
RITCHIE
ROBERTSON
The
Enlightenment
The Pursuit of
Happiness
1680–1790
'Humane, learned
and gloriously rich'
TOM HOLLAND, THE TIMES

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THE ENLIGHTENMENT

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'Robertson's far-flung thematic survey probes the work of philosophers and ideologues, among them Thomas Jefferson, Voltaire, and Immanuel Kant, and expertly interprets the period's art and literature, including Samuel Richardson's melodramatic novel *Clarissa*, which set all of Europe to weeping. Thanks to Robertson's elegant prose and lucid analyses, this massive and deeply erudite work serves as a stimulating and accessible introduction to a watershed period in the intellectual development of the West' *Publishers Weekly*

ABOUT THE AUTHOR

Ritchie Robertson is Taylor Professor of German at the University of Oxford. He is a member of the board of the Voltaire Foundation, which promotes research on the Enlightenment, and is a frequent reviewer for the *Times Literary Supplement*.

RITCHIE ROBERTSON

The Enlightenment

The Pursuit of Happiness, 1680–1790

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Penguin Books is part of the Penguin Random House group of companies
whose addresses can be found at global.penguinrandomhouse.com

First published by Allen Lane 2020
Published in Penguin Books 2022
001

Typeset by Jouve (UK), Milton Keynes
Printed and bound in Great Britain by Clays Ltd, Elcograf S.p.A.

The authorized representative in the EEA is Penguin Random House Ireland,
Morrison Chambers, 32 Nassau Street, Dublin D02 YH68

A CIP catalogue record for this book is available from the British Library

ISBN: 978–0–141–97940–3

www.greenpenguin.co.uk

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To Katharine

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Preface

Historians often claim that the period they are studying or writing about is important for the present, but it is undeniable that the Enlightenment has a particularly urgent message for our time. Opponents of tyranny, injustice and superstition often appeal to 'the values of the Enlightenment'. With the definite article, 'the Enlightenment' refers to a historical period, which for the purposes of this book runs from about 1680 to about 1790. Within this, the Enlightenment stands for the endeavours of thinkers, writers and practical administrators in many countries to increase the well-being of humanity, and to do so by the process called (without the article) 'enlightenment'. For them, to enlighten humanity is to clear away the false beliefs which have blinded people to their own interests; to oppose the power of institutions, especially the organized Churches, which have encouraged such blindness; to arrive at a true understanding of human nature, and of the political and economic societies in which people live; to increase people's well-being and happiness; and to do so by close attention to empirical facts and the use of reason. The conviction animating these endeavours is that the world need not be a vale of tears; the earth is the destined home of humanity, and a place where happiness is attainable.

Recently, the case for the Enlightenment has been put with particular eloquence by the psychologist Steven Pinker and the philosopher Susan Neiman. 'The era', according to Pinker, 'was a cornucopia of ideas, some of them contradictory, but four themes tie them together: reason, science, humanism, and progress.'[1] Neiman's summary of Enlightenment values has a somewhat different emphasis. Alongside freedom and autonomy, she singles out 'happiness, reason, reverence and hope' as 'values cherished by every thinker who was central to the Enlightenment'.[2] By including 'reverence', perhaps surprisingly, Neiman means that the believers in a rational religion, who formed much of the Enlightenment mainstream, meant to substitute for the questionable God presented by the Churches a conception of divinity that measured up to humanity's moral intuitions.

There is, however, another view of the Enlightenment, which was acknowledged, even when being dismissed, by another defender of the

Enlightenment, the late historian Eric Hobsbawm, in a lecture he delivered in 1992:

> I believe that one of the few things that stands between us and an accelerated descent into darkness is the set of values inherited from the eighteenth-century Enlightenment. This is not a fashionable view at this moment, when the Enlightenment can be dismissed as anything from superficial and intellectually naïve to a conspiracy of dead white men in periwigs to provide the intellectual foundation for Western imperialism. It may or may not be all that, but it is also the only foundation for all the aspirations to build societies fit for *all* human beings to live in anywhere on this Earth, and for the assertion and defence of their human rights as persons.[3]

The 'dead white men in periwigs' have been accused of holding, and imposing on others, a blinkered, rationalistic view of the world; of using science and technology to confirm humanity's domination of nature, ultimately for the benefit of industrial capitalism; of reducing human beings to interchangeable, manipulable units, and classifying them in schemes that reinforced race- and gender-based hierarchies; and of subjecting the non-European world to an imperialism justified by Western claims to possess universal values.[4]

The grain of truth in some of these charges has been hugely exaggerated by two factors. The first is simply insufficient knowledge of what was really said, written and done in the Enlightenment. The second is a fault to which even defenders of the Enlightenment are sometimes prone: what historians call 'presentism' – that is, a tendency to see the past only from a present-day perspective, and to ignore or underestimate its difference from the present. Pinker's term 'humanism', for example, could mislead incautious readers. Nowadays it serves well to define a secular morality, based not on supposedly divine commandments but on the sympathies which, as Enlighteners increasingly realized, bound human beings together in a community that transcended national frontiers. Yet the word 'humanism' was not used in this sense until the mid-nineteenth century.

In this book, I have tried to remain aware of the continuities between the present and the past, but to avoid projecting present-day concerns onto a period separated from us by several centuries. The proponents of the Enlightenment, whom I shall henceforth call 'Enlighteners', inhabited a very different world from ours and had very different assumptions. In the opinion of most Enlighteners, God had planned the universe in accordance with laws (which had recently been discovered by Isaac Newton), and had then left it to run its orderly course. Only a small minority thought there was no God, and they took care not to advertise their scepticism. Even the

boldest thinkers estimated the age of the earth at no more than a hundred thousand years. Species were thought to be constant: God would not have created beings only to let them become extinct. In the political world, the default mode of government, despite its acknowledged shortcomings, was monarchy. Republics were rare. Direct democracy, as known mainly from the history of ancient Rome and Athens, was distrusted, because experience showed that power usually fell into the hands of demagogues and this led to anarchy, followed by tyranny. Only representative democracy could work, as in the fledgling United States and – to a still very limited extent – in Britain. Women could have no part in politics, though this assumption was rendered dubious by the conspicuous success of women in governing the empires of Austria and Russia. We should not expect to find in the Enlightenment, therefore, some early version of the liberal values of the present day; but we can certainly find there the seedbed in which many of these values germinated.

I have tried to present a rounded picture of the Enlightenment, and, in doing so, to challenge some of the current notions about it. In particular, the cliché of 'the age of reason' needs to be questioned. Yes, Enlighteners did indeed advocate and exemplify the use of reason, as opposed to blind trust in authority. The claims made by authorities, notably the Churches, needed to be challenged: philosophically, by disclosing the often glaring flaws in their arguments, and historically, by asking what foundation there was for the assertions made in the Scriptures and in subsequent theological writings. Moreover, reason had many obvious practical applications. In education, in criminal law and in farming, for instance, there were many methods inherited from earlier generations which, on examination, showed themselves to be unsuitable for their alleged purposes. So there is a lot in this book about practical enlightenment: about the concrete proposals by Enlighteners, including enlightened monarchs, for making the world better and people happier. Whether by freeing people from false beliefs or by increasing their material well-being, the pursuit of happiness, long before Thomas Jefferson used the phrase in drafting the American Declaration of Independence, was the overriding purpose of enlightened thought and activity. Accordingly, although 'reason' is an important concept throughout this book, its governing idea is the pursuit of happiness.

It should not be thought that in setting up reason against traditional authority, the Enlightenment, as some of its critics have argued, was in danger of creating another authority just as tyrannical as its predecessors. The process of enlightenment consists not in teaching people what to think, but in teaching them *how* to think. Immanuel Kant's famous formulation, published in 1784, cannot be repeated too often: the

watchword of enlightenment is 'Have the courage to use your *own* intellect!'

Nor should reason be identified with logic and calculation. The philosophers of the seventeenth century regarded geometrical reason, where each statement follows ineluctably from the foregoing, as the model of rational thought. In the Enlightenment itself, 'reason' is much more often synonymous with 'good sense' or 'common sense'. Common sense can be a force for change: one can look at a time-honoured practice, such as hereditary monarchy or capital punishment, and ask for evidence that it really achieves what it is conventionally supposed to.

What the slogan 'the age of reason' obscures, however, is that the Enlightenment was also the age of feeling, sympathy and sensibility. Well before the Enlightenment, legal theorists in particular had asked about the sources of social solidarity that bound people together into a community. Enlighteners argued that fellow feeling, mutual sympathy, was at the heart of human nature and of people's coexistence in society. Society was not an aggregation of isolated individuals, but a body of people interconnected by the exchange of emotions. Human interconnectedness, an innate love of dealing with one another and exchanging goods, was the impulse that Adam Smith identified as the basis of commercial society. It was no accident that Smith wrote first a treatise on emotions and later a treatise on economics. *The Wealth of Nations* (1776) presupposed the earlier *Theory of Moral Sentiments* (1759). The Enlightenment actively promoted what Pinker calls 'the humanitarian revolution'.[5]

The term 'age of reason' also implies a false opposition between reason and religion. Certainly the Enlightenment strongly opposed the ill-founded historical and philosophical claims made by the Churches, and the moral tyranny for which these claims provided a pretext. They equally opposed the prevalence of superstition among uneducated people. But enlightenment also occurred *within* the Churches. It was widely thought possible to have a rational religion that at least played down the supernatural element in Christianity and transferred the emphasis to the moral and ethical content of religious teaching.

In this book I try to present the Enlightenment not only as an intellectual movement but also as a sea change in sensibility, in which people became more attuned to other people's feelings and more concerned for what we would call humane or humanitarian values. For this purpose, I draw extensively on literature, especially narrative fiction. It is surprising how little use most studies of the Enlightenment make of literature. Yet it is in literature, and in the recorded response to literary texts, that we can find evidence for major shifts in collective feeling. Above all, the great, emotionally

compelling novels of the mid-eighteenth century, by Richardson, Rousseau and Goethe, provided their readers with an education in empathy that flowed over into increased sympathy with oppressed members of society.

Another preconception associates the Enlightenment first and foremost with Paris. One thinks readily of Voltaire, the most brilliant and versatile writer of the age, and of the great collective project, the *Encyclopédie*, directed with superhuman dedication by Diderot. Without doubt, Paris carried a greater weight in the history of the Enlightenment than any other city, but it is now recognized that the Enlightenment was truly international. Enlightened activity can be found from Philadelphia to St Petersburg. In particular, the importance of Germany, including the 'classical age' of Goethe and Schiller, and of Scotland, the home of David Hume and Adam Smith, is increasingly being acknowledged.

It has therefore been argued that we should think, not of '*the* Enlightenment', but of a large number of distinct national Enlightenments. It is absolutely right that the study of the Enlightenment needs to be sensitive to local differences. In France, the bearers of the Enlightenment were predominantly the self-styled *philosophes* of Paris; in Germany, they were often the administrators who did their best to reform the many German states. But this distinction is not hard and fast. In France, Anne-Robert-Jacques Turgot was an enthusiastic Enlightener and an administrator; in Germany, Kant was a philosopher (though, as a professor, he was also a state official). In any case, the concept of different national Enlightenments takes for granted that there was an overall Enlightenment of which they formed different facets.

A stronger scepticism would object to the term 'the Enlightenment' on the grounds that it was not used at the time. By that argument, however, most historical period terms would have to be discarded. Medieval people did not say, or know, that they were living in the Middle Ages. Those who lived through the religious upheavals of the sixteenth century could not suspect that their time would eventually be labelled the Reformation. However, people in the eighteenth century knew that something momentous was happening, and they actually called it the spread of enlightenment, reason, philosophy, *lumières*, or *Aufklärung*. They looked back in horror to the religious wars of the sixteenth and seventeenth centuries and saw that advances in philosophy, including 'natural philosophy' (what we would now call science), had begun to diffuse tolerance and reason more widely – though still not widely enough.

'Natural philosophy' had proved its worth in the Scientific Revolution of the seventeenth century. It provided the Enlightenment with a model of reliable knowledge. Scientific knowledge was trustworthy because it was based on empirical study of the world. But because it could so often be corrected

by more accurate observations, its authority was always provisional, never absolute – in contrast to the authority still claimed by the Churches. An interest in science, especially the physical sciences, was widespread in the Enlightenment. Philosophers extended their scientific approach to what David Hume called 'the science of man', and to society through the study of law, political systems and what came to be called 'political economy'.

Although it is justified to speak of 'the Enlightenment', one should not therefore assume that the Enlightenment was a homogeneous movement, or that all Enlighteners thought the same. General statements beginning 'The Enlightenment' are unavoidable – there are plenty in this book – but they should always be treated with caution. Many Enlighteners opposed capital punishment as being inhumane and ineffectual, but some justified it because it acknowledged the status of the individual as a moral being who was responsible for his offences and must be prepared to atone for them. The concept of human rights may well be thought one of the most valuable of the Enlightenment's legacies, but some Enlighteners questioned the very notion. The Enlightenment is sometimes dismissed out of hand by the argument that its proponents had a starry-eyed conception of progress and imagined that a perfect society was just around the corner. A few people did think this way, and their illusions will be described in the following chapters, but most Enlighteners were realistic enough to see that progress was neither inevitable nor irreversible, and that all societies were liable eventually to decline and decay. Not for nothing is the Enlightenment's greatest work of history Edward Gibbon's *Decline and Fall of the Roman Empire* (1776–89).

Many misunderstandings of the Enlightenment arise from the abuse of hindsight. At the end of the period stands the French Revolution. It is easy, but wrong, to interpret the Enlightenment as a prelude to the Revolution, and to imagine groups of radical philosophers plotting to overthrow the established order. In fact, the Enlighteners who wanted major social changes expected those changes to be made from above, not from below. They were impressed by the sweeping reforms that enlightened rulers had introduced in Prussia, Russia, Austria and many smaller states. By the 1780s it was becoming increasingly apparent that France was unlikely to bring in economic reforms or curtail the damaging privileges enjoyed by the nobility. But, as with the fall of Communism in 1989–90, nobody expected the French Revolution until it happened. It was a new event, significantly different from the American Revolution often considered its predecessor and catalyst. Those who welcomed its initial bold reforms did not perceive the unstoppable dynamic that would lead to the Reign of Terror and eventually – as critics of 'democracy' had always warned – to the

arrival of a dictator, in this case Napoleon. Another abuse of hindsight consists in projecting the imperialism of the nineteenth century back onto the eighteenth. Enlighteners were intensely interested in the world outside Europe. That world was explored for practical purposes, above all for trade, though also to support geopolitical rivalries among the European powers. If, as was generally believed, there was a large southern continent, then it mattered very much which European power would be the first to discover and lay claim to it. By the eighteenth century the commercial exploitation of non-European territories was in full swing. But the depredations of the English, French and Dutch East India Companies were constantly attacked by Enlighteners, above all in that great but nowadays too little read work the *Histoire des deux Indes* (*History of the East and West Indies*), on which the abbé Raynal collaborated with Diderot and others. In order to convey the complexity of Enlightenment cosmopolitanism, I have avoided the words 'Eurocentric' and 'Orientalist'. Both words were useful in the past, but they have by now declined, at worst into mere boo-words, at best into crudely moralistic labels for cultural relations.

There are many studies of the Enlightenment which can claim classic status, beginning with the book on the philosophy of the Enlightenment written by the German-Jewish philosopher Ernst Cassirer on the eve of the Nazi catastrophe. With the partial exception of Cassirer, I have kept these books at arm's length. This is a study of the Enlightenment, not of books about the Enlightenment. Anyone who wants a judicious overview of Enlightenment research can find it in the opening chapter of *The Case for the Enlightenment* (2005) by John Robertson (no relation). I have presented my own view of the Enlightenment, so much so that some of its prominent advocates, as well as its detractors, if they bother to read that far, will probably be annoyed. I refer constantly to primary texts to allow the writers of the Enlightenment to speak for themselves. I offer thumbnail summaries of some of the key works of the Enlightenment, and I sometimes argue with their authors. Anyone who thinks it pointless to argue with dead authors should remember that their ideas are still alive. Although as a scholar I am committed to a historical understanding of literature and philosophy, I am also conscious that historicism can be a dead hand laid on the past, denying it the power to interfere with our thinking and disturb our complacencies. Part of my purpose is to depict the Enlightenment as a set of ideas that are still vital, and a set of controversies that are still unresolved, at the present day.

In undertaking to write a book on the Enlightenment I have ventured far outside my comfort zone. I am therefore deeply grateful to the

Enlightenment scholars who have read and commented on all or some of this book. Catriona Seth, Joachim Whaley, David Wootton and Brian Young read and commented valuably on an earlier version of the entire text; Laurence Brockliss, Kevin Hilliard and Dorinda Outram read substantial portions. I thank Diarmaid MacCulloch and Faramerz Dabhoiwala for advising me on publishing, and most especially my agent, Catherine Clarke of Felicity Bryan Associates, for negotiating on my behalf. I am grateful above all to my editor, Stuart Proffitt, who invited me to undertake this work, and whose meticulous reading and re-reading very much benefited the book; and also to my wife, Katharine Nicholas, whose shrewd advice induced me to remodel, and considerably improve, several chapters. Needless to say, responsibility for the opinions expressed, and for any remaining factual errors, is entirely mine.

I have also benefited greatly from my involvement with the Besterman Centre for the Enlightenment at Oxford, from the unrivalled knowledge of Voltaire which its director, Nicholas Cronk, shared with me, and from attending its weekly Enlightenment workshops, organized by Kelsey Rubin-Detlev and more recently by Avi Lifschitz. I owe warm thanks to Martin van Gelderen for generously inviting me to spend a year as a senior research fellow at the Lichtenberg-Kolleg in Göttingen, and to his invariably helpful colleagues Dominik Hünniger and Kora Baumbach. While in Göttingen I benefited not only from access to superb libraries but also from many conversations with László Kontler, Anthony La Vopa, Dorinda Outram and Mara van der Lugt. I am grateful to David Wootton for allowing me to read his book *Power, Pleasure, and Profit: Insatiable Appetites from Machiavelli to Madison* (2018) before its publication. Looking further back, I owe thanks, as often before, to the late Edward Timms, with whom, as long ago as 1991, I co-edited a volume on *The Austrian Enlightenment and its Aftermath*. I owe more diverse debts to Audrey Borowski, Peter Ghosh, Martin Gierl, Andrew Kahn, Paschalis Kitromilides, Laura Anna Macor, Karen O'Brien, Jim Reed, John Robertson, Kelsey Rubin-Detlev and David Womersley. The many pleasures of studying the Enlightenment include the licence to trespass across disciplinary boundaries and to establish intellectual and personal friendships with fellow-scholars from many areas. But the greatest motive for studying this subject is the awareness that the Enlightenment, though distant in time, remains vitally important. In an age that seems dominated by 'fake news', widespread credulity, xenophobia and unscrupulous demagogues, it matters more intensely than ever to hold on to reliable knowledge, to be aware of our common humanity, and to pursue the possibility of human happiness.

