thread*, indicate several important features of the new negotiation: If the human body is a biological machine, how can the machine model provide us with a better understanding of biological mechanisms? How can the unique experience of the individual be acknowledged and respected? Many private interests are poised to exploit knowledge of genetic mechanisms – but should it be possible for those interests to patent individual genes within the human body, to treat them as commodities, as if they were merely mechanical devices up for grabs on a winner-take-all basis? Are technologies based on human mechanisms being developed for public benefit or merely for private gain? Will these technologies be accessible to low-income developing countries as well as to wealthy industrialized countries? Are the risks posed by such technologies properly understood, whether in terms of privacy or safety? Are such technologies likely to extend our potential, or to diminish it instead? Is there some way of anticipating the effects of technology development, given the power of some innovations to transform our relationship with Nature and with each other? Remembering that we are men and women, not disposable machines, will help us answer such question wisely. So will revisiting the profound historical, philosophical and spiritual roots of our civilization.

In this work, we have made a few claims about spirituality, without, however, citing spiritual or other religious authorities in defence of these claims. This has been deliberate.

Science is made up of hypotheses, observations and experiments, subject to constant renewal and replacement. Scientific knowledge cannot definitively answer the fundamental questions of where we come from, why we are here, and where we are going. Some scientists refuse to answer these questions, as they are simply unanswerable in a scientific context. At the same time, the instrumental-naturalist world-view that has grown up around modern science is one-dimensional and cannot represent the person in terms solely of observable facts and mechanisms.[5] But this world-view has proven so compelling that scientific knowledge often ends up being diverted away from its original secular course, to support larger moral evaluations and powerful allegories, as if it were a substitute for religious belief.

Meanwhile, from Galileo to Darwin, religious institutions have sometimes engaged in a conflict with modern science over the matter of knowledge. Biblical literalism and appeals to religious authority only obscure the issue, where science is concerned. According to André Chouraqui, author of *L'Univers de la Bible*,[6] and the only person ever to have translated the Torah, the New Testament and the Koran, "*The Bible* is not a scientific work."[7] It reflects the state of knowledge at the time when it was written and edited, and is thus not a reliable source of information, today, on physics or biology. *The Bible* is certainly not in competition with contemporary science. The particular details in religious traditions age. The underlying values, since they are universal, do not.

In any case, spiritual knowledge is not a rational programme. It consists of a form of unknowing, which is elusive and has generally been distorted by the over-rationalizations of systematic theologians and Christian philosophers (one has only to think of Descartes). This form of unknowing is best experienced through love. But love is better lived than described, let alone argued about. Love cannot be "modeled" with a computer!

That science and spirituality do not converge at a recognizable meeting-point has long been recognized. "Philosophy," Francis Bacon wrote, "may therefore be conveniently divided into three branches of knowledge: knowledge of God, knowledge of Nature, and knowledge of Man, or Humanity.... The divisions of knowledge are not like several lines that meet in one angle, but are rather like branches of a tree that meet in one stem (which stem grows for some distance entire and continuous, before it divide itself into arms and boughs)...."[8]

The Renaissance recovery of the classical value that man could be the measure of all things amounted to an intellectual revolution in its own right. It handily displaced the medieval view that God was the only appropriate measure, and placed the focus on everything to be gained by the study of humanity. The universal men of the Renaissance, like Alberti and Leonardo, were able to redirect their focus, while keeping in close touch with their inner, spiritual nature.

As long as "man the machine" was used in a context where man was still the measure of all things, as long as technology was still on a human scale, the metaphor was relatively benign. The machine is a tool, which can be used for good or ill. The negative and destructive effects of technology on humanity will increase if the machine is taken to be the measure of all things, a model, an equation, a prescription and even a substitute for living men and women. If the machine is placed once again at the service of humanity, then it is more likely that positive and creative effects will flow from the machine.

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[1] Charles Taylor's *Sources of the Self* gives a comprehensive view of the resistance to the new instrumental view, from Cambridge Platonism through Christian piety and Romanticism. A modern example of resistance in popular culture, is *The Prisoner*, whose defiant words in the first episode, *Arrival*, are still capable of stirring us today, many years later: "I will not make any deals with you. I've resigned. I will not be pushed, filed, stamped, indexed, briefed, debriefed or numbered. My life is my own."

[2] Examples are the recent Hollywood films *Artificial Intelligence* and *Simone*.

[3] John Sulston and Georgina Ferry, *The Common Thread* (London, 2002), p. 250.

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[4] It should be noted that Sulston emphatically disagrees with my views on spirituality.
[5] On this subject, see Taylor, *op. cit.*, especially pp. 382-384.
[6] André Chouraqui, *L'Univers de la Bible* (Paris, 1982) 10 vols. & *Le Coran, l'appel* (Paris, 1990).
[7] Interview conducted by author, October 2002.
[8] *De Dignitate et Augmentis Scientiarum*, in *Francis Bacon: A Selection of His Works*, p. 412.

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In the first category appear (a) reference works, (b) general works on history, philosophy, religion and science written before 1900, and (c) general works on history, philosophy, religion and science written after 1900.

In the second category appear (a) Primary (Literary) Sources related to a specific chapter (Leonardo, Vesalius etc.), and (b) Secondary Sources related specifically to that chapter. In some cases, individual critical and interpretative essays, which have proven particularly interesting, are listed separately from the volumes of such essays in which they appeared. The latter volumes appear under the name of the volume editor.

Many works consulted were not literary, for example Leonardo's drawings, notebooks, paintings, statuary, models and engineering works. These works have been consulted in travelling or permanent exhibitions in a variety of locations, from Montreal to New York, Washington, London, Paris, Milan, Florence and Venice to Krakow and St. Petersburg. Also a visit to the anatomical theatre at the University of Padua proved helpful, although in its current form, it more likely dates back to the time of Harvey and Hobbes than to that of Vesalius. Finally, the author conducted interviews with leading scientists, scholars and a film director.

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