Note on Translations

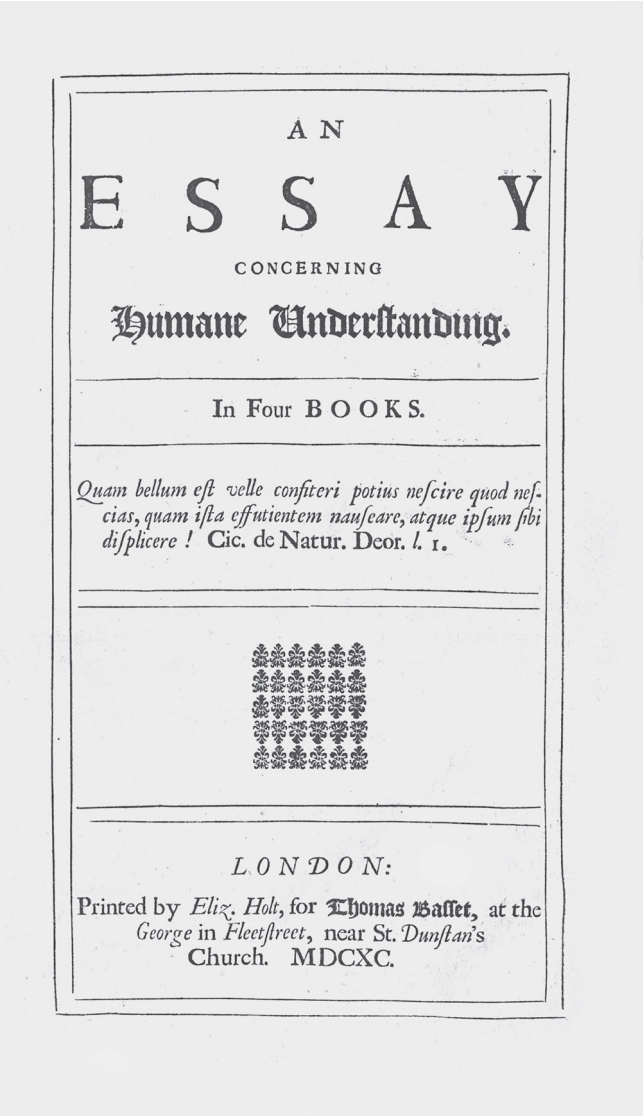
Translations are my own unless otherwise stated. Quotations are normally given in English only, except for passages of poetry. There I have given the original followed usually by a plain prose translation.

1

Happiness, Reason and Passion

The Enlightenment declared the conviction that the goal of life was happiness, and that if this goal could be attained at all, it was to be found in the here and now, despite the manifold imperfections of earthly life. As early as 1671, the philosopher Gottfried Wilhelm Leibniz defined wisdom as 'the science of happiness'.[1] John Locke wrote in 1677: 'The businesse of man [is] to be happy in this world by enjoyment of the things of nature subservient to life health ease and pleasure and by the comfortable hopes of another life.'[2] Locke publicly reaffirmed the priority of happiness in his *Essay concerning Human Understanding* (1690), one of the Enlightenment's foundational texts: 'I lay it for a certain ground, that every intelligent being really seeks happiness, which consists in the enjoyment of pleasure, without any considerable mixture of uneasiness.'[3] Alexander Pope, in the *Essay on Man* (1733–4), famously apostrophized 'happiness! our being's end and aim'.[4] The 'pursuit of happiness' was, equally famously, among the basic human rights formulated by Thomas Jefferson in the preamble to the American Declaration of Independence in 1776. But this pursuit was not confined to Western Europe and North America. Far away, in what is now Romania, Iosipos Moisiodax, head of the Princely Academy at Jassy (now Iaşi), defied the Orthodox Church by issuing a similar message in his *Apology* (1780): 'Sound Philosophy . . . is a comprehensive theory, which investigates the nature of things always with an eye to their end, so that it preserves, it promotes the true happiness that mankind, as mankind, can enjoy upon the earth.'[5]

'Happiness' and its equivalents – *bonheur*, *félicité*, *felicità*, *Glück*, *Glückseligkeit*, *lycksalighet* – epitomize what one leading contemporary historian of the Enlightenment has called 'the commitment to understanding, and hence to advancing, the causes and conditions of human betterment in this world', which gave the Enlightenment its intellectual coherence.[6] It was this aim that underlay the attention that Enlighteners gave to society, to the study of forms of government, to political economy, and to history,



AN

ESSAY

CONCERNING

Humane Understanding.

In Four BOOKS.

Quam bellum eſt velle confiteri potius neſcire quod neſcias, quam iſta effutientem nauſeare, atque ipſum ſibi diſplicere ! Cic. de Natur. Deor. *l.* 1.

LONDON:

Printed by *Eliz. Holt*, for Thomas Baſſet, at the *George* in *Fleetſtreet*, near St. *Dunſtan's* Church. MDCXC.

The original title-page of Locke's *Essay concerning Human Understanding*. Despite bearing the date 1690, the book was actually published in 1689. The Latin quotation runs: 'How fine to be willing to admit that one does not know what one does not know, instead of spewing out such nonsense and disgusting oneself!' (Cicero, *On the Nature of the Gods*).

which was often understood as a narrative of development from the barbarism and anarchy of the early Middle Ages to the relative liberty and prosperity of modern commercial society. It helped to motivate not only the pursuit of scientific knowledge but also such practical endeavours as the improvement of farming techniques, the attempt to make punishment more humane and at the same time more effective, and the search for methods of education that would bring out pupils' individuality and equip them to understand the world around them. The textual counterpart of these endeavours was the *Encyclopédie*, the compendium of knowledge, including crafts and techniques, compiled with enormous effort and against frequent official opposition by Denis Diderot and his collaborators. And the campaigns waged by some Enlighteners against the Churches – as well as the campaigns often undertaken within the Churches by believers who wanted to reconcile the doctrines of Christianity with the demands of common sense – were intended to demolish the falsehoods that kept people in unhappy intellectual immaturity and social subjection. A dimly imagined happiness might exist beyond the grave, but the prospect could not compensate for the shortcomings of this life. If happiness was possible – and that was far from certain – Enlighteners wanted to attain it before death. To them, happiness was not, as it often is in present-day discussions, simply a subjective state, such as might be induced by chemicals; it meant attaining the preconditions for personal happiness, including domestic affection, material sufficiency and a suitable degree of freedom.[7]

Such a conviction was far from self-evident. It meant overcoming centuries of Christian teaching that represented this world as a mere vale of tears in which we had to earn the true happiness that could only be found in heaven. St Augustine, the theologian who more than any other shaped the character of medieval (and subsequent) Christianity, declared that, even for the righteous, true happiness was unattainable in our present life.[8] The medieval pope Innocent III, in his much-read treatise on the wretchedness of life, observed: 'We be all borne yelling and crying, to the end we may expresse our myserie'; after which things would only get worse, especially as, for most people, misery on earth was a mere prelude to much greater suffering in hell.[9] The Enlightenment was only possible once such assumptions had been discarded. Hence, we must consider it not only as a philosophical movement aiming ultimately to increase earthly happiness, but also as part of a tectonic shift in outlook, a far-reaching change in mentality.

The belief that the purpose of human life is the attainment of happiness is called 'eudaemonism'. But eudaemonism leaves open the question of what happiness is, and whether it is attainable at all. These were central

questions for the Enlightenment, both in theory and (as we shall see in Chapter 8) in practice.

IS HAPPINESS POSSIBLE?

On the possibility of happiness, the classical and Christian traditions disagreed. Many classical philosophers, and many of their Enlightenment successors, were eudaemonists: they assumed that happiness was the final end of human life.[10] Horace's poem beginning 'Beatus ille' attributes happiness to a simple and independent farmer; in a seventeenth-century translation:

> Happy the Man whom bounteous Gods allow
> With his own hands Paternal Grounds to plough![11]

Jesus, however, presented his hearers with the paradox that to be happy you had to be poor in this life, because then you would be amply recompensed in a future life: the Vulgate, using the same word as Horace, has him say 'beati pauperes quia vestrum est regnum Dei' (Luke 6:20), tendentiously translated in the Authorized Version not as 'Happy are the poor' but as 'Blessed be ye poor: for yours is the kingdom of God.'

In the ancient world, earthly happiness was thought to be attainable, and not just for the farmers nostalgically celebrated by Horace and Virgil. It might consist in the exercise of virtue, or in sensual pleasure. The philosopher Epicurus (341–270 BCE) taught people to abandon unnecessary fears: of the gods, who had no concern with humanity, and of death, which led merely to non-existence. Freed from these fears, the individual should not expect 'supreme' felicity, but could aim for 'subalterne or graduall' felicity,

> a certain state, in which a man may be as Happy as the Frailty of his Nature will permit; or such, in which he may enjoy very much of necessary Goods, and suffer very little of Evils: and consequently, wherein He may spend his daies pleasantly, calmly, and permanently, so far forth as the Condition of his Country, Society, Course of life, Constitution, Age, and other Circumstances shall give leave.[12]

Freed from these fears, the individual could cultivate happiness, or at least minimize pain, by friendship, healthy living and moderate pleasures.

Insofar as Epicurus was known during the Middle Ages, he was thought to be an immoral sensualist. Dante placed him and his followers in the sixth circle of hell for claiming that the soul dies with the body. A better

understanding of Epicurean philosophy gradually followed the rediscovery of his follower Lucretius, whose poem *De rerum natura* (*On the Nature of the Universe*, first century BCE) was unearthed in 1418 by the humanist Poggio Bracciolini. Early modern admirers of Epicurus had to express themselves cautiously, however, since he was in bad odour as an atheist and (unjustly) for supposedly advocating sensual self-indulgence (as Ben Jonson's Sir Epicure Mammon does in *The Alchemist*).[13]

However, Enlighteners were also sharply aware of the difficulties – illness, bereavement, misfortunes of all kinds – that frustrated the individual's desire for happiness. So they seldom ventured to aspire beyond the modest and prudent ambitions formulated by Epicurus. 'Enquiries after Happiness, and Rules for attaining it,' said Joseph Addison, 'are not so necessary and useful to Mankind as the Arts of Consolation, and supporting one's self under Affliction. The utmost we can hope for in this world is Contentment; if we aim at any thing higher, we shall meet with nothing but Grief and Disappointments.'[14] David Hume advocated an even lower-key Epicureanism: 'in general, no course of life has such safety (for happiness is not to be dreamed of) as the temperate and moderate, which maintains, as far as possible, a mediocrity, and a kind of insensibility, in every thing.'[15]

Despite such caution, most Enlighteners agreed not only that happiness was desirable, but that its attainment was provided for in the scheme of things. Even some pious Christians believed that God wanted people to be happy. 'The production of Happiness seems to be the only motive that could induce infinite Goodness to exert infinite Power to create all things; for, to say truth, Happiness is the only thing of real value in existence,' opined the conservative politician Soame Jenyns in 1757.[16] Other thinkers, more remote from Christianity, ascribed the same intention to nature, as the philosopher and administrator Anne-Robert-Jacques Turgot did when addressing the Sorbonne in 1750: 'Nature has given all humanity the right to be happy: needs, passions, and a reason which is combined with these different principles in a thousand ways, are the forces she has given it to attain this goal.'[17]

Was happiness solely the concern of the individual, to be attained in isolation? One could certainly satisfy one's sensual desires, as the materialist Julien Offray de La Mettrie notoriously advocated. A much-bruited but apocryphal story had him meet an appropriate death in 1751 by keeling over at a Berlin dinner-table after gorging on truffles.[18] Or one might do the opposite: the physician George Cheyne, who ascribed depression, along with a wide range of illnesses, to over-indulgence in eating and drinking, in 1733 recommended temperance and virtue as the sure route to happiness: 'for Virtue and Happiness are literally and really Causes and

Effects'.[19] Or one might conclude, with the scientist Émilie du Châtelet, that one should satisfy one's passions so far as feasible – the most rewarding passion being that of study. Du Châtelet also recommends avoiding gloomy thoughts and cultivating pleasant illusions; the greatest pleasures come from love, although (or because) it includes illusion.[20] Her essay on happiness makes sad reading, for it was written at some time in the late 1740s during the breakdown of her long relationship with Voltaire, and is really an analysis of her own unhappiness.[21]

Acknowledging that individual happiness was hard to attain, the Enlightenment explored the concept of 'public happiness'. The welfare, and hence the happiness, of the population could and should be the object of government. Princes therefore should not resemble Louis XIV, who had come close to beggaring France through such magnificent but exceptionally costly projects as Versailles and through expensive and destructive wars. An influential critique of such policies (published without the author's consent) was *Les Aventures de Télémaque* (*The Adventures of Telemachus*, 1699), by François de Salignac de la Mothe-Fénelon, archbishop of Cambrai. In what was to become one of the most popular novels of the following century, the son of Ulysses learns the art of government by touring various countries around the Mediterranean. In the most famous episode, his tutor Mentor, who is the goddess Athena in disguise, undertakes to reform the kingdom of Salente, whose shortcomings recall those of France, in order to render its population happy: 'Happy are these men, without ambition, distrust or deceit, provided the gods bestow upon them a virtuous king!'[22]

A good king, whose first and all-absorbing concern was the happiness of his people, became the ideal of enlightened absolutism. There were classical models among the good Roman emperors, such as Alexander Severus, who, according to Edward Gibbon, combined wisdom with power so that 'the people, sensible of the public felicity, repaid their benefactor with love and gratitude'.[23] Frederick the Great, king of Prussia from 1740 to 1786, said of princes that their 'only function must be to work for the happiness of mankind'.[24] Enlightened philosophers and administrators in the German lands shared this ideal. So the young French revolutionary Louis-Antoine de Saint-Just was mistaken when in 1794, introducing a measure that would confiscate the goods of 'enemies of the revolution' and transfer them to the poor, he boasted: 'Happiness is a new idea in Europe.'[25] On the contrary, it had long been a commonplace.

But how was public happiness related to private happiness? Christian Wolff, the most influential philosopher of the early German Enlightenment, affirmed that public happiness, which it was the state's duty to promote, would ensure the private happiness of every individual.[26] In the

dialogues on Freemasonry by Gotthold Ephraim Lessing, *Ernst und Falk* (1778), the speaker who is closest to being the author's mouthpiece argues the opposite way, starting from the individual and asserting that public happiness is simply the happiness of every individual: 'The happiness of the state is the total of the individual happinesses (*Glückseligkeiten*) of all its members. There is no other.'[27] The administrator Johann Heinrich Gottlob von Justi argued that the two were so closely related as to be inseparable. Happiness was always social, since it required the satisfying feeling of performing one's duty towards one's fellow-humans. By working on one's own happiness, one was also advancing that of others. 'Anyone who wishes truly to further the happiness of humanity must undoubtedly set to work to further his own happiness. So he must first have overcome his own passions.'[28]

With these ideals, it was tempting to seek a formula for happiness. Jeremy Bentham's quantitative principle, 'the greatest happiness of the greatest number', later dubbed the 'felicific calculus', has a long prehistory in the Enlightenment.[29] Its first occurrence is in 1725 in the work of the Glasgow-based philosopher Francis Hutcheson: '*that Action is best*, which accomplishes the *greatest Happiness* for the *greatest Numbers*'.[30] Hutcheson and his successors, evidently impressed by the mathematical achievements of Isaac Newton in the *Principia* (1687), often try to quantify the search for happiness in mathematical terms. Thus Hutcheson offers his readers an extremely forbidding mathematical equation, in which B stands for Benevolence, A for Ability, S for Self-love, I for Interest, and M for 'the Moment of Good':

> the entire Spring of good Actions is not always *Benevolence alone*; or of Evil, *Malice alone*; (nay, sedate Malice is rarely found) but in most Actions we must look upon *Self-love* as another Force, sometimes conspiring with *Benevolence*, and assisting it, when we are excited by Views of *private Interest*, as well as *publick Good*; and sometimes opposing *Benevolence*, when the good Action is any way *difficult* or *painful* in the Performance, or *detrimental* in its Consequences to the *Agent*. In the former Case, $M = B + S \times A = BA + SA$; and therefore $BA = M - S = M - I$, and $B = \frac{M - I}{A}$. In the latter Case, $M = B - S \times A = BA - SA$; therefore $BA = M + SA = M + I$ and $B = \frac{M + I}{A}$.[31]

François-Jean de Chastellux provided a simpler formula in *De la félicité publique* (*On Public Happiness*, 1770). Individual happiness cannot be measured, but the preconditions for happiness, that is, the *félicité publique*, can. Happiness is what remains of (a) after subtracting (b) and (c), where (a) is the amount of work a man can do without becoming

miserable, (b) is the amount of work he must do to secure basic necessities, and (c) is the amount of work demanded of him by his rulers. Happiness is secured by the relation among these three elements.[32]

At the other extreme from these enthusiastic planners, some other Enlightenment figures were thoroughly sceptical in evaluating the possibility of happiness. Pietro Verri, a leading Enlightener in Milan, argued that happiness was not something positive, but consisted only in the cessation or diminution of pain. A simple calculation shows that pain predominates in life: 'The sum total of painful sensations must in every man be greater than the sum total of pleasurable sensations.'[33] Unhappiness, according to Verri, consists in the excess of our desires over our power to fulfil them. The answer is not to suppress our desires, as a Christian ascetic would recommend, for that leads to a condition of vegetation rather than life, but rather the prudent management of our desires, for example by eliminating whatever in them is chimerical. It is not reasonable to pursue wealth, for example, without forming a clear idea of one's object and the disadvantages, such as continual worry, that attend it. Reason must be deployed not to reduce compassion and affection, but to direct them effectively, and to avoid throwing oneself away on unworthy objects of love.[34] Moreover, the progress of enlightenment and reason equip humanity better every day to recognize error, to perceive the world as it is, and thus to advance on the road to happiness (or at least to less unhappiness).[35]

Immanuel Kant, in his home city of Königsberg, which he never left, had read Verri, but was even more sceptical about the possibility of happiness. Writing on moral philosophy in the *Grundlegung zur Metaphysik der Sitten* (*Groundwork of the Metaphysics of Morals*, 1785), Kant argues that if nature had designed us principally to be happy, we would have been endowed with a sure instinct, like animals, not equipped with such an uncertain guide as reason. Happiness is a gift of fortune, like health and power, but not an unqualified good, because it can be abused. A rational and impartial onlooker would surely think that happiness was misplaced if it were enjoyed by a wicked person. The only unqualified good is the good will that recognizes and performs our moral duty towards other people. Admittedly, it is part of our duty to seek our own happiness, because if we are unhappy, worried and frustrated we will be tempted to violate the demands of morality. But our duty is more important than our happiness and may well require us to sacrifice some of our happiness for it. Duty is motivated not by the desire for happiness, but by obedience to the moral law. We have to obey the maxim that Kant calls the categorical imperative: '*I ought never to act except in such a way that I could also*

will that my maxim should become a universal law'.[36] The moral law constitutes 'the idea of another and far worthier purpose of one's existence, to which therefore, and not to happiness, reason is properly destined, and to which, as supreme condition, the private purpose of the human being must for the most part defer'.[37]

In saying this, Kant seems to strike a blow at the whole tradition of Enlightenment philosophy, from Leibniz on, that maintained that the exercise of reason could lead to happiness. However, Kant is not *against* happiness. He admits that we are naturally inclined to search for happiness, but he argues that nature has destined us never to find it. We will always be somewhat discontented, and that very discontent is good for us by spurring on our energies and our creativity. Just as there can be no final and perfected state of public happiness, so there can be no final and perfect individual happiness.[38]

Kant's philosophy is frequently claimed as the culmination of the Enlightenment. Often, however, as here, Kant intervenes in an Enlightenment debate in order to question its assumptions and take the argument off in a new direction. Kant's arguments lead out of the Enlightenment's comfortable harmony between God, nature and humanity and into a severe, unforgiving landscape that would later be dominated by the Victorian sense of duty. It was in this spirit that George Eliot (herself steeped in German thought), walking with F. W. H. Myers in the Fellows' Garden at Trinity College, Cambridge,

> stirred somewhat beyond her wont, and taking as her text the three words which have been used so often as the inspiring trumpet-calls of men, – the words, *God*, *Immortality*, *Duty*, – pronounced, with terrible earnestness, how inconceivable was the *first*, how unbelievable the *second*, and yet how peremptory and absolute the *third*.[39]

FREEDOM FROM FEAR

If the Enlightenment had a collective mission, part of it was 'the slow vanquishing of fear'.[40] Early modern people had a great deal to be afraid of. Some of the evils they feared were imaginary, but many were all too real. In an age when medical treatment largely stagnated, illness was almost universal.[41] Smallpox left many permanently disfigured. Beggars, despite laws against vagrancy, displayed their disabilities in public: 'Persons of delicate fibres and a weak constitution of body', claimed Adam Smith in 1759, 'complain, that in looking on the sores and ulcers which are exposed

by beggars in the streets, they are apt to feel an itching or uneasy sensation in the correspondent part of their own bodies.'[42]

Most people's diet was poor in fruit and vegetables, so that scorbutic diseases were common. When staying in the south of France in 1764, Tobias Smollett, a doctor, found himself suffering from scurvy, which he attributed to a salty coastal atmosphere.[43] The poor in England had a monotonous diet in which bread and cheese predominated; in France, the diet of 95 per cent of the poor was cereal.[44] Poor people got little protein and were permanently undernourished. Those who could afford it ate a protein-rich, meat-heavy diet, as we see from the huge meals lovingly recorded in Parson Woodforde's diary. Such unhealthy diets promoted dropsy, gout and 'the stone', the formation of agonizing blockages in the urinary tract. For all, but especially for the poor, infancy was a particularly dangerous time. It is estimated that in England a third of children, and in France half, died before the age of five. Average life expectancy in eighteenth-century England was 37; in France before 1750, life expectancy among those who survived infancy was 40.25 years for men, and 41.2 years for women.[45]

Illness, if not fatal, had to be lived with. Operations were a form of torture that people usually preferred to avoid. Few people, remarks Pietro Verri, can stand being present when the lithotomist 'cuts open a living man to extract the stone'.[46] In 1811 Frances Burney (by then married to Alexandre d'Arblay, and living in Paris) was diagnosed with breast cancer and consented to a mastectomy. Her breast was cut open by surgeons, of course without anaesthetic (other than some wine which may have contained laudanum), and the cancerous tumour removed. Her letter to her sister, written nine months after the event, records it in unsparing detail: 'I began a scream, that lasted unintermittingly during the whole time of the incision – and I almost wonder that it rings not in my Ears still! so excruciating was the agony.'[47]

Epidemics, famine and war were less frequent than in the past, but still recurrent dangers. Bubonic plague had largely vanished; the last great outbreak in Western Europe was in Marseilles and its environs in 1720, which carried off some 120,000 victims. In 1696–7, famine killed a quarter of the population of Finland, some 100,000 people.[48] Elsewhere, though famines became rare, bad harvests awakened cultural memories of near-starvation. In 1774, a disastrous harvest, combined with the deregulation of the grain trade, provoked the widespread riots known as the 'Flour War' in France; further harvest failures in the 1780s led to murderous attacks on grain stores.[49] Tuscany and some other parts of Italy experienced a famine in 1764–5 that deeply shocked contemporaries.

War was a normal implement of political policy and often decided succession disputes, notably the Wars of the Spanish Succession (1701–14) and the Austrian Succession (1740–48). Armies marched through farmland, destroying crops, and in occupied areas soldiers routinely burned, killed, raped and plundered, reducing the surviving population to beggary.[50] Such devastation might be the work of undisciplined soldiers, especially the 'light troops', such as Russian Cossacks and Austrian Croats, that accompanied regular armies and were especially feared for their love of torturing and mutilating their captives. It was also sometimes practised as a deliberate policy of terror, as when French troops destroyed all the towns in the Rhenish Palatinate in 1689, or when British and Austrian troops ravaged Bavaria in 1704.

Enlightenment historians pointed out that modern warfare was, nevertheless, far less savage than in the ancient world, where people fought desperately to avoid massacre or enslavement. In a sermon of 1755, the eminent cleric and historian William Robertson noted 'the little ferocity and bloodshed which accompany modern victories', ascribing it to the spirit of Christianity.[51] Certainly some attempts were made to limit attacks on civilians, as during the duke of Marlborough's campaign in the Netherlands in 1705–11. Some wars did approach the model of the 'cabinet war', fought on limited territory by disciplined troops who were supplied by commissariat organizations instead of living off the land. Even so, the lives and property of civilians were readily sacrificed to the necessities of war. Hume asks rhetorically: 'What governor of a town makes any scruple of burning the suburbs, when they facilitate the approaches of the enemy? Or what general abstains from plundering a neutral country, when the necessities of war require it, and he cannot otherwise subsist his army?'[52]

For civilians in wartime, the fall from prosperity to misery could be almost instantaneous. During the Great Northern War (1700–1721), Swedish forces, in revenge for earlier devastation, approached the Danish-owned town of Altona on the night of 9 January 1713, ordered the inhabitants to leave the town immediately, and burned it to ashes. The refugees, having reached the gates of nearby Hamburg, were denied admittance because its citizens were afraid of infectious diseases, so most of the homeless died in front of the walls of Hamburg.[53] And people's terror was sustained not only by war, but also by rumours of war. In a largely illiterate society, news was transmitted by rumour, with the inevitable exaggeration and deficient sense of what was probable.[54]

Even normal life became frightening as soon as the sun set. In contrast to the light pollution that nowadays lightens the darkness around every town or village, moonless or overcast nights were truly dark. Admittedly,

human beings have reasonably good night vision, and lanterns and torches were often available to help nocturnal travellers.[55] Nevertheless, nighttime provoked both superstitious fear of spirits and realistic fear of lurking criminals.

There was not much that Enlighteners could do about these evils, though, as we shall see in Chapter 8, enlightened administrators tried hard to make everyday life more secure. Adam Smith argued that people had the best chance of happiness in a commercial society. Not only did free economic activity lead eventually to the diffusion of prosperity across the population, but it required order and security provided by the government:

> Commerce and manufactures can seldom flourish long in any state which does not enjoy a regular administration of justice, in which the people do not feel themselves secure in the possession of their property, in which the faith of contracts is not supported by law, and in which the authority of the state is not supposed to be regularly employed in enforcing the payment of debts from all those who are able to pay. Commerce and manufactures, in short, can seldom flourish in any state in which there is not a certain degree of confidence in the justice of government.[56]

In the meantime, Enlighteners tried to free people from the additional burden of imaginary terrors. Chief among these were the terrors of religion. The poet Louis Racine, a Jansenist, believing in Original Sin and predestination like his father the dramatist, imagined Paradise as a hierarchy of fear:

> L'ordre régnoit alors, tout était dans son lieu:
> L'animal craignoit l'homme, et l'homme craignoit Dieu.[57]

[At that time order reigned, everything was in its proper place:
animals were afraid of man, and man was afraid of God.]

Exactly, retorted the Enlightenment: religion was about fear. '[I]t must be acknowledg'd,' says a persuasive speaker in Hume's *Dialogues Concerning Natural Religion*, 'that, as Terror is the primary Principle of Religion, it is the Passion, which always predominates in it, and admits but of short intervals of Pleasure.'[58] A God who inspired fear rather than love could hardly be the perfectly good being that Christianity claimed. '[T]o fear God any otherwise than as a consequence of some justly blameable and imputable act is to fear a devilish nature, not a divine one', argued the diplomat and philosopher Lord Shaftesbury in 1699.[59]

Enlighteners targeted also the everyday anxieties induced by superstition. An early issue of the *Spectator* in 1711 deplores the fears aroused by

spilling salt or laying one's knife and fork across each other. 'As if the natural Calamities of Life were not sufficient for it, we turn the most indifferent Circumstances into Misfortunes, and suffer as much from trifling Accidents, as from real Evils . . . A Screech-Owl at Midnight has alarm'd a family, more than a Band of Robbers.'[60] These campaigns gradually achieved so much success that Samuel Johnson could write in 1770:

> One of the chief advantages derived by the present generation from the improvement and diffusion of philosophy, is deliverance from unnecessary terrours, and exemption from false alarms. The unusual appearances, whether regular or accidental, which once spread consternation over ages of ignorance, are now the recreations of inquisitive security. The sun is no more lamented when it is eclipsed, than when it sets; and meteors play their coruscations without prognostick or prediction.[61]

Thunder and lightning were particularly alarming. Readers of the Bible remembered that God had spoken to Moses in thunder on Mount Sinai. When, in 1505, the young Martin Luther was caught in a thunderstorm in the open air, he vowed to become a monk, and kept his vow despite his father's disapproval.[62] In 1641 the fourteen-year-old Robert Boyle was terrified by a thunderstorm in Switzerland, first into thinking that the world was about to end, then into resolving to lead a fully Christian life.[63] Even without fearing divine wrath, people were generally afraid of thunder: when Jean-François Marmontel stayed with his lover Marie de Navarre at her country house around 1745, she so much feared thunder that on a stormy day she would have her meals in the wine-cellar, amid fifty thousand bottles of champagne.[64] Later in the century, however, the devout came to regard thunder with awe rather than terror, while for others thunder became a source of the aesthetic thrill labelled 'sublime'.[65]

Lightning strikes were interpreted as signs of God's wrath, even though they tended especially to hit church spires. When St Michael's Church in Hamburg was struck by lightning in 1750, an extraordinary day of fasting and prayer was ordained for the entire city. A great symbolic moment for the Enlightenment, and for its project of freeing humanity from needless terrors, occurred in 1752 in Philadelphia. During a thunderstorm, Benjamin Franklin flew a kite with a pointed wire at the end and succeeded in drawing electric sparks from a cloud. He thus proved that lightning was an electrical phenomenon and made possible the invention of the lightning-rod, which, mounted on a high building, diverted the lightning and drew it harmlessly to the ground by means of a wire. Humanity no longer needed to fear fire from heaven. In 1690 the conservative-minded diplomat Sir William Temple could still call thunder and lightning 'that great

Artillery of God Almighty'.[66] Now, instead of signs of divine anger, they were natural phenomena that could be mastered. When another Hamburg church spire was struck by lightning in 1767, a local scientist, J. A. H. Reimarus, who had studied in London and Edinburgh, explained its natural causes in a paper read to the Hamburg Patriotic Society, and advocated lightning-rods as protection.[67] Kant, whose early publications were on natural science, called Franklin 'the Prometheus of modern times', recalling the mythical giant who defied the Greek gods by stealing fire from heaven and giving it to the human race.[68]

Gradually a change of outlook was occurring. Extraordinary events need not be signs from God; they might just be natural phenomena, which could be understood and brought under some measure of human control.

THE WITCH CRAZE AND ITS END

The Enlightenment was not only a conscious undertaking by philosophers to improve the quality of human life. It was also part of an enormous change in mentality: an uneven but decisive transformation of people's understanding of the world and of their basic assumptions. This can be illustrated by examining the most dramatic manifestation of fear in pre-Enlightenment Europe: the great witch craze that, beginning in the late Middle Ages, raged with renewed fury from about 1560 to the mid- to late seventeenth century, and claimed some fifty thousand victims. This phenomenon fascinates and puzzles historians, who still dispute how it began and why it ended.[69]

Nothing could more illustrate the dominion of fear over pre-Enlightenment minds than the witch craze, and nothing could be more antithetical to the Enlightenment. We cannot, however, give the Enlightenment credit for defeating witch-beliefs, for by the late seventeenth century, when the Enlightenment was just gathering pace, the belief in witchcraft was already in steep decline. The nineteenth-century Irish historian and rationalist William Lecky pointed out that the growth of scepticism about witchcraft 'was mainly silent, unargumentative, and insensible; that men came gradually to disbelieve in witchcraft, because they came gradually to look on it as absurd'.[70] The Enlightenment did not cause the diminution of witch-beliefs; rather, that diminution was among the preconditions which enabled the Enlightenment to emerge.

The conviction that some humans can injure or destroy people, livestock and crops by spells, the evil eye or the assistance of supernatural beings is found in most cultures and was endemic in European popular belief. Fear

of witchcraft reached a new and extraordinary intensity in the early modern period. Witchcraft persecutions were sometimes initiated by people who attributed their misfortunes to malevolent neighbours, sometimes by zealous rulers or magistrates. Lawyers investigating such charges thought they were beginning to uncover a huge network of evildoers directed by the Devil himself. Confessions extracted by torture revealed that the witches' activities were a parody of Christian ritual.[71] They were magically transported – monthly, weekly, or several times a week – to large gatherings called sabbats, where they celebrated a Black Mass, worshipped the Devil, kissed his anus, feasted at his expense, and copulated with him. The sabbat was central to the investigation, because the accused, under pressure to reveal who else had attended, came up with names of neighbours who were, in turn, arrested and interrogated, thereby proving to the inquisitors the horrifying extent of the witch conspiracy.[72] As for the mental state of the accused, deranged by arrest, confinement, crippling tortures and sleep deprivation (the *tormentum insomniae*), there are twentieth-century analogies in the victims of Stalin's purges, who, under similar pressure, came out with whatever nonsense their interrogators wanted to hear.[73] In both cases, the absurd testimonies are attributable not only to torture and mental derangement, but to a kind of complicity: victims persuade themselves that they actually are guilty, and confess to whatever their interrogators want in order to attain a kind of purification.[74]

Historians have wondered why learned inquisitors were so keen not just to accept, but to elaborate hugely, the fantasies of the uneducated. Part of the puzzle is that over the preceding centuries educated elites had become more, not less, willing to believe in witchcraft. In the so-called Dark Ages, many claims about witchcraft were treated officially with scepticism. In the later Middle Ages, however, the Church exerted its authority against heretics, declaring them to be in league with the Devil.[75] The image of the heretic became conflated with that of the witch. Anxiety about witches was increased by the religious divisions that split Christendom soon afterwards. All sides in the Reformation found convenient scapegoats in witches and Jews.

The myth of the witches' sabbat was a new element. It is now agreed to be a construction by the inquisitors, incorporating bits of popular superstition and enlarged into a coherent fantasy by the inversion of Christian imagery. More than a popular belief, it was a delusion of the learned. The demonologists, who produced shelves of erudite treatises around 1600, have been claimed as the leading intellectuals of their day, and even as reputable scientists.[76] Armed with an unfalsifiable theory, the licence to confirm it by torture, and a conviction that they were Christendom's

last defence against the power of Satan, these intellectuals had, in reality, the destructive effect that their fantasy ascribed to witches.

The demonologists were responding to an extraordinary situation, though not the one they imagined. From about 1560 onwards, Europe was in the grip not of Satan and his minions, but of the Little Ice Age.[77] Wet springs, cold summers, frequent hailstorms, crop failure and food shortages became the norm. Glaciers advanced down Alpine valleys. Lake Constance froze over in 1563 and again in 1672–3. Baffled and terrified by what they saw as unnatural weather, people sought an explanation and a scapegoat in the supposed maleficent practices of witches. It has been shown that phases of particularly bad weather coincided with collective panics leading to persecutions.[78] Thus the first great witch-hunt in south-western Germany, in the town of Wiesensteig, began when the local ruler had some women arrested on suspicion of causing a violent hailstorm, which severely damaged crops, in August 1562. By December, sixty-one supposed witches had been executed.[79] Such extensive destruction, it was thought, could not be the work of a single person but pointed to a conspiracy, which must be uncovered by whatever means.

Eventually the witch craze petered out. The last major episode in Europe was the Swedish persecution of 1668–75, though the Salem witch-trials in remote New England followed in 1692. Isolated cases continued. The last person sentenced to death for witchcraft in England was Jane Wenham in 1712: she was found guilty by a jury, despite the scepticism of the judge, but reprieved after a neighbour appealed to Queen Anne.[80] A decade later, an insane old woman from the parish of Loth, in the extreme north of Scotland, was burned at the stake for bewitching pigs and poultry; she was further accused of transforming her daughter into a pony, having her shod by the Devil, and riding about on her.[81] In the German-speaking world, well over a hundred people were executed for alleged witchcraft during the eighteenth century. The last, at Glarus in Switzerland in 1782, was Anna Göldi, a domestic servant who was accused of causing her employer's eight-year-old daughter to vomit pins. Her employer, a town councillor, who led the prosecution, was rumoured to have been sexually involved with her. The author of the only contemporary account of the case seems aware of the anachronistic and implausible nature of the charge. Writing in a defensive tone, he professes an enlightened scepticism about witchcraft but claims that his scepticism was overcome by the irrefutable empirical evidence (an enlightened criterion of knowledge) presented at the trial.[82] One suspects that this was an officially commissioned apologia for Göldi's torture and execution.

When witchcraft accusations were no longer taken seriously by the legal authorities, the people often took the law into their own hands. In 1751,

at Tring in Hertfordshire, an old couple, reduced to beggary, were seized by the mob and thrown into a horse-pond, where the woman drowned.[83] Similar cases are recorded from nineteenth-century France. In 1839, in Valensole (Basses-Alpes, now Alpes-de-Haute-Provence), a farmer killed an elderly woman who he thought had caused the death of numerous sheep and pigs; the neighbours agreed with his suspicions of her.[84]

The riddle for historians is how and why educated elites ceased to believe in witchcraft. For example: in 1652 a woman was condemned and burned in Geneva for witchcraft. Less than forty years later, a judge examining her trial records had not the slightest doubt 'that her whole crime was to be very credulous and extraordinarily timid'.[85] There was a two-stage process. In the first stage, the educated stopped supporting witch-trials, while still admitting the possibility of witchcraft. In the second, even the possibility of witchcraft came to seem ridiculous.

The first stage is relatively easy to explain. One could admit that witchcraft was possible and yet doubt whether it was remotely as common as the inquisitors maintained. The Bible said: 'Thou shalt not suffer a witch to live' (Exod. 22:18), so there must be witches, but perhaps not many.[86] The mass executions and the accompanying terror and social disruption could only be justified by cast-iron proofs, whereas the inquisitors relied on fantastic stories obtained by torture. The decline in witch-belief accompanied an increased concern to examine evidence scrupulously as a means of establishing truth.[87] Admittedly, the demonologists claimed to have empirical evidence in the confessions of suspects; the uniformity of these confessions seemed to confirm that witchcraft was widespread, though really it only demonstrated the imaginative poverty of the obsessed inquisitors. But for those not obsessed, it was not good enough to condemn someone to death for her answers to leading questions given in unbearable pain, nor for the alleged discovery on her body of extra teats at which she suckled her familiars. The Jesuit Friedrich Spee argued in *Cautio criminalis* (*Precautions for Prosecutors*, 1631) that torture was not only cruel but also counterproductive: there might be some real witches, but innumerable innocent people were convicted too, especially as the inquisitors thought that those who obstinately refused to confess under torture were just as guilty as those who confessed. The jurist Christian Thomasius, who enjoyed defying convention both in philosophy and in academic dress, thought that Spee, though too prudent to say so openly, had effectively undermined belief in witchcraft.[88] Thomasius himself argued in *De crimine magiae* (*On the Crime of Magic*, 1701) that the Devil, though real, had no material existence, and therefore pacts and orgies with the Devil were impossible, a mere amalgam of pagan and popish fantasies.

Why was it, he wondered, that people were eager to believe fantastic tales about the Devil, yet would dismiss as an 'enthusiast' anyone who ascribed material events to good angels?[89] 'What judge, I ask, would be so absurd and stupid as to lend credence to a thousand old women if they claimed to have been in heaven, danced with St Peter, or slept with his hound?'[90]

The courts eventually heeded these doubts. 'Evidence' that had convinced the witch-finder Matthew Hopkins in the 1640s no longer satisfied English judges and juries later in the century.[91] In Germany at the same period, accusations of witchcraft were commonly dismissed as unfounded slander, and were even made a punishable crime.[92] In France, an edict of 1682 forbade prosecutions for witchcraft; anyone who tried to practise black magic could still be tried, but for obscenity or sacrilege.[93] Witchcraft played only a marginal role in the 'affair of the poisons', a panic concerning a supposed conspiracy against the life of Louis XIV. Although between 1675 and 1682 no fewer than 218 people were arrested and 36 executed for involvement in this conspiracy, only 2 were accused of witchcraft.[94] Yet when the witch craze was at its height, demonologists had claimed that witches, being enemies of God, must be particularly hostile to kings, as the Lord's Anointed; hence James VI of Scotland, himself a learned demonologist, thought that the storms that assailed his ship as he was returning to Scotland from Denmark with his bride in 1590 must have been raised by witches, and witch-trials were held in Edinburgh and Copenhagen.[95] Times had changed: the records of Scottish kirk sessions and criminal courts reveal that 'throughout the initial decades of the eighteenth century, the courts heard more cases of bestiality than they did of witchcraft'.[96]

How are we to explain the second stage – the increasing reluctance of educated people to believe in witchcraft, and, indeed, in the magical universe in which witches had a place?[97] Historians used to point to the rise of the 'new philosophy'.[98] In René Descartes' model of the universe, initially adopted in England by the Royal Society, all physical processes, albeit under God's management, could be explained as matter in motion, with no magical or occult forces. Nowadays such an explanation for the decline of witchcraft belief is doubted as being too 'intellectualist'.[99] There is certainly no simple relationship between the rise of science and the decline of magic. At the very least, it must have taken a long time for modern philosophy to be absorbed to any significant degree by a wider educated public. Moreover, the Royal Society as a body paid scarcely any attention to witchcraft or other alleged supernatural phenomena, implying thereby that such matters were unworthy of serious attention.[100]

Those who reject the 'intellectualist' conception routinely note that one could be committed to the new scientific methods and still believe in

witchcraft. The example usually given is that of Joseph Glanvill, a Fellow of the Royal Society, who firmly believed in witchcraft and thought it should be subjected to empirical investigation – not to disprove it, but to find out how it worked.[101] Glanvill, however, is not an ideal witness for the coexistence of scientific and witchcraft beliefs. In his posthumously published treatise *Saducismus Triumphatus* (1681), in which he denounces sceptics by associating them with the Sadducees of the New Testament who denied the immortality of the soul, he shows himself decidedly credulous. His arguments for the reality of witchcraft boil down to three: 1) we know so little about the supernatural that anything is possible, including the transformation of witches, with the Devil's help, into cats and hares; 2) the testimony for witchcraft is so strong that it cannot be doubted; 3) disbelief in witches implies disbelief in God.[102] Moreover, Glanvill presents these arguments as answers to frequently asked questions. His interlocutors object, for example, that the actions ascribed to witches are '*ridiculous* and *impossible* in the nature of things', and must be 'but an *illusion* of *crasie imagination*'.[103] Glanvill denounces such sceptics as 'a sort of *Infidels*, though they are not ordinary among the *meer vulgar*, yet are they numerous in a little higher rank of *understandings*'.[104] He gives the impression of trying to hold back a rising tide of scepticism, and of being unable to afford the slightest concession to the 'Infidels' whose conception of 'the nature of things' differs so markedly from his.

Scepticism may in fact have been much commoner than the written evidence suggests. In the late sixteenth century, Michel de Montaigne, arguing that one should be cautious about all testimony, says: 'how much more natural that our mind should be enraptured from its setting by the whirlwind of our own deranged spirit than that, by a spirit from beyond, one of us humans, in flesh and blood, should be sent flying on a broomstick up the flue of his chimney'.[105] His English contemporary Reginald Scot, in a comprehensive demolition of witchcraft beliefs, maintains that so-called witches are either victims of injustice, or else confidence tricksters. Scot is particularly instructive when criticizing the lax standards of evidence required in witch-trials and the psychological tricks and physical tortures used by interrogators (gruesomely reminiscent of modern secret-police methods), which he sums up as 'parciall and horrible dealings, being so apparentlie impious, and full of tyrannie'.[106]

In mid-seventeenth-century England, and even later, it was imprudent to declare openly one's scepticism about witchcraft and magic. One risked being associated with the dangerous radical Thomas Hobbes, who in *Leviathan* (1651) put forward a materialism that explicitly denied the reality of supernatural phenomena, or with the freethinkers who

challenged magical beliefs in the early eighteenth century.[107] Arthur Wilson, a spectator at the trial of twenty-five witches at Chelmsford in 1646, 'could find nothing in the Evidence that did sway me to thinke them other then poore, mallenchollie Envious, mischievous, ill disposed, ill dieted, atrabilious Constitutions' with over-active 'fancies working by grosse fumes & vapors', but he wisely kept his diagnosis to himself.[108] Besides, it was intellectually over-bold to assert flatly that *all* such phenomena were illusory. Hence Robert Boyle, one of the leading figures of the Scientific Revolution, affirmed in his correspondence with Glanvill that a few accusations of witchcraft might be true, and also took an open-minded interest in evidence for alchemy and for the 'second sight' recorded in the Highlands.[109] As late as 1711, Addison says cautiously: 'I believe in general that there is, and has been such a thing as Witchcraft; but at the same time can give no Credit to any Particular Instance of it.' In the same essay he warns readers of the *Spectator* against the absurdity and inhumanity of imputing witchcraft to harmless old women such as his fictional figure Moll White.[110] In his *Political History of the Devil* (1726), written in an ironic tone that implies scepticism without declaring it, Defoe ridicules the idea that witches can command the Devil by spells, and that their crimes can be exposed by throwing them into a pond. He says these beliefs are 'too simple to be believ'd, [yet] so universally receiv'd for Truth, that there is no resisting them without being thought atheistical'.[111]

The definitive treatise against witchcraft, published by Francis Hutchinson in 1718, shares Addison's caution.[112] Hutchinson concedes the reality of spirits, on the grounds that it would be 'Irrational to imagine, that we poor Worms of the Earth should be the Head of the Creation'.[113] But he points out that the Bible's testimony to good and evil spirits bears no resemblance to the tales told about dealings between witches and the Devil, and maintains that such stories 'if not altogether, yet for the greatest Part, . . . are made by the Imaginations of Men'.[114] The disordered imaginations are those not only of the victims, but also of the persecutors. Hutchinson is scathing about the judicial methods of inquisitors and the confused evidence of their victims: 'The gross Part of our Stories of the Devil, are grounded upon the Confessions of Brainsick People, after Superstition or ill Usage had made them Mad.'[115] Thus he identifies much witchcraft testimony as the product of the superstition of inquisitors, who torture victims into madness and thus obtain whatever confessions they want.

The accumulated evidence may suggest not that people *became* sceptical about witchcraft, but that an already widespread, though inadmissible, scepticism could eventually be uttered. Caveats like Addison's, admitting the possibility of witchcraft, do not imply any firm or ardent belief, but are

merely a formal acknowledgement. Even during the great persecutions, how many people really credited the fantasies of the inquisitors? There may have been many people like Arthur Wilson who did not even commit their scepticism to paper. Similarly, in 1930s Russia, how many really believed that the Old Bolsheviks were directing a vast conspiracy against Stalin?

REASON

The Enlightenment criticized both popular belief and religious and political authority by means of reason. The familiar term 'the age of reason', implying that humanity can henceforth be guided by reason instead of blind faith, goes back to the Enlightenment itself. Turgot in 1750 called the preceding hundred years 'the century of reason' because of its scientific achievements.[116] Thomas Paine in 1794 gave the title *The Age of Reason* to his unsparing critique of theology.

The meanings attached to 'reason', however, were diverse. Support for the primacy of reason was often found in the ancient philosophy of Stoicism. The Stoics flourished in Athens from about the third century BCE, and versions of their philosophy were transmitted to posterity by the Latin writers Cicero and Seneca. According to Stoicism, man's reason enabled him to lead a virtuous life by discerning the rational order of the universe. All events happened by necessity and must be accepted without complaint. One cannot control external events, but one can control one's own emotions, and one should discipline them or even suppress them by cultivating *apatheia* or insensibility.

This philosophy had a particular appeal during an era of rebellions and wars, when disruption was exacerbated (as we have seen) by the Little Ice Age. It also suited the age of absolute government. It suggested that the ideal prince should be rational, like the divine power whose earthly representative he was, and should demand strict obedience from his subjects. It provided a positive ethos for a public servant by emphasizing steadfastness, self-control and rigorous performance of duty.[117] This was the message of *De constantia* (*On Steadfastness*, 1584), the best-selling treatise by the Dutch philosopher Justus Lipsius. Lipsius did his best to create a Christian Stoicism, interpreting the recognition of divine power as submission to God's providence. Emotion is not to be suppressed altogether, but firmly subordinated to reason, which inculcates the great virtue of steadfastness: 'being regulated by the rule of right Reason is the very root whereupon is settled the high and mighty body of that fair oak Constancy'.[118] The steadfast man will show mercy to others, but will not waste

time on pity, either for himself or them. Here the difficulty of joining Christianity and Stoicism is already apparent.

Stoicism, says the historian Ernst Cassirer, with its demand that reason should overcome emotion, 'not only dominates the philosophy of the seventeenth century, but it permeates the intellectual life of the age in general'.[119] It is prominent in seventeenth-century drama. Shakespeare's Horatio, a man who is 'not passion's slave' and 'more an antique Roman than a Dane', is a successful Stoic. Julius Caesar, Othello and Coriolanus are unsuccessful ones. George Chapman's Bussy D'Ambois dies a Stoic death: 'The equall thought I beare of life and death / Shall make me faint on no side; I am up. / Here, like a Roman statue, I will stand / Till death hath made me marble.'[120] Plays featuring martyrs, such as Pierre Corneille's *Polyeucte* (1642) and Daniel Casper von Lohenstein's *Epicharis* (1665), invite us not to pity the martyr but to admire his or her fortitude. However, literature puts philosophies to a practical test by asking how they play out in real life. Shakespeare's Coriolanus, having resolved not to 'obey instinct, but stand / As if a man were author of himself / And knew no other kin', collapses in tears when confronted by his mother.[121] Even successful Stoic heroes often show an off-putting theatricality. Instead of quietly being stoical by themselves, they insist on displaying their fortitude to an audience.[122]

As Shakespeare's heroes show, Stoicism was a difficult philosophy to live by. It was vigorously opposed by Christian thinkers who took their stand on Augustine's doctrine of Original Sin. Since Adam's fall, man could not be master of himself. He was a weak and sinful creature whose will was constantly assailed and usually defeated by his passions. Not his own feeble efforts, but only divine grace, could lead him to virtue and ultimate salvation.[123] Even without the aid of theology, it was repeatedly pointed out during the eighteenth century that Stoicism was false to the facts of experience. Samuel Johnson in *Rasselas* (1759) presents a philosopher whose principles of fortitude are overturned by grief at the death of his daughter.[124] Henry Fielding introduces into *Tom Jones* (1749) a Stoic philosopher called Square, who is always talking about the eternal fitness of things and the insignificance of pain: 'In pronouncing these [sentiments] he was one Day so eager, that he unfortunately bit his Tongue; and in such a Manner, that it not only put an End to his Discourse, but created much Emotion in him, and caused him to mutter an Oath or two.'[125]

Neo-Stoic thought was developed by the Dutch-Jewish philosopher Baruch Spinoza, who, because of his supposed atheism, was excommunicated in 1656 by the Jewish community of Amsterdam and forbidden by the Dutch authorities to publish his works. In Spinoza's philosophy, freedom

from the bondage of the emotions can only be attained by reason. Reason admits us to the knowledge of God, which Spinoza also describes as the intellectual love of God. We already exist within God, for God is immanent in Nature, that is, in the universe. The universe, being divine, is therefore perfect, and our task is to align ourselves with that perfection, not by suppressing our emotions as the Stoics advocated, but by bringing them under proper control. 'In life,' writes Spinoza, 'it is especially useful to perfect, as far as we can, our intellect, or reason. In this one thing consists man's highest happiness, or blessedness. Indeed blessedness is nothing but that satisfaction of mind which stems from the intuitive knowledge of God.'[126] This attractive philosophy won Spinoza many admirers, especially when people knew of his difficult life: having been expelled from Amsterdam's Jewish community he lived alone, earned his living by polishing lenses, and devoted himself to philosophy and (as we shall see in a later chapter) to highly original studies of the Bible. He was often seen as a saintly figure in his dedication to thought unruffled by passions.[127]

How much influence Spinoza's practice of reason had on the Enlightenment is disputed. His equation of God with nature, commonly misinterpreted as pantheism, was sometimes mocked. In his *Historical and Critical Dictionary* (1696), Pierre Bayle condemns Spinoza's identification of God with nature as atheism and assails it with a whole series of arguments. For example: if God is everything, he must have mutually contradictory qualities at the same time, and perform logical impossibilities. One should not say 'the Germans have killed ten thousand Turks' but 'God modified into Germans has killed God modified into ten thousand Turks'.[128] Many others understood Spinoza as a materialist who anticipated the radical view of such French Enlighteners as Baron d'Holbach and La Mettrie, that the world was a system of mechanical necessity. Yet that would be incompatible with Spinoza's claim that we are free to use our reason and divert our energies from worldly passions to the love of God.[129] Much of Spinoza's alleged influence therefore rests on misunderstandings of his work. Attempts to trace his impact often, in fact, focus on 'Spinozism', a loose complex of ideas including atheism, materialism and monism, which, when Spinoza's work was known more by reputation than at first hand, was readily foisted onto Spinoza himself.[130]

Reason was accorded similar primacy in the intellectual method to which Descartes, and other pre-Enlightenment philosophers of the seventeenth century, were committed. They hoped to attain knowledge of the world that was absolutely certain. Their model was the logical certainty provided by mathematics. Knowledge should start from a principle that was known intuitively and was beyond doubt. From that principle, a chain

of rigorous arguments should be constructed, as in geometry. Each proposition could be deduced from the one before it, demonstrated to be true, and give rise to another proposition which could be demonstrated in its turn. Thus the certainty of the initial principle would be transmitted all the way down the chain of reasoning and result in a system of knowledge that was free from doubt. Even when mathematical certainty was unobtainable, as in the study of nature, the precision of mathematics might supply a model of clarity. The tireless popularizer of natural science Bernard le Bovier de Fontenelle explained in 1709 how the spirit of geometry can be applied to many other subjects: 'A work on ethics, politics, criticism, or even eloquence, other things being equal, is merely so much more beautiful and perfect if it is written in the geometric spirit.'[131]

In early modern politics, too, reason was assigned a special role. Political thinkers developed the concept of rational calculation known as reason of state (*Staatsräson*, *Staatskunst*, *raison d'état*, *ragione di stato*). This concept is particularly associated with Machiavelli, although he does not use the term. Like the later 'reason of state' theorists, Machiavelli is concerned first and foremost with the effectiveness of politics. In *The Prince* (1532), he advises on how a prince may best gain and secure power; in the *Discourses* (1531), he discusses how a republic may best flourish. Moral considerations are ignored. The question whether it is better for a prince to be loved or feared by his subjects, for example, is treated as a purely pragmatic one.[132] Later in the sixteenth century, however, the methods that Machiavelli recommended to his Prince came to be described as the principles of government suitable for absolutism. The expedients that Machiavelli had recommended for an unstable situation were now adopted as the inevitable art and craft of government. The term 'reason of state' came into common use, denoting a conception of government as a self-contained and autonomous technique, an art of management, which could be studied and perfected.[133]

The idea was most influentially formulated by the Catholic priest and diplomat Giovanni Botero in his treatise *Della ragion di stato* (*On Reason of State*, 1589).[134] Botero describes a prince's virtues as justice, liberality, valour and prudence. Under the heading of prudence he gives a series of maxims that sound pragmatic and Machiavellian. The first is: 'Let it be taken for a settled matter that in the deliberations of princes interest overcomes every other consideration, and so the prince ought not to trust any friendship nor relationship nor alliance nor any other bond with negotiating partners that is not based on interest.'[135] He advises the prince on how to preserve his reputation: thus, if the prince is weak, he must take care to hide his weakness. Dealing with heretics and infidels, the prince

should be absolutely ruthless. The worst heretics are, in Botero's view, the Calvinists – he was writing when the Netherlands were in rebellion against Spain. By infidels he means the Ottoman Empire. He thinks the means used by heretics and infidels ought, when effective, to be adopted and used against them. For example, one should stir up factions and dissensions in enemy countries; Botero says: 'the pretended queen of England used this method – which we [i.e. his fellow-Catholics] should use with enemies of the faith – with the Catholic King in Flanders and with the Most Christian King in France'.[136] Here, as in the many subsequent writers on reason of state, the ends justify the means. Its advocates insisted that rational calculation, far from being immoral, was itself a moral action in order to secure the well-being of the state. Rather than mere deceit, the statecraft of a politic king consisted in astute political judgement, in knowing how to adjust his behaviour to circumstances.[137]

Thinkers of the Enlightenment, however, rejected such principles. David Hume suggests that one should not equate all politics with 'reason of state'. Thus the earl of Bristol, negotiating between James I and Philip III of Spain over the marriage between James's heir and the Spanish infanta, may have relied on humane as well as strictly political considerations:

> Perhaps, too, like a wise man, he considered that reasons of state, which are supposed solely to influence the councils of monarchs, are not always the motives which there predominate; that the milder views of gratitude, honour, friendship, generosity, are frequently able, through princes as well as private persons, to counterbalance these selfish considerations.[138]

Gibbon gives a disapproving account of the Roman emperor Septimius Severus, whose deceitful acts 'cannot be justified by the most ample privileges of state reason'.[139] Kant is most forthright in rejecting 'the serpentine coils of an immoral doctrine of prudence'.[140] He distinguishes sharply between the political moralist, who relies solely on experience and never rises to the level of principle, and the moral politician, who is aware not only of what people do now but of what they may do in the future when their potential is more fully realized. While the short-sighted political moralist decides on his purpose and then finds the most effective means, the moral politician will choose his means in the light of the principle 'do as you would be done by' or the categorical imperative, here formulated as: 'Act in such a way that you can wish your maxim to become a universal law (irrespective of what the end in view may be).'[141] Here as elsewhere, Enlightenment reason was not a matter of unfeeling, amoral means–ends calculation; that was appropriate, rather, to the age of rationalism and absolutism from which the Enlightenment had moved on.

Around the turn of the seventeenth and eighteenth centuries, philosophy made a sharp change of direction, which is fundamental to the Enlightenment. Rationalism began giving way to empiricism; the authority of Descartes yielded, though slowly and unevenly, to that of John Locke. Locke's *Essay concerning Human Understanding* (1689) was the authoritative statement of empiricism. Locke compared the infant's mind to a *tabula rasa*, a blank slate, or 'white paper', and argued that all ideas came from experience.[142] The mind perceives, not external objects directly, but ideas proceeding from those objects, which depend on the mind for their existence. Ideas may be simple or complex. They may concern primary or secondary qualities. Primary qualities, such as size, actually exist in external objects; secondary qualities, such as smell, texture, or colour, result from the relations between the object and the observer's sensory apparatus. This distinction saved Locke from the suspicion of scepticism or idealism. In his philosophy there really is an external world, even though we cannot know it directly. Reason enables us to distinguish true from false perceptions.

Locke's empiricism had major consequences for the study of the world around us.[143] Aristotle had maintained that scientific investigation aimed at knowledge of the essential natures of things, and that such knowledge must be necessarily true. Descartes agreed, maintaining that our clear and distinct ideas about the world must be true because they are guaranteed by a benevolent God who would not deceive us. For Locke, however, knowledge comes only from experience, and our experience can never disclose to us the inner essences of things. We can know only the surface of the world, not its hidden depths. And what we know is not even the phenomena of the world, but the ideas which these phenomena produce in our minds; and not even the ideas, but the relations among these ideas. 'Knowledge then seems to me to be nothing but the perception of the connexion and agreement, or disagreement and repugnancy of any of our ideas.'[144] While it would be absurd to doubt the reality of the external world, it would be mistaken to claim that we can have any certain knowledge of it. The study of the external world can never claim certainty, only a degree (often a very high degree) of probability.

Thus empiricism directed attention away from abstract principles to the data of experience. Hence, while the philosophers of the pre-Enlightenment period favoured the geometric method, reasoning deductively from first principles, their successors worked by induction, first observing particular details and arriving eventually at general truths. In the mid-eighteenth century, the Enlightener Jean Le Rond d'Alembert called the former method the *esprit de système*, implying the love of system for its own sake; in its place he aimed to substitute an *esprit*

systématique, which is controlled by experience. The *esprit de système* favours closed, rigid systems, whereas the *esprit systématique* accepts the authority of empirical phenomena and comes to conclusions that are provisional and can be modified in the light of further findings.[145] The *esprit systématique* was embodied in the Enlightenment's great intellectual and practical enterprise, the *Encyclopédie*, which d'Alembert helped to compile, and which undertakes to present, within a single system, the principles on which all arts and sciences are based, as well as the relevant factual details. To do this, as d'Alembert explained in his 'Preliminary Discourse', it was necessary to go back to the origins of all our ideas, not in abstract reflection but in sensation. The Encyclopedists began by examining 'the genealogy and the filiations of our knowledge, the causes that must have given them birth, and the characters that distinguish them; in a word, to ascend to the origin and the generation of our ideas'.[146]

Enlightened thinkers, especially in France, also spoke of the 'philosophical spirit' that distinguished their century. Thus the abbé Dubos in 1733 speaks of 'this superiority of reason, which we call philosophical spirit'.[147] Diderot says in 1749: 'we live in a century in which the philosophical spirit has rid us of a great number of prejudices'.[148] The expression 'philosophical spirit', however, is not itself a philosophical term; it is used in a variety of different ways, and is perhaps best understood as a slogan around which Enlighteners could rally.[149] It was in a similarly broad sense that Joseph Addison used the word 'philosophy' when he defined the purpose of his new daily paper, the *Spectator*: 'I shall be ambitious to have it said of me, that I have brought Philosophy out of Closets and Libraries, Schools and Colleges, to dwell in Clubs and Assemblies, at Tea-Tables and in Coffee-Houses.'[150]

'Philosophy' and 'philosopher' are key words to define the activity and the character of the Enlightenment intellectual. Since the philosopher deals with a wide range of subjects, beyond the bounds of academic philosophy, it is convenient to use the word *philosophe* so as to reduce the academic associations of the English word. The *philosophe* does not claim that philosophy, or the exercise of reason, can solve every problem or provide a complete understanding of life. Rather, the ambitions of the *philosophe* are strikingly modest. Believing, with Locke, that all our knowledge comes ultimately from the senses, and is thus empirical, not metaphysical, in origin, the *philosophes* do not profess to know what lies behind empirical phenomena.[151] They do not inquire into the ultimate nature of things. Voltaire, who promoted Locke's philosophy in France, agreed with him in placing religious belief outside the scope of human knowledge. *Philosophes* associate philosophy especially with 'natural

philosophy', or, as we would now say, natural science. Natural philosophy has criteria for determining truth which owe nothing to religion; it interprets experience with the help of reason, and hence becomes the model for all knowledge. It can even provide a model for the conduct of one's life. In the *Encyclopédie* article 'Philosophe', Diderot says that the *philosophe*, unlike the bulk of humanity, reflects on the causes of things, reasons before he acts, and is thus capable of furthering his own and others' happiness by avoiding disagreeable sensations and obtaining congenial experiences. The *philosophe* is not a solitary sage but a sociable being, who wishes to help others. Thus he places himself under the guidance of reason as the Christian submits to the guidance of divine grace: 'Reason is for the *philosophe* what grace is for the Christian. Grace tells the Christian how to act; reason guides the *philosophe*.'[152]

The turn from rationalism to empiricism means that when Enlighteners speak of reason, they rarely mean logical or mathematical reasoning. They use phrases such as 'right reason', 'good sense' (*le bon sens*), 'common sense', 'sound reason', 'sound philosophy' (*la saine philosophie*, *die gesunde Vernunft*). This 'reason' is not a specialized faculty, requiring logical or mathematical training. In the words of Cicero, one of the classical authorities to whom the Enlightenment most often appealed, it is common to all humanity:

> True law is right reason, consonant with nature, spread through all people. It is constant and eternal; it summons to duty by its orders, it deters from crime by its prohibitions . . . There will not be one law at Rome and another at Athens, one now and another later; but all nations at all times will be bound by this one eternal and unchangeable law.[153]

Thus when Enlighteners advocate reason, they usually mean the use of this 'right reason' and good sense to arrive at truth by means of debate. They urge people to be rational, but, still more, to be reasonable. Enlightened reason, typically, is a faculty that is exercised not in solitude, but in dialogue with others. The *philosophe*, according to Diderot, 'combines a spirit of reflection and judgement with manners and qualities that are sociable'.[154] The others in dialogue may be the physical people with whom one conducts an argument, or the opinions stored in books; in either case, conversation and reading are essential additions to the intellectual material that the individual can draw on. Reason is shown not only in calculation, but also in judgement: in judging whether a narrative is plausible, an argument convincing, or a course of action likely to succeed. Judgement is exercised above all in social life. In this sense, although few people can be philosophers, philosophy, or sound judgement, may spread throughout

society.[155] Hume expresses this aspiration in An *Enquiry concerning Human Understanding* (1748), where he hopes that

> though a philosopher may live remote from business, the genius of philosophy, if carefully cultivated by several, must gradually diffuse itself through the whole society, and bestow a similar correctness on every art and calling. The politician will acquire greater foresight and subtilty, in the subdividing and balancing of power; the lawyer more method and finer principles in his reasonings; and the general more regularity in his discipline, and more caution in his plans and operations.[156]

Very often these terms are used in an oppositional sense. Writers appeal to the evident facts of experience, or to the dictates of unprejudiced reason, in order to oppose the claims of political or religious authorities. In a treatise subtitled *An Appeal to the Consciences and Common Sense of the Christian Laity*, the Anglican bishop Benjamin Hoadly in 1716 defended the rights of the individual conscience against the authority of the Church of England's clergy. Hume, summoning 'good sense' to oppose prejudice, equates it with 'reason'.[157] In France, the freethinking Baron d'Holbach disseminated his views under the title *Good Sense, or Natural Ideas opposed to Supernatural Ideas* (1772).[158] And in America, Thomas Paine prompted the War of Independence with his inflammatory pamphlet *Common Sense* (1776), attacking the unreasonable and tyrannical measures of the British government.

The role of reason was the repeated theme of a debate on the meaning of enlightenment that was conducted in Berlin in the 1780s.[159] It was this debate that produced Kant's famous essay, 'Beantwortung der Frage: Was ist Aufklärung?' ('An Answer to the Question: What is Enlightenment?') The essay is usually, and justifiably, taken as a definitive formulation of enlightenment, summing up a century of philosophical discussion.[160] But it also points beyond the Enlightenment in new directions.

Kant's essay appeared in the *Berlinische Monatsschrift* (*Berlin Monthly*), a major journal of Enlightenment thinking, in December 1784, prompted by an earlier contribution to the same journal. The suggestion had been made that marriage need not be a religious ceremony, only a civil one. The clergyman Johann Friedrich Zöllner complained that such proposals threatened to 'shake the first principles of morality, degrade the value of religion, and to confuse people's heads and hearts under the name of *enlightenment*'. He added in a footnote: '*What is enlightenment?* This question, which is almost as important as "What is truth?", needs to be answered before one sets about enlightening! And I have never yet found an answer!'[161] The journal received two essays in reply. One was by the

Berlin Jewish philosopher Moses Mendelssohn, who distinguished between intellectual enlightenment (*Aufklärung*) and broader social refinement (*Kultur*), and pointed out that the two could easily get out of sync: thus the French had more *Kultur*, the English more *Aufklärung*, while the ancient Greeks had excelled in both.[162] The other reply was sent by Kant from Königsberg on the distant Baltic coast.

Kant begins with a firm definition of enlightenment that can hardly be quoted too often:

> *Enlightenment is man's emergence from his self-incurred immaturity. Immaturity* is the inability to use one's own understanding without the guidance of another. This immaturity is *self-incurred* if its cause is not lack of understanding, but lack of resolution and courage to use it without the guidance of another. The motto of enlightenment is therefore: *Sapere aude!* Have courage to use your *own* understanding![163]

Most people, Kant continues, are too lazy to think for themselves. They allow guardians of various kinds to think for them, and the guardians are only too happy to take control and reduce their charges to a position like that of domestic animals, or small children who cannot walk without leading strings.[164]

The metaphor of 'immaturity' (*Unmündigkeit*) deserves a closer look. If you are *unmündig*, you have not yet come of age, and are not yet considered legally as a responsible adult. Until you are *mündig*, you must obey a guardian (*Vormund*). Since everyone attains maturity by the passage of time, Kant's metaphor implies that humanity as a whole must likewise become mature in the course of history. Enlightenment, or learning to think for oneself, is thus a process guaranteed by nature.

In the word *Vormund*, the syllable *mund* is derived from an archaic word meaning 'protection', but it happens also to be the modern German word for 'mouth', so one can, if one wants, read into Kant's wording the implication that immature people are forbidden to speak and must rely on guardians to speak on their behalf. Such an implication is appropriate, for in Kant's essay thinking for oneself leads to speaking for oneself. Kant is concerned with how the mature individual takes part in the wider conversation of a community.

Kant conceived enlightenment as involving reasoned criticism of the social order. But his essay also shows the narrow limits within which, even under the enlightened monarch Frederick the Great, such criticism could be expressed. In Frederick's Prussia, which is the immediate and unavoidable context of Kant's essay, that conversation is subject to various restrictions. There are figures in authority who tell one not to argue (Kant

puts into their mouths the disparaging term *räsonnieren*). Thus a soldier must not argue back when an officer gives him orders, and a layman should not argue about theology with a clergyman, who knows better and whose superior knowledge is attested by his office. The clergyman himself, as a public servant, is obliged to teach the official doctrines of the Church. This is what Kant, a little confusingly, calls 'the private use of reason': the restrictions on intellectual expression imposed by professional responsibilities. However, the clergyman can also exercise 'the public use of reason'. As a learned man, he can publish articles querying this or that dogma of his Church. Similarly, as a private citizen I must pay my taxes, but as a member of the public I can argue in the press about the state's fiscal policy. This has been called Kant's ' "two hats" doctrine': with my private hat on I must serve the state, but with my public hat on I can argue for the improvement of its institutions.[165] In this way, Kant hopes, enlightened discussion can gradually modify and liberalize the state.

Kant admits that the process of enlightenment still has a long way to go. 'If it is now asked whether we at present live in an *enlightened* age, the answer is: No, but we do live in an age of *enlightenment*.'[166] An age of enlightenment is one in which people are free to think as their intellect guides them. No body, even the Church, can permanently restrict freedom of thought by prescribing what people must believe, now and for ever. The attempt to forbid the progress of enlightenment 'would be a crime against human nature, whose original destiny lies precisely in such progress'.[167]

By this insistence on freedom, Kant gives a new and important twist to the debate on enlightenment. He is not interested only in *what* people think, but also, and rather more, in *how* they think. Enlightenment is not a set of ideas but an intellectual practice for exploring the unknown.

The thinking that Kant advocates is not some rarefied intellectual activity available only to a few. In his initial injunction, he urges people to use their 'understanding' (*Verstand*); in the body of the essay he uses the word 'reason' (*Vernunft*) and advocates the use of one's own reason. In the technical language of philosophy, 'understanding' is the faculty that processes the empirical information delivered by the senses and needs to be assisted by 'reason' as the supreme faculty of abstract thinking.[168] Writing for a wider audience, however, Kant does not observe this technical distinction, but uses 'understanding' and 'reason' interchangeably in his plea for critical and independent thinking.

THE PASSIONS

A perennial problem in moral philosophy and psychology has been what relation should be desired between reason and the passions. The violence of the passions can all too easily overwhelm the sovereignty of reason. An ancient allegory in Plato's *Phaedrus* represents reason, or the rational part of the soul, driving a chariot pulled by two horses. One of the horses is noble and obedient, the other is restive and troublesome. The noble horse stands for such praiseworthy passions as righteous indignation, but the other embodies unruly passions, desires and lusts. The charioteer has the difficult task of keeping both horses under control, pursuing the right course and heading towards the goal of wisdom.[169] Reason aims at an understanding of the cosmic order. If one has such understanding, one will know how to tame the ignoble horse and to use the noble horse for good and wise purposes. Aristotle similarly maintains that the passions can be subjected to rational control: to 'being infused with, and thus docile to, rational insight into what is appropriate'.[170]

This classical contrast between reason and passion often implied a further contrast between the mind and the body. In the much-quoted Priests' Chorus from Fulke Greville's drama *Mustapha* (1609), reason and passion are placed in tragic opposition:

> Oh wearisome Condition of Humanity!
> Borne under one Law, to another bound:
> Vainely begot, and yet forbidden vanity,
> Created sicke, commanded to be sound:
> What meaneth Nature by these diverse Lawes?
> Passion and Reason, self-division cause . . .[171]

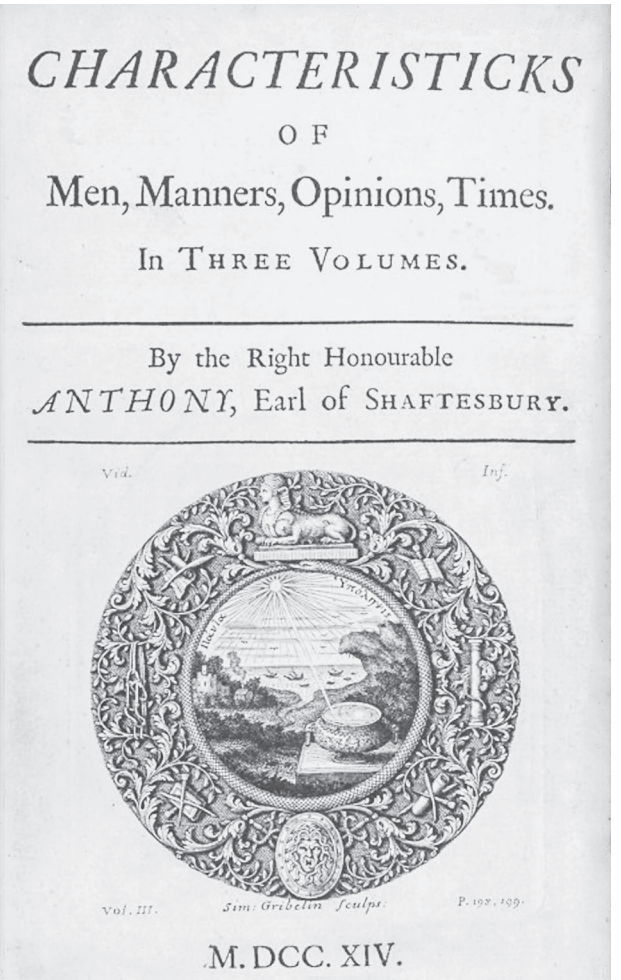
Although the priests are supposed to be Muslims, the antithesis they formulate sharply recalls the conflict expressed by St Paul between the law of God, which he affirms intellectually, and another law located in his body: 'For I delight in the law of God after the inward man: But I see another law in my members, warring against the law of my mind, and bringing me into captivity to the law of sin which is in my members' (Romans 7:22–3).

As we approach the Enlightenment, however, the antithesis becomes less sharp, and the passions receive more positive treatment. Descartes discussed the passions in a late essay, *Les Passions de l'âme* (*The Passions of the Soul*, 1649). The soul here is the agent of thoughts. Being immaterial, it is distinct from the body, but the part of the body with which it interacts most closely is the pineal gland, situated in the brain. Through this gland,

the brain can be affected by animal spirits, i.e. very subtle parts of the blood composed of tiny and fast-moving bodies. Thoughts may be active, when they are willed by the soul, or passive; among the latter are perceptions of external objects and physical sensations, and perceptions taking place within the soul. These last are 'perceptions, or sensations, or emotions of the soul that we refer particularly to the soul itself, and that are caused, sustained, and fortified by some movement of the [animal] spirits'.[172]

Passions of the soul are potentially valuable. Unlike the Stoics, Descartes thinks they should not be suppressed, but put to good use. Thus, while I know rationally that I should run away from an angry bull, the passion of fear enables me to run all the faster. In another situation, the passion of courage may animate me to resist a danger. Whether fear or courage predominates in a given situation depends on the disposition of my brain. However, this too is to some extent under my control. A strong soul will form 'firm and definite judgements concerning the difference between good and evil, according to which it has resolved to conduct the actions of its life'.[173] Strength of soul can be cultivated and become habitual. The strong soul, however, does not overcome a passion such as fear by a mere act of will; rather, it summons up examples and reflections that promote the countervailing passion of courage. Thus it is important not to overcome the passions, but to manage them. Descartes concludes that the passions 'are all good of their nature', and that we are to avoid only 'their misuse or their excess'.[174] In the very last section he goes even further, affirming that since 'it is the passions alone that make for all that is good or bad in this life', 'the greatest benefit of wisdom is that it teaches us to master the passions so thoroughly and to handle them so skilfully that the evils they cause are perfectly bearable, and can even, all of them, be a source of joy'.[175]

In the philosophy of Shaftesbury, at the turn of the eighteenth century, the 'affections or passions' are all-important.[176] We are connected with other people, he says, by 'natural affection, parental kindness, zeal for posterity, concern for the propagation and nurture of the young, love of fellowship and company, compassion, mutual succour and the rest of this kind', which serve the good of the species as a whole.[177] Equally natural to us is the sense of right and wrong. Virtue consists in the right direction and degree of the affections, 'a certain just disposition or proportionable affection of a rational creature towards the moral objects of right and wrong'.[178] The role of reason is 'to secure a right application of the affections'.[179] Thus it enables us to avoid such aberrations as selfishness, cruelty, idolatry, or the attribution to one's gods of evil demands, or the excess of an essentially good impulse, as when religious devotion turns into



The second edition of Shaftesbury's *Characteristicks*. The corrections were made just before the author's death in 1713. The medallion alludes to two passages from Graeco-Roman philosophy quoted in Shaftesbury's text. The Greek words from Marcus Aurelius within the medallion mean 'all is opinion'. The ray of light striking the bowl of water illustrates a passage from Epictetus: 'As is the water dish, so is the soul; as is the ray which falls on the water, so are the appearances. When then the water is moved the ray too seems to be moved, yet is not. And when, accordingly, a man is giddy, it is not the arts and the virtues which are thrown into confusion, but the spirit to which they belong; and when he is recovered so are they.'

fanaticism. For Shaftesbury, the passions are now the locus of the moral life. Reason simply formulates the goals to which our affections instinctively draw us, and corrects us when our affections risk getting out of hand.

A similarly modest role is assigned to reason in Pope's *Essay on Man* (1733–4). Humanity is actually animated by the passions, which are different modes of self-love, and may be either good or bad, depending on their purpose. Reason restrains self-love and weighs up the different goals it might seek.

> Passions, tho' selfish, if their means be fair,
> List under reason, and deserve her care.[180]

Even when the mind is dominated by a ruling passion, reason can 'rectify, not overthrow, / And treat this passion more as friend than foe'.[181] Without passion, reason would be helpless. Reason provides the sailor with a chart to show where he is going, but passion moves the ship:

> On life's vast ocean diversely we sail,
> Reason the card, but Passion is the gale.[182]

It is a short step, and a short interval of time, from Pope's presentation of reason as merely a guide to passions, to Hume's reversal of their usual roles in his *Treatise of Human Nature* (1739–40). Hume opposes the common tendency, both in philosophy and in ordinary discourse, to contrast reason with passion and to maintain that rational beings should obey the dictates of reason and keep their passions firmly in check. This, according to Hume, is a fallacy pervading most of moral philosophy, both ancient and modern. As a rejoinder, Hume undertakes to show, '*first*, that reason alone can never be a motive to any action of the will; and *secondly*, that it can never oppose passion in the direction of the will'.[183] Reason can direct our judgement, by telling us what causes will produce desirable or undesirable effects, but what makes us perform or avoid any action is the prospect of pleasure or pain to be derived from it; and though reason can tell us what may happen, it cannot directly *make* us do anything. We do things because we want to, and it is our passions, not our reason, that make us want to. Indecision is not a conflict between passion and reason, but a conflict between two opposing desires. Therefore it is passion, not reason, that motivates our actions. 'Reason is, and ought only to be the slave of the passions.'[184]

This claim, one might rejoin, is so striking because Hume is stretching the meaning of the word 'passions'. Although it suggests primarily violent passions such as greed, ambition or lust, Hume is extending it to include even the mildest form of desire. On his showing, it is passion, not reason, that makes one go about one's daily business, but 'passion' would seem

an absurdly grandiose word for such mild and ordinary motivations. Even allowing for dramatic overstatement, however, Hume has sharply adjusted the familiar understanding of human nature. His originality can be appreciated by a comparison with a passage from Kant's essay 'Versuch über die Krankheiten des Kopfes' ('Essay on the Maladies of the Head', 1764), written before he had read Hume. Kant acknowledges that the will is motivated by passions, that the intellect serves to identify goals and helps towards their attainment, and that passions can easily get out of hand. Somebody who fails to control his passions is a fool (*Tor*), whether besotted by love or carried away by milder obsessions with building, collecting pictures, or acquiring books. A wise man is free from passions, though Kant admits that, as the passions are so all-pervasive, we may have to search for this wise man in the moon.[185] Kant deplores the power of the passions, which Hume provocatively celebrates.

As yet few people agreed with the primacy Hume gave to the passions. The article 'Passions' in the *Encyclopédie* acknowledges that the passions are essential to human life: 'It is the passions that set everything in motion, that bring the picture of this universe to life, and, so to speak, give the life and soul to its various parts.'[186] The author nevertheless deplores the propensity of the passions to escape from control and the difficulty that reason experiences in maintaining a balance among them. The article ends by adopting Pope's image of a sea voyage in which passion too often blows the ship off course:

> Sad picture of the state to which man is reduced by his passions! surrounded by reefs, driven by a thousand contrary winds, could he ever reach the port? Yes, he can; for him there is a reason that moderates the passions, a light that shines on him, rules that guide him, a vigilance that sustains him, a prudence of which he is capable.[187]

This, however, was already a backward-looking view. The Enlightenment, the so-called 'age of reason', would increasingly rely on the guidance of the emotions. Reason untempered by feeling was felt to be inadequate, even dangerous. 'Virtue born of reason alone,' said Pietro Verri, 'makes us just, faithful, discreet and circumspect; but that which springs from sentiment makes us generous, affectionate, benevolent; the first tends to remove evil from our actions, the second urges us with positive actions towards the good.'[188] By 1795 Friedrich Schiller could condemn an enlightenment that applied only to the intellect without also educating the emotions: 'That enlightenment of the mind, which is the not altogether groundless boast of our refined classes, has had on the whole so little of an ennobling influence on feeling and character that it has tended rather to bolster our

depravity by providing it with the support of precepts.'[189] Accordingly, by the late eighteenth century the Enlightenment was increasingly dominated by emotion rather than reason, in ways to be explored in detail in the chapters that follow. The concept of sympathy, as the glue holding society together, would be explored by philosophers from Shaftesbury to Adam Smith. Sensibility, an emotional participation in other people's experiences, would be promoted by the great novels of the mid-century – Richardson's *Clarissa*, Rousseau's *La Nouvelle Héloïse*, Goethe's *Werther* – and helped to motivate such social reforms as the campaign against slavery. The indulgence of individual appetites, which powered a commercial economy but was often stigmatized as wanton 'luxury', would become a central theme in debates about society. And in aesthetics, the concept of the sublime, in which emotion and reason were imagined as interacting, would be a central topic from Burke's *A Philosophical Enquiry into the Origin of our Ideas of the Sublime and Beautiful* (1757) to Kant's *Critique of Judgement* (1790).

INTERPRETING THE ENLIGHTENMENT

How, in the early twenty-first century, should we define and interpret the Enlightenment? The best starting-point remains the definition of the Enlightenment, already quoted, as a coherent intellectual movement united by a 'commitment to understanding, and hence to advancing, the causes and conditions of human betterment in this world'.[190] This formulation, however, needs some qualifications. Yes, the Enlightenment was a conscious and deliberate attempt by thinkers better to understand humanity – and the world in which humans live – in order to promote happiness. Philosophers, whom we might today describe rather as intellectuals, sought to influence public opinion through a rapidly growing network of communications and, sometimes, by persuading the more open-minded kings and emperors of the time to introduce enlightened reforms. Here their efforts interacted with the work of administrators, especially in France and the German states, who were seeking to improve people's living conditions and public order. Alongside the intellectuals, therefore, we must give credit to the university-trained administrators, bearing in mind that the two categories often overlapped.

Besides the agency of philosophers and administrators, however, I have tried in what follows to take account of larger, impalpable shifts in outlook, for which I have already used the term 'mentality' as a useful shorthand.[191] An essential precondition for the Enlightenment was the Protestant Reformation, which changed the way people understood

reality. It helped to weaken belief in the supernatural, whether in the magic offered by the Church (e.g. the alleged transformation of bread and wine into the body and blood of Christ) or in the natural world. It contributed to what the sociologist Max Weber would much later call the 'disenchantment of the world'. And it undermined the Church's authority: instead of a single Church, there were now Churches with diverse attitudes to authority, and theology became a subject about which laymen too could argue.[192]

By weakening the repressive authority of the Churches, the Reformation made possible another essential precondition of the Enlightenment: the investigation of the natural world known, however controversially, as the Scientific Revolution. The natural world no longer appeared as a complex of occult forces and symbolic meanings, but as a field available for scientific investigation. When in 1682 Pierre Bayle mocked the idea that comets were portents of disaster, he was expressing what was already the standard view held by educated people; although the comet of 1680 caused some popular alarm, comment on it in the press was generally light in tone.[193] The mathematical calculations of the movement of comets published by Edmond Halley in 1705 did not dispel superstition; superstition was already on the wane.[194] Similarly, belief in witchcraft was already disappearing before Enlighteners – excepting a few isolated voices at earlier periods – debunked its absurdity.

The Enlightenment is therefore presented here in two interconnected ways: both as a deliberate undertaking and as the continuation of a shift in mentality; indeed, it could be summed up as the interaction between the two. Treatises and campaigns against superstition reinforced a tendency that was already under way, and that tendency in turn made intellectual arguments seem even more persuasive. Thanks to the growth of the print media, illustrated by 'moral weeklies' written by Joseph Addison, Richard Steele and their many imitators, debates among philosophers were transmitted in accessible form to a wide public. Accordingly, I have at many points drawn on life-writings and travel literature to present aspects of people's experience during the eighteenth century.

In doing so, I have taken a particular interest in records of emotional experience. The Enlightenment, as I have been arguing, is not adequately described as 'the age of reason'. The rationalism of the seventeenth century, represented by Descartes, gave way gradually to the empiricism of Locke and to the emphasis on emotion ('affections') found in the influential writings of Shaftesbury. As the eighteenth century wore on, emotion, sensibility and desire became increasingly prominent in philosophy, in social life and in literature. For this reason, unlike most other books on the Enlightenment, this one not only includes a chapter on aesthetic theory

but refers frequently to literature, and to records of the reception of literary works, as evidence of shifts in outlook, or of what Raymond Williams called 'structures of feeling'.[195]

Any study of the Enlightenment has to answer some basic questions: not only *what* the Enlightenment was, as in the previous paragraphs, but also *when*, *where* and *how many*. I have chosen to begin with the 1680s, the decade that saw the publication of Bayle's *Letter on the Comet* and Isaac Newton's *Principia* (1687), as well as the 'Glorious Revolution' in Britain which asserted the sovereignty of Parliament. Ending in 1790 acknowledges that the French Revolution was a historical turning-point, whether or not it is interpreted as the outcome of Enlightenment endeavours; it also leaves us on the threshold of Romanticism, a diverse and fuzzy movement in which we find attempts to restore a magical conception of the universe, and a new enthusiasm for the Middle Ages, which Enlighteners considered a benighted and semi-barbarous period.

Where was the Enlightenment? Its location is not solely a geographical matter. There is 'a certain degree of nationalist pride still linger[ing] around the issue of who "owns" the Enlightenment'.[196] Robert Darnton wrote in 1997 that the Enlightenment was 'a movement, a cause, a campaign to change minds and reform institutions . . . which can be located in time and pinned down in space: Paris in the early eighteenth century.'[197] Later in his essay, he qualified this by mentioning many other centres of the Enlightenment, from Edinburgh to Philadelphia. Similarly, a classic study of the Enlightenment by Peter Gay puts the emphasis on France.[198] This is unavoidable: if any single figure was identified with the Enlightenment, then and now, it was Voltaire; if any single enterprise typified the Enlightenment, it was the *Encyclopédie*, directed by Diderot and d'Alembert; and the Paris *philosophes* were highly visible and controversial figures. Jonathan Israel, who traces the Enlightenment back to impulses from the late-seventeenth-century Netherlands, and whose massive studies extend from Peru at one extreme to Greece and Russia at the other, nevertheless gives prolonged and detailed attention to France.[199] Israel, like Margaret Jacob earlier, also makes an impassioned case for the crucial importance of the Netherlands as the seedbed of Spinozism, the centre of relatively free publishing, and a place of refuge for Huguenots and freethinkers exiled from France.[200]

What about the British Isles? In the eighteenth century, England was often thought to be the heartland of the Enlightenment thanks to the achievements of Bacon, Newton and Locke. The Russian traveller Nikolai Karamzin wrote, on arriving in London in 1790: 'I am engaged in philosophising: sorry. Such is the action of the English climate. Here is the birthplace of Newton, Locke and Hobbes!'[201] Whether one can properly speak of an

English Enlightenment is disputed.[202] John Pocock has argued that England had an 'Arminian Enlightenment', i.e. dedicated to religious toleration; but his two main exhibits – the sceptical historian Gibbon and the Anglican bishop William Warburton, whose eccentric ideas about interpreting the Old Testament were mocked by many, including Gibbon – hardly strengthen his case.[203] In contrast to France, Scotland or Naples, there was no cohesive group of *philosophes* or self-aware proponents of Enlightenment. Enlightened thinking in England was widespread, but diffuse.[204] And even the term 'the Scottish Enlightenment', first used in 1900, became widely current only in the 1960s, though a 'Scottish school of philosophy' was influentially identified by one of its members, Dugald Stewart, at the beginning of the nineteenth century and was generally recognized thereafter.[205]

Germany has traditionally been the stepchild of Enlightenment studies. That is in part due to conventions of German historiography. For a long time, histories of German culture treated the Enlightenment as a foreign body. They identified it with rationalism and French influence, limited it to a few decades in the early and mid-eighteenth century, and recorded with relief the advent of the *Sturm und Drang* movement in the 1770s. With Johann Gottfried Herder, the young Johann Wolfgang Goethe and others, a movement praised for its irrationalism got under way, anticipating the Romanticism that past generations saw as the quintessential expression of the German spirit. This dated narrative is clearly rooted in nineteenth-century nationalism.[206] Recently, however, it has been powerfully argued that not only Lessing and Kant, but Goethe, Schiller and Herder should be understood as carrying on the aims and values of the Enlightenment.[207] They therefore play a prominent part in this book, though (with a few exceptions) I have confined myself to their works published before 1790.[208]

Given that the Enlightenment can be found in so many different countries, it has often been asked whether we can really call it a single phenomenon. Pocock is perhaps the best-known critic of a single conception of 'the Enlightenment', arguing that 'it occurred in too many forms to be comprised within a single definition and history, and that we do better to think of a family of Enlightenments, displaying both family resemblances and family quarrels'.[209] Here Pocock seems to be using Wittgenstein's concept of 'family resemblances' as a way of capturing similarities among diverse phenomena, but the concept has been criticized as woolly.[210] One can identify diversity within the Enlightenment without dissolving the concept; and by retaining the concept of 'Enlightenment', even without the definite article, as Pocock does, one acknowledges that such diversity is spanned by an overarching unity. An important study of the Enlightenment

in various nations did not go so far as to talk of different Enlightenments.[211] I much prefer Israel's argument that to talk even of different national Enlightenments is 'decidedly the wrong framework for so international and pan-European a phenomenon'.[212] And, of course, the Enlightenment was not only pan-European but also American, extending not only to the northern part of the continent but also, despite the power of the Church, to Spanish America.[213]

A final problem in discussing the Enlightenment is that, more than most historical movements, it demands a double optic. As part of the past, removed from us by several centuries, it needs to be studied with the distance and the objectivity proper to the historian. But the detachment of the historian can often seem to lay a dead hand on the past, putting people and conflicts that were once alive into a historical deep freeze. That would be particularly unfortunate in dealing with a movement that still speaks urgently to the present. We often hear and read impassioned pleas to uphold Enlightenment values in the face of tyranny and superstition. Some distinguished historians and philosophers have issued such appeals with compelling arguments and persuasive eloquence.[214] In invoking 'Enlightenment values', however, one can fall into the trap that historians deplore as 'presentism': distorting the past by interpreting it too much in the light of the present. When Jonathan Israel opens his monumental series of volumes on the Enlightenment by telling us that it replaced outdated values, 'intellectually and to a degree in practice', with 'the principles of universality, equality and democracy', his interpretation is unmistakably influenced by hindsight.[215] There are many pressing present-day issues, such as the current troubles of democracy, about which the Enlightenment has little guidance to offer. The greatest crisis of the present and imminent future, the devastation of the environment by man-made climate change, is one of which only the very faintest premonitions can be found in the Enlightenment.

Nevertheless, it would be hard not to find the Enlightenment inspiring, insofar as it involved the advance of reason, good sense and empirical inquiry against superstition, blind prejudice and the authority arrogated by political and ecclesiastical bodies. The Enlightenment's search for the betterment of human life, for the increase of happiness, required a more accurate understanding of the world. Cassirer speaks of 'the almost unlimited power which scientific knowledge gains over all the thought of the Enlightenment'.[216] That understanding of the physical and natural worlds was transformed by the Scientific Revolution, which provided the Enlightenment with a model of knowledge and impelled it to extend its inquiries to what Hume called 'the science of man' and to the study of society. But the precondition for these, the Scientific Revolution, first claims our attention.

2
The Scientific Revolution

In medieval and Renaissance Europe, 'natural philosophy', or the study of the natural world, was based on the canonical texts by Aristotle and commentaries on them.[1] Aristotle thought knowledge should be deductive: it should proceed from first principles to the study of phenomena, instead of starting with the phenomena and inferring general principles from them. Among Aristotle's principles was teleology. Animate and inanimate beings seek to attain a goal. The goal of an acorn is to become an oak tree. Phenomena behave in accordance with their intrinsic character: thus, stones fall downwards because it is in the nature of stones to do so – that's what stones do. By the seventeenth century some people perceived that such arguments were vacuous. Hence in 1673 Molière ridiculed doctors for maintaining that opium induces sleep because of its 'dormitive' (i.e. sleep-inducing) properties.[2] The empirical study of nature had to contend with the seemingly unchallengeable authority of Aristotle, which continued to dominate university curricula throughout Europe until the mid-eighteenth century: when Adam Smith arrived at Oxford from the more progressive University of Glasgow in 1740, he was annoyed to find that Oxford was still teaching Aristotle's 'exploded system'.[3]

There was a long-standing view, first found in the twelfth-century poet Alan of Lille, that God had revealed himself to humanity not only in the Bible but also in the natural world, which was a book displaying God's wisdom and goodness.[4] But just as the Bible communicated on several levels, and required learned and patient exegesis, so the book of nature was likewise difficult to read. Natural phenomena were also symbolic: thus the pelican, which was said to feed its young with blood from its own breast, symbolized the self-sacrifice of Christ for humanity. The entire natural world, the macrocosm, was linked to man, the microcosm, by a vast network of correspondences. As George Herbert affirmed in his collection *The Temple* (1633):

Man is all symmetrie,
Full of proportions, one limbe to another,
And all to all the world besides:
Each part may call the furthest, brother:
For head with foot hath private amitie,
And both with moons and tides.[5]

The sixteenth century, however, already saw the advent of literal-mindedness. Interpreters of the Bible, including many Catholics as well as Protestants, showed less interest in the supposed allegorical dimensions of the biblical text and attached ever more importance to its literal meaning.[6] Martin Luther insisted on the primacy of the literal sense as 'the highest, best, strongest'.[7] In the seventeenth century, students of the natural world increasingly concentrated on the actual properties of its denizens that were available for empirical inspection. Natural phenomena, animals and plants, were not symbols with hidden religious meanings. For an increasing number of people, comets were not portents of disaster, and thunder was not the voice of God. Natural phenomena were of interest because of the ways in which they originated, functioned and interacted, as the scientific observer described them.

But this did not mean that nature ceased to be divine. The world was a wonderful, coherent, interlocking system, and in its harmony, perceptible to anyone but explained by the scientist, it manifested the wisdom and benevolence of its Creator. It was described as an 'economy', meaning 'an intricate system of interrelated, functional parts'.[8] The great eighteenth-century botanist Carl von Linné (better known as Linnaeus) popularized the phrase 'the economy of nature' to describe the interrelatedness of natural phenomena, which, he was convinced, had been designed by God: 'By the Œconomy of Nature we understand the all-wise disposition of the Creator in relation to natural things, by which they are fitted to produce general ends, and reciprocal uses.'[9] Linnaeus elsewhere described the natural world as like a well-organized social hierarchy, but only as a metaphorical comparison. In the vegetable kingdom, for example, mosses corresponded to 'the poor laborious *peasants*', grasses to the '*Yeomanry*', herbs to the gentry, while trees were the nobility among plants because 'they are deeply rooted, elevate their heads above their fellow-citizens, and protect them from storms, heat and cold'.[10]

The study of nature presupposed a major shift in mentality. Curiosity had to become respectable, even admirable. The Churches had long condemned curiosity as an attempt to pry into the secrets of God; St Augustine repeatedly speaks of it as 'sacrilegious'.[11] In his *Confessions* he condemns

a friend who was curious about gladiatorial shows, and who contemplated marriage simply out of curiosity about sex.[12] He himself, echoing the New Testament's condemnation of 'the lust of the eyes' (1 John 2:16), deplores this desire as the soul's 'vain and curious desire, veiled under the title of knowledge and learning, not of delighting in the flesh, but of making experiments through the flesh'.[13] The late-medieval theologian Jean Gerson wrote a treatise, *Contra vanam curiositatem* (*Against Vain Curiosity*), warning against the desire to penetrate into the secrets of nature.[14] Such an attitude is echoed in *Paradise Lost*, when Milton makes the Archangel Raphael rebuke Adam for being interested in astronomy: 'Dream not of other worlds'.[15] Even in the eighteenth century, the Northamptonshire poet Mary Leapor wondered about the moon –

> Who that beholds the full-orb'd Moon arise,
> That chearful Empress of the nightly Skies;
> Who wou'd not ask (cou'd learned Sages tell)
> What kind of People on her Surface dwell?[16]

– but restrained her curiosity by reflecting that God might not have intended us to know such things.

BACON OR DESCARTES?

Francis Bacon, in his manifesto for empirical research, *The Advancement of Learning* (1605), replied firmly to those biblical authorities, Solomon and St Paul, who had condemned learning as unprofitable and as conducing to vanity. Provided it did not serve conceit or ostentation, Bacon argued, learning would enable us to appreciate the wisdom of God, as revealed both in the Bible and in the creation:

> let no man, upon a weak conceit of sobriety or an ill-applied moderation, think or maintain that a man can search too far or be too well studied in the book of God's word or in the book of God's works; divinity or philosophy; but rather let men endeavour an endless progress or proficience in both.[17]

Curiosity led many people into a fascination with freaks of nature ('monsters') and the exotic artefacts that were collected in cabinets of curiosities or *Wunderkammern*. Writing in a more serious spirit, the authors of the *Encyclopédie* gave little attention to wonders, supplying only a short and dismissive article on the marvellous ('Merveilleux').[18]

Natural philosophy was considered intellectually superior to natural history. The former inquired into the causes of things and drew on

mathematics to place its findings on a quantitative basis. The latter accumulated observations of the natural world, and arranged them in taxonomic systems, but it had no higher intellectual ambitions.[19] Sometimes it was mocked for triviality. The 'virtuoso', who might be an inquirer into natural history, was a standard object of satire. In Thomas Shadwell's play *The Virtuoso* (1676), one of Sir Nicholas Gimcrack's irritated nieces calls him 'A Sot, that has spent 2000 *l.* in Microscopes, to find out the Nature of Eels in Vinegar, Mites in Cheese, and the Blue of Plums, which he has subtilly found out to be living Creatures.'[20] Nevertheless, the collections made by natural historians eventually formed the basis of today's museums, and the classification and cataloguing of specimens was not an antiquarian exercise but an essential intellectual undertaking. The Irishman Sir Hans Sloane, whose accumulation of dried plants, manuscripts, books, coins and medals, bequeathed to the nation, formed the core of the British Museum (established by an Act of Parliament in 1753), declared that 'the collection and accurate arrangement of these curiosities constituted my major contribution to the advancement of science'.[21]

How should the scientist, or the 'natural philosopher', set about studying the world? Francis Bacon's programme for science, which would exercise a decisive influence down to our own day, was set out in *The Advancement of Learning*. Bacon was aware that the world had been changed by three inventions: the compass, which made possible the discovery of America and the sea route to Asia; the printing-press, which permitted mass communication; and gunpowder, which sustained the power of absolute monarchs. The intellectual sciences needed to advance similarly. Bacon therefore rejected the empty abstractions of scholastics who immersed themselves in Aristotle and ignored the world around them:

> For the wit and mind of man, if it work upon matter, which is the contemplation of the creatures of God, worketh according to the stuff and is limited thereby; but if it work upon itself, as the spider worketh his web, then it is endless, and brings forth indeed cobwebs of learning, admirable for the fineness of thread and work, but of no substance or profit.[22]

He also rejected the search for occult knowledge, undertaken by some Renaissance thinkers who placed their faith in magic. Instead, the natural philosopher should undertake the empirical study of the world around him. Mere empiricism, however – the accumulation of data – was as bad as desk-bound reasoning. There should be a marriage between experience and theory. Investigations along these lines should be conducted by research communities, like the one Bacon imagined in his fantasy *The*

New Atlantis (1627), and rest on the authority of shared public knowledge, not on the personal authority of a magus.

Bacon's dismissal of Aristotelian abstractions was supported by such hands-on experimenters as Robert Boyle. Boyle complained that scholastic philosophers following Aristotle tried to explain phenomena by appealing to certain real entities or qualities that were separate from the phenomena and existed in some realm beyond observation. Thus, if asked why snow dazzles the eyes, they would reply that snow had a '*Quality* of Whiteness' that dazzled the eyes by its very nature.[23] This was as vacuous as the 'dormitive' quality mocked a few years later by Molière.

The new philosophers accepted the demystified picture of the universe. Early in the seventeenth century, the conception of nature as an animated play of interconnected forces came under attack from what was called 'the mechanical philosophy'.[24] The Catholic priest and mathematician Marin Mersenne objected that conceiving the universe as animate tended to draw God into the universe and present a kind of pantheism. Ironically, it was in order to preserve the distinctness of the supernatural that Mersenne proposed a version of the mechanical philosophy, in which nature consisted in inert matter, and the supernatural force was needed to account for all activity.[25] In 1649, in another version of the mechanical philosophy, Pierre Gassendi revived the classical theory of Epicurus that matter consisted of atoms, and argued that atomism, despite its origins in pre-Christian philosophy, was perfectly compatible with Catholicism.[26] Such caution was necessary because mechanism was also upheld by Thomas Hobbes, who was generally considered to be an atheist and therefore beyond the moral pale.

The version of the mechanical philosophy that achieved most impact was that of Descartes. Although he is chiefly remembered now as a philosopher, Descartes' philosophy was intended to support his science, by providing a basis in absolutely certain knowledge. If I examine my ideas rigorously and winnow out all those that might be false, I am left with a small number of clear and distinct ideas, including the idea of God. Since God is completely good, it is impossible that he should deceive me by making me believe ideas that are in fact false. This small stock of ideas, including the abstract concepts of shape, motion and extension (the property of occupying space), therefore provides the basis for knowledge, and Descartes implies that the knowledge of the world deduced from these basic ideas can be arranged in a quasi-logical sequence, like the propositions of geometry. The knowledge thus obtained, however, does not resemble our everyday empirical knowledge of material objects. It is knowledge of 'things as they really are – knowing them as God knows them'.[27]

The sensory qualities we perceive simply correspond to the effect of bodies on our nerves. 'The nature of body consists not in weight, hardness, colour and the like, but simply in extension.'[28]

All matter is extension. There can therefore be no empty space, no vacuum. The whole of space is filled up by tiny bodies or particles, an idea Descartes developed under the influence of his friend the Dutch mathematician Isaac Beeckman.[29] This corpuscular theory marks a rejection of Aristotle's assumption that matter consists of four basic elements: earth, air, water and fire. Beeckman and Descartes suppose instead that the world consists of homogeneous particles, and the differences among phenomena can be explained by the particles' movement. This presents another problem, however, for if the world is completely filled by particles, it might follow that the movement of one particle communicates itself to all other particles, so that every part of the world is in constant motion. To avoid this consequence (and the perpetual sea-sickness it would imply), Descartes supposes that matter moves in circles, which he calls vortices (*tourbillons*). A fish that swishes its tail in a deep pool displaces the water around it, but does not move all the water in the pool.[30] Similarly, any motion displaces matter, which goes round in a circle and finally fills up the space from which it started. This provides an explanation for the orbits of the planets round the sun.

The problem Descartes never solved, and that would puzzle scientists and philosophers throughout the eighteenth century, was how extension was connected with the other side of reality, namely thought. What connected *res extensa* with *res cogitans*, matter with thought, the body with the soul? Descartes speculated that the two were somehow connected by 'animal spirits', which enter the brain through the pineal gland, located in the back of the neck.[31] This fanciful physiology did not carry much conviction, and Descartes' physics would eventually be overthrown by Newton, yet for many Enlightenment thinkers Descartes remained an exemplary figure. His project of returning to first principles made him an inspiring advocate of reason, and his insistence on clear and distinct ideas made him an enemy of obfuscation.[32]

The Cartesian separation of thought from extension had consequences for the understanding of the spiritual world. In his four-volume treatise *De betoverde weereld* (*The World Bewitched*, 1691–3), Balthasar Bekker argued that the Cartesian separation of body from spirit was presupposed in the Bible: 'Nature teaches that spirit and body are of such distinct natures that they cannot have the slightest connection: Scripture says more or less the same, but not so clearly, because it takes the distinction for granted and leaves sound reason to work it out.'[33] Hence the Devil, being

a spirit, could not assume material form. If he exercised any influence, it was on people's minds, but tales of meeting with him, signing pacts with him, or copulating with him were among the relics of pagan belief, which found a congenial home in Catholicism. Bekker, a Dutch pastor, affirmed his belief in good and bad spirits.[34] His main concern was to provide a critical interpretation of the Bible that took its text literally while minimizing its supernatural content.[35] He argued that when the Bible referred to angels or devils, the best translation would be 'messenger' or 'enemy', and that its supernatural language was only a poetic embellishment. His book was translated into German (three times) and French, but only the first volume appeared in English. On the Continent, it gave rise to a furore that has been described as 'assuredly the biggest intellectual controversy of Early Enlightenment Europe'.[36] Conservative theologians complained that by questioning the reality of Satanic power, Bekker proved that Cartesianism must ultimately destroy Christian belief; others accused Bekker of undermining theology and making it subordinate to philosophy.

The mechanical philosophy was a powerful instrument for describing those aspects of nature that could be quantified. By comparing the universe to a clock, it offered a clear and intelligible model, free from mystery and obscurity. Thus, in Fontenelle's *Entretiens sur la pluralité des mondes* (*Conversations on the Plurality of Worlds*, 1686), in which a philosopher gives an intelligent and receptive noblewoman chatty lessons in Cartesian astronomy, his pupil is pleased by the analogy:

> By what you say, said *Madame la Marquiese*, Philosophy is become very Mechanical. So very Mechanical, said I, that I am afraid men will quickly be ashamed of it; for some would have the Universe no other thing in Great, than a Watch is in Little; and that all things in it are ordered by Regular Motion, which depends upon the just and equal disposal of its Parts: Confess the Truth, Madam, have not you had heretofore a more sublime *Idea* of the Universe, and have not you honoured it with a better Opinion than it deserved? I have known several esteem it less since they believed they knew it better; and for my part, said she, I esteem it more since I knew it is so like a Watch: And 'tis most surprising to me, that the course and order of Nature, how ever admirable it appears to be, moves upon Principles and Things that are so very easie and simple.[37]

Although Descartes expressed admiration for Bacon, the empirical research advocated by Bacon was not compatible with the intellectual method to which Descartes, and other pre-Enlightenment philosophers of the seventeenth century, were committed.[38] While Cartesian rationalism cleared away much philosophical lumber, it made little direct contribution

to the positive understanding of the natural world. Descartes' vortices, for example, were a theoretical construct that could not survive critical examination. Descartes is notorious also for his attempt to apply the mechanical philosophy to animals: he thought it at least probable that they were machine-like, their movements being automatic actions and reactions (like the involuntary contraction of a muscle).[39] Some of his followers went further, asserting that the howling of a beaten dog was a mere reflex by an automaton incapable of pain. This was a convenient doctrine for the hard-hearted, but could scarcely convince anyone with much experience of animals. It was duly mocked by Voltaire: 'he claims that animals are pure machines, which look for food without having an appetite, which always have organs of feeling in order never to experience the slightest sensation . . .'[40] Eventually, the shortcomings of the mechanical philosophy in explaining organic life would lead to its replacement by theories based on sensibility, which will be examined in Chapter 6.[41]

The empirical study of the world was the motor of the Scientific Revolution, which one historian of science has called 'the most profound revolution achieved or suffered by the human mind' since Greek antiquity.[42] The high points of this revolution include Nicolaus Copernicus' publication of the heliocentric system in 1543; Galileo's astronomical observations made from 1609 onwards with the help of the telescope; William Harvey's demonstration of the circulation of the blood in 1628; Christiaan Huygens' discoveries in mechanics, including the theory of the pendulum (1656); Antonie van Leeuwenhoek's observation of animalculae with the microscope, made known in 1676; and Newton's law of universal gravitation, presented in his *Principia mathematica* (1687). Not all of them relied on experiment: mathematics and associated studies, for example, remained based on calculation, as in classical times.[43] Others, however, were transformed by the invention of instruments such as the telescope, the microscope, the barometer and the air-pump. Experimentation was known in the period before Bacon, but experiments were often simply thought-experiments, never conducted in practice, or else they were intended only to confirm what had already been established theoretically. The great innovation was to conduct real, physical experiments without knowing in advance what the outcome would be.[44]

How to date the Scientific Revolution is controversial. Rather than starting with Copernicus, as is customary, its most recent historian proposes dating it from 1572, when the Danish astronomer Tycho Brahe observed a new star, a supernova, in the constellation Cassiopeia. This observation fatally undermined the hitherto dominant authority of Aristotle. Within Aristotelian science, the appearance of a new star was

impossible, for the heavens, unlike the impermanent sublunary world, were supposed to be unchanging.[45] Now one of Aristotle's basic tenets was proved wrong by experience.

Contemporaries did not talk about the 'Scientific Revolution', a phrase first used only in 1915.[46] The word 'revolution' still normally meant a cyclical movement, not a major and irreversible change. But they had no doubt that something big was happening. The achievements of recent science were a major theme in the long-running debate known as the 'Querelle des Anciens et des Modernes' ('Quarrel of the Ancients and the Moderns').[47] Though it had antecedents in seventeenth-century Italy, the debate was really launched by Charles Perrault on 27 January 1687, when he read his poem *Le Siècle de Louis le Grand* (*The Century of Louis the Great*) to the French Academy. Here, and in the dialogues entitled *Parallèle des anciens et des modernes*, Perrault pointed out that the ancients knew neither Christianity, modern science, nor polished taste. The science of Aristotle had been completely superseded by the invention of the telescope and the microscope and by the discovery of the circulation of the blood. Homer, despite his greatness, made his heroes often brutal, undignified and vulgar. Fontenelle weighed in with the claim that the best tragedies of Sophocles and Euripides were inferior to those of the brothers Corneille. The superiority of the ancients was upheld in France by the theologian Bossuet and in England by Sir William Temple and his sometime secretary Jonathan Swift, who imagined writers slugging it out in *The Battle of the Books* (1704). But the moderns acquired a powerful defender in Voltaire, for whom the age of Louis XIV was an unsurpassable pinnacle of cultural achievement. In his view, Locke was a better philosopher than Plato, St Peter's a more beautiful building than the Capitol.[48]

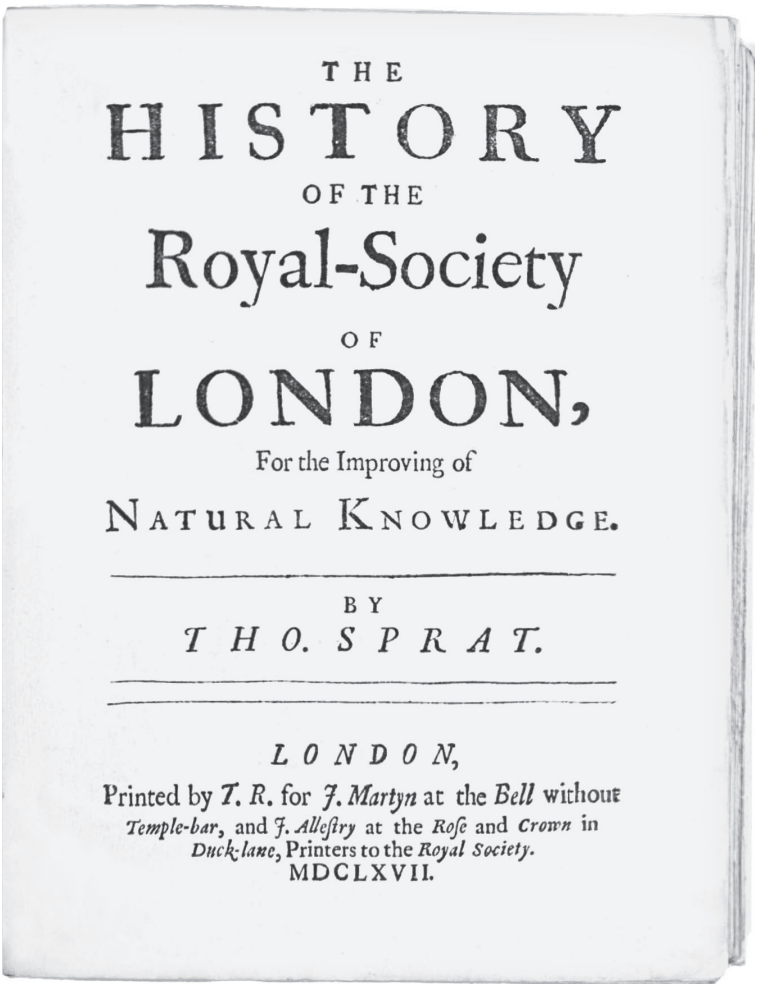
Progress was easier to demonstrate in the sciences than in the arts. Fontenelle, who in 1697 was appointed Perpetual Secretary of the Paris Académie des Sciences, argued in his contribution to the debate that in poetry the summit of achievement could be reached fairly quickly, whereas sciences such as physics, medicine and mathematics required the coalescence of an immense number of different views and an extreme precision in reasoning. It was inevitable, therefore, that the scientific attainments of the present should far surpass those of the past, and that our own posterity – who, Fontenelle remarked in passing, might by that time be Americans – would look back condescendingly at us. 'Nothing', he concluded, 'hinders the progress of things, nothing sets such bounds to the intellect, so much as the excessive admiration for the ancients.'[49]

Weighing up the achievements of the 'ancients' and the 'moderns' in 1694, William Wotton devotes most of his attention to 'natural philosophy' (what

we would now call the sciences). He describes the modern inventions that have made new knowledge possible, especially the telescope and the microscope, but also the thermometer, the 'baroscope' (barometer), the air-pump and the pendulum clock. He notes that the ancients made little use of mathematics and that they often relied on authority instead of experience. By contrast, the work of 'the new Philosophers, as they are commonly called' is based on four principles.[50] First, all terms used must be intelligible, with no appeal to 'occult forces' and the like. Second – a key idea of the Scientific Revolution and of the Enlightenment – nothing is accepted merely on authority, but 'Matter of Fact is the only Thing appealed to'.[51] Third, the understanding of nature must be based on mathematics. And fourth, general conclusions can only be based on a large number of experiments or observations. 'So that the Inferences that are made from any Enquiries into Natural Things, though perhaps set down in general Terms, yet are (as it were by Consent) received with this Tacit Reserve, *As far as the Experiments or Observations already made, will warrant*.'[52] The last point is especially important. Not only must science be clear, factual, quantifiable and empirical, but it cannot aspire to absolute certainty. Although some early modern thinkers hoped to extend the certainty of geometrical demonstration to the natural world, such hopes are chimerical. Wotton was right: scientific knowledge, even if so well established that we cannot imagine it being overturned, is in principle always provisional and capable of being corrected.[53]

To write like this, Wotton had to use the intellectual and linguistic toolkit that made the Scientific Revolution possible. It was necessary to question the authority of Aristotle and other ancient natural philosophers, to show that the world contained things they had not known about, and to do so with concepts that had not previously been available. There had to be a concept of discovery, an acceptance that many things were unknown but real and waiting to be found. Columbus discovered America; Galileo discovered the moons of Jupiter. There had to be a concept and practice of experimentation. The discoveries made experimentally had to be recognizable as facts – truths known by experience – which helped to reveal that nature operated by regular laws. Miracles, as violations of the laws of nature, became increasingly hard to believe in. Isaac Newton wrote in 1703: 'Natural Philosophy consists in discovering the frame and operations of Nature, and reducing them, as far as may be, to general Rules or Laws, – establishing these rules by observations and experiments, and thence deducing the causes and effects of things.'[54]

Bacon's programme for collective research was put into practice by the English Royal Society, founded in 1660 and given a royal charter in 1662.



THE
HISTORY
OF THE
Royal-Society
OF
LONDON,
For the Improving of
NATURAL KNOWLEDGE.

BY
THO. SPRAT.

LONDON,
Printed by *T. R.* for *J. Martyn* at the *Bell* without *Temple-bar*, and *J. Allestry* at the *Rose* and *Crown* in *Duck-lane*, Printers to the *Royal Society*.
MDCLXVII.

The title-page of Sprat's *History* (1667). Despite its title, the book is less a history of the Society, founded only in 1660, than a manifesto for its scientific mission.

Its principles were set out in Thomas Sprat's *History of the Royal-Society* (1667). Largely written in 1664, soon after the Society's foundation, Sprat's book is less a history than a manifesto, formulating ideals that would be widely shared in the Enlightenment.

The Society is devoted to the study of nature. It is in no way hostile to religion: some early natural philosophers, such as Edmond Halley, were privately sceptical, but most sought evidence for God's wisdom in the order and regularity that their investigations revealed in nature. But it strictly avoids religious matters: 'they meddle no otherwise with *Divine things*, than onley as the *Power*, and *Wisdom*, and *Goodness* of the *Creator*, is display'd in the admirable order, and workman-ship of the Creatures'.[55] It rejects the opposite extremes of atheism and fanaticism ('dogmatism'); the latter painfully recalls the sectarian conflicts of the Civil War and Interregnum. Sprat advocates 'the calmness, and unpassionate evenness of the true Philosophical Spirit'.[56]

As Sprat describes it, the Society is to be a laboratory, not a school; to centre not on the relation of teacher and pupil, but on 'a free Philosophical Consultation'.[57] Experiments are performed in public and discussed in detail in order to be clear about 'the matter of *Fact*': what actually happened in the experiment, what effect it produced, and from what possible causes.[58] The Society has no particular interest in the natural wonders that 'virtuosi' assembled in their cabinets of curiosities. Its members 'regard the *least*, and the *plainest* things, and those that may appear at *first* the most *inconsiderable*; as well as the *greatest Curiosities*'.[59] The language they use is to be free from rhetorical embellishment or obscurity: 'a close, naked, natural way of speaking; positive expressions; clear senses; a native easiness: bringing all things as near the Mathematical plainness, as they can: and preferring the language of Artizans, Countrymen, and Merchants, before that, of Wits, or Scholars.'[60] The Society is international, linked with the Académie des Sciences in Paris, the Accademia del Cimento in Florence, and scholars such as the Dutch mathematician Huygens.

The Society held formal meetings, conducted by the chairman with his mallet, and carefully recorded.[61] Their commonest venue was Gresham College, near Holborn.[62] Eminent scientists in Britain and abroad were invited to join. In practice, of course, only those resident in London attended frequently. Meetings were often followed by dinner-parties or coffee-house gatherings (rather as one might now go to the pub after a seminar), so that it has somewhat unfairly been compared to a gentlemen's club. It was dedicated to corporate experimentation, before both scientific and lay witnesses. Its members hoped also to develop it into a research institute, but they failed to obtain an endowment beyond a gift of property worth £1,300 from

Charles II, and the Society was sustained largely by its members' subscriptions. Only the secretary, and a curator responsible for experiments, received salaries. Members pursued research at their own expense, paying for their own instruments. They were predominantly from the professional and landed classes. Sprat, anxious to demonstrate the Society's inclusiveness, stresses that, at the king's request, it has elected the demographer John Graunt, although 'he was a Shop-keeper of *London*'.[63] But only 6 per cent of the Society's members between 1660 and 1685 were merchants or tradesmen; the largest single group consisted of doctors and professional scholars (31 per cent), followed by aristocrats and landowners (30 per cent).[64]

In order to communicate with the wider scholarly world, the Society published a journal, the *Philosophical Transactions*, which still exists. Directed by the Society's secretary, the German-born Henry Oldenburg, the *Transactions* soon became 'the leading European scientific periodical', although, in contrast to contemporary learned journals such as the Leipzig *Acta Eruditorum*, its contents were almost always in English, not Latin.[65] The observations it recorded sometimes recall the tradition of 'wonders': the very first issue contains a report communicated by Robert Boyle, 'An Account of a very odd Monstrous Calf'; the calf was born with a threefold tongue, no joints in its hind legs, and a large stone between its fore and hind legs. Boyle's sober description is clearly not intended to arouse wonder but to provide material for the understanding of anatomical processes.[66] There is occasional credulity. Some reports from the Hebrides by Sir Robert Moray, alongside a fascinating description of life on 'Hirta' (St Kilda), include an account of the tiny creature inside a barnacle; having observed it through a microscope, Moray concluded that it was a minuscule goose, and thus found confirmation for the medieval tradition that barnacle geese grow from barnacles.[67] This shows that the Scientific Revolution was a long and gradual process, in which traces of the past could survive for a long time.

The concepts of the Scientific Revolution and of scientific progress, crucial for the Enlightenment, have been challenged in recent decades. Steven Shapin points out that the Scientific Revolution was not a 'singular and discrete event'; the term was not used by contemporaries, nor was 'science'; their activities were highly diverse, and in some cases continuous with medieval investigations of nature (one might instance the barnacles).[68] That seems obvious. We also find the far stronger claim, not merely that the activities of scientists can be studied sociologically (which, again, is obvious), but that the social milieu of science affects, perhaps determines, the substantive character of scientists' findings. Scientific research is what Ludwig Wittgenstein called a 'form of life' and a 'language game',

conducted by a specific community.[69] Scientific truth is the result that satisfies that community by matching the rules of its game. The Royal Society, for example, was an 'experimental community' playing by the rules of the 'experimental game'.[70] It was not the strength of empirical evidence, but the manipulation of power relations, that decided which findings were valid. Scientific research is 'a contest among alternative forms of life and their characteristic forms of intellectual product [which] depends upon the political success of the various candidates in insinuating themselves into the activities of other institutions and other interest groups.'[71]

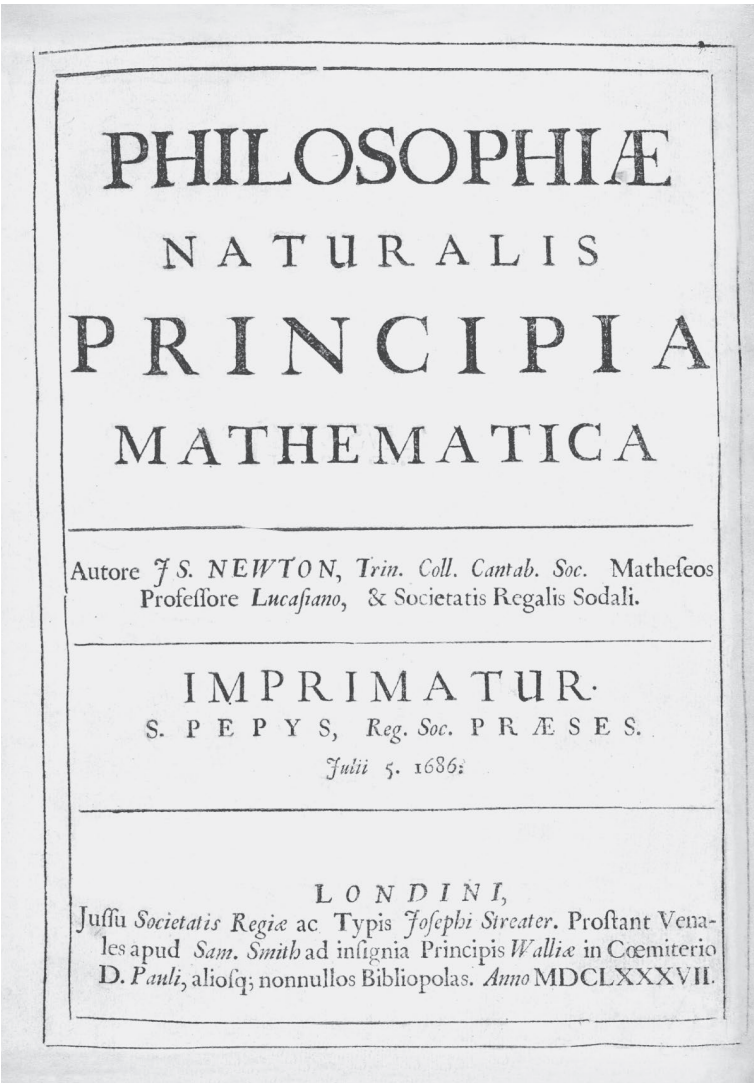
This is not scepticism but relativism. Scepticism does not deny that truth is discoverable, but looks critically and cautiously at claims to have discovered it. A justified scepticism would point out that science is often wrong. After all, science proceeds through controversies, in which one side must be wrong by definition. But mistaken ideas often have a long life before being refuted. Throughout the Enlightenment period it was believed that when something burns, it emits an element called phlogiston; this belief was refuted by the chemist Antoine-Laurent de Lavoisier only in 1777 (though, unknown to the Western European public, the Russian scientist Mikhail Lomonosov had already disproved it in 1756).[72] Strong relativism, on the other hand, implies that science is never wrong, because any theory accepted by scientists counts as valid science. So it is difficult to see how one can accept relativism and yet acknowledge that science is 'certainly the most reliable body of natural knowledge we have got'.[73]

The concept of scientific progress has similarly been challenged. It is certainly naïve to think that scientific research consists in piling up facts until a complete and accurate picture of the universe will be attained. More plausibly, scientific knowledge goes through periodical massive adjustments induced by new discoveries. So it can be argued that the Scientific Revolution of the seventeenth century not only happened but was one of many scientific revolutions. More recent ones are associated with such names as Darwin, Einstein, and Crick and Watson. According to Thomas Kuhn, in a classic book, a scientific revolution obliges scientists to adopt a different worldview, so that after it they are 'responding to a different world'; a few pages later Kuhn magnifies his claim by saying that, after Copernicus, 'astronomers lived in a different world'.[74] Research within one world makes progress towards solving specific problems, but Kuhn is reluctant to admit that there is progress across revolutions, because that raises the question of the goal of scientific progress, and Kuhn rejects the idea 'that there is some one, full, objective, true account of nature and that the proper measure of scientific achievement is the extent to which it brings us closer to that ultimate goal'.[75]

Yet it is counterintuitive to claim that as science changes, it gives us not a better understanding of the world, but an understanding of 'a different world'. Present-day astronomers know much more about the universe than Ptolemy did, but it would be absurd to say they are studying a different universe. As one of Kuhn's commentators points out, many scientific insights have survived from earlier periods and are unlikely ever to be discarded. Scientists are not likely to disprove Harvey's discovery of the circulation of the blood, or Thomson's discovery of the electron.[76] Scientific knowledge is bound up with discovery – with finding out aspects of reality that are not 'constructed' or 'produced', but were always there waiting to be found, like America and the Andromeda Nebula.

NEWTON AND NEWTONIANISM

Isaac Newton, one of the Enlightenment's great icons, was a dedicated proponent of experimental science. His brilliance was recognized early. He was appointed Lucasian Professor of Mathematics at Cambridge in 1669, when he was twenty-seven. He was slow to publish: of his two most famous works, the *Principia* (in full, *Philosophiæ naturalis principia mathematica* or *Mathematical Principles of Natural Philosophy*) appeared only in 1687, the *Opticks* in 1704. Even as an undergraduate, however, he was already getting to grips with Descartes: in notes headed 'Quaestiones', he imagined how Descartes' assertions might be tested experimentally.[77] In his early optical research, he conducted dangerous experiments on himself by staring at the sun for a long time to find how his vision of colours was affected, and poking a bodkin into the recess behind his eye to observe the circles that then appeared.[78] In his *Opticks* Newton formulated the experimental method by saying that natural philosophy should begin with analysis: 'This Analysis consists in making Experiments and Observations, and in drawing general Conclusions from them by Induction, and admitting of no Objections against the Conclusions, but such as are taken from Experiments, or other certain Truths. For Hypotheses are not to be regarded in experimental Philosophy.'[79] In the second edition of the *Principia* (1713) he made the much-quoted claim: 'Hypotheses non fingo', 'I do not feign hypotheses', meaning that he did not suppose, or hypothesize, imaginary entities in order to explain natural phenomena.[80] An example of such imaginary entities would be Descartes' vortices. Another would be the epicycles (smaller circles moving within larger ones) that the Ptolemaic system of astronomy hypothesized to explain the variations of the speed and direction of the heavenly bodies.



PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA

Autore *J S. NEWTON*, *Trin. Coll. Cantab. Soc.* Matheſeos Profeſſore *Lucaſiano*, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
Julii 5. 1686.

LONDINI,
Juſſu *Societatis Regiæ* ac Typis *Joſephi Streater*. Proſtant Venales apud *Sam. Smith* ad inſignia Principis *Walliæ* in Cœmiterio D. *Pauli*, alioſq; nonnullos Bibliopolas. *Anno* MDCLXXXVII.

The title-page of Newton's *Principia* (1687), mentioning that its publication was authorized by Samuel Pepys, who was President of the Royal Society from 1 December 1684 to 30 November 1686.

Newton of course built on the discoveries of his predecessors. Earlier in the century, Galileo had proved experimentally that all bodies fall at the same speed, irrespective of their mass, and thus worked out laws of terrestrial motion, while Johannes Kepler had explained planetary motion by showing that the planets moved not in circles but in elliptical orbits. No room was left for Descartes' vortices, nor for his principle, inherited from antiquity, that 'nature abhors a vacuum'. Newton was able to describe mathematically how bodies are able to move in empty space and affect one another at a distance, by demonstrating the existence of universal gravitation, whereby every particle of matter is attracted to every other by quantifiable forces. This single and elegant principle explained such diverse phenomena as the motion of the planets and the ebb and flow of the tides. His originality rested on 'a clearly thought out procedure for combining mathematical methods with the results of experiment and observation'.[81]

Unlike the universe conceived by the theories of mechanical philosophy, Newton's universe was not wholly self-regulating. It had room for God. Opposing Descartes' view that the world was completely filled with matter, Newton argued that it contained much empty space that was a suitable dwelling-place for God.[82] As Voltaire said in a popular exposition of the *Principia*, a Frenchman who travels to London 'had left the World a *plenum*, and he now finds it a *vacuum*'.[83] God was, moreover, needed to correct various 'inequalities' in planetary motion, which, if not attended to, would eventually cause the universe to run down.[84] Newton's antagonist Leibniz took particular exception to this idea that the universe was so ill-constructed that God had periodically to crank it up.[85] Moreover, when hard bodies collided, some motion was always lost, requiring God's intervention: 'Motion is more apt to be lost than got, and is always upon the Decay.'[86] Newton also puzzled some readers by refusing to explain what gravitation was in itself. To him, it was a force whose effects were clearly visible and calculable: any attempt to go further and probe its intrinsic nature would have looked like a regression to the Renaissance search for occult knowledge.

Newton's followers saw him as a devout Christian. After his death, however, it emerged that throughout his life he had carefully concealed his heterodoxy. He disbelieved in the doctrine of the Trinity. Although he accepted Christ as the Son of God, he thought the Son far from equal with the Father. By extensive studies in Church history, he had established to his own satisfaction that the doctrine of the Trinity had been imposed on the Council of Nicaea (325 CE) by the artful prelate Athanasius, who had also encouraged the pernicious growth of monasticism. Newton had also

invested a great deal of time and money in alchemy. Books on alchemy formed one-tenth of his library, and his alchemical manuscripts have been estimated to contain at least a million words.[87] Even more voluminous are his researches on ancient chronology, in which he tried to reconcile the timescale given in the Old Testament with the chronologies offered by ancient non-Christian writers.[88] And he devoted much energy to proving that modern science had been known to the ancients, that Plato and Pythagoras understood universal gravitation, that the Egyptian 'god' Thoth had really been a human teacher who knew that the earth went round the sun, and that the early chapters of Genesis (at that time ascribed to Moses) contained a scientific account of the creation of the world, which Moses had expressed in figurative language for the benefit of his naïve audience.[89] How could the greatest mathematician of all time, living on the threshold of the Enlightenment, have wasted his energy on such eccentric and futile researches?

It used to be thought that Newton likewise saw alchemy as the operation of the divine spirit within the material universe, though the prevailing view now is that Newton took a more sober view of alchemy.[90] Despite its association with charlatans, there might be something in it (as Robert Boyle also thought); it might provide insight into natural processes other than the mechanical combination of chemical elements. Alchemists sought to transmute base metal into gold. Transmutation was already familiar from the vegetable kingdom, where a tiny seed could grow and change into a tree. Metals were thought to 'grow' in the earth. Perhaps they could be induced to follow a similar transmutative process, whereby they might grow into gold? Perhaps an indwelling spirit could be harnessed for this purpose?[91] Such speculations were mistaken, but that does not make them absurd.

In his interpretation of Church history, Newton shared – in an extreme degree – the anti-Catholicism that was standard in Britain in his day. It was exacerbated, as we shall see in the next chapter, by the schemes of James II to restore Catholicism in Britain, which led to James's expulsion the year after the *Principia* was published. But Newton's animus was supported by his research into the text of the Bible, which enabled him, for example, to show that the verses alleged to confirm the doctrine of the Trinity were absent from early manuscripts. His interpretations of Scripture were based not on inspiration but on a strict method. He wrote:

> Too much liberty in this kind savours of a luxuriant ungovernable fansy [*sic*] & borders on enthusiasm . . . He that without better grounds then his private opinion or the opinion of any human authority whatsoever shall

> turn scripture from the plain meaning to an Allegory or to any other less naturall sense declares thereby that he reposes more trust in his own imaginations or in that human authority then in the Scripture.[92]

Biblical chronology was a reputable and important study. In the next century, the Encyclopedist d'Alembert would call it one of the twin supports of history, the other being geography; it would be the hobby of the young Edward Gibbon; and Goethe would call chronology 'the most difficult of all subjects'.[93] Newton sought to make it rigorous by using astronomy to supplement and correct written texts, as biblical scholars now use archaeology. His revised chronology centred on the correct dating of the voyage of the Argonauts. Chiron the Centaur, the teacher of Jason, the expedition's leader, had created a sphere on which the then visible constellations were drawn. Newton worked out where Chiron had placed the equinoxes on the sphere, compared it with the value for the annual precession of the equinoxes given in the *Principia*, and thus dated the expedition to 937–6 BCE.[94] As for the interpretation of biblical prophecy, the restoration of the scientific learning of the ancients and the reconciliation of the Old Testament with classical mythology, these may sound like Mr Casaubon's 'Key to all Mythologies' in *Middlemarch*, but they were serious studies with well-established traditions (as was Casaubon's), including the long-standing view, still common in the nineteenth century, that the ancients had a wisdom, or *prisca sapientia*, which had been obscured but could be recovered.[95] It may now look quaint to accept the literal truth of the Old Testament and Greek mythology; but their authority was still firmly enthroned, and it would have been eccentric not to accept them.

Very few of Newton's contemporaries knew about his work on alchemy, chronology and prophecy. His study of chronology was published only after his death. The alchemical writings were neglected until the twentieth century. Newton's contemporary fame rested securely on the *Principia*, and to a lesser extent on the *Opticks*. The few who were qualified to assess the *Principia*, which appeared initially in a print run of at most 400 copies, immediately recognized a masterpiece that explained the dynamics of the physical universe on the basis of a small number of mathematical laws of motion. Newton's fellow-member of the Royal Society, Edmond Halley, wrote an anonymous review of the *Principia* in its *Transactions*: 'This incomparable Author . . . has at once shewn what are the Principles of Natural Philosophy, and so far derived from them their consequences, that he seems to have exhausted his Argument, and left little to be done by those that shall succeed him.'[96]

On the Continent the *Principia* received a more cautious reception.

Many readers struggled with the transition from the difficult but compelling mathematics of Books I and II to the account of universal gravitation in Book III. How could theoretical mathematics explain physical events? What *was* gravitation? What caused it?[97]

The eventual acceptance of Newtonianism in France was in part due to the brief popular account given by Voltaire in his *Lettres philosophiques* (1734).[98] That Voltaire's book was promptly banned by the *parlement* of Paris only added to its appeal. For the learned world, the crucial step was taken by the mathematician Pierre Louis Maupertuis, who in his book *Discours sur les différentes figures des astres* (*Discourse on the Various Shapes of the Heavenly Bodies*, 1732) showed that the Cartesian picture of the universe required continual untidy adjustments, whereas Newton's universal gravitation offered, by contrast, a simple and elegant quantitative principle. 'Framed this way, Newton became the real avatar of Cartesian clear and distinct reasoning while the Cartesians were shown to be lost in a haze of mechanist confusion.'[99]

The spread of Newtonianism across Europe was far from a smooth triumphal progress. In France, academics not only found the *Principia* a severe challenge to their mathematics, but were reluctant to accept that parts of the universe could be empty even of the subtle matter postulated by Descartes.[100] In Germany Newtonianism encountered an obstacle in the philosophical school associated with Leibniz and Christian Wolff, though the fate of Wolffianism was sealed when the anti-Wolffian mathematician Leonhard Euler joined the Berlin Royal Academy in 1741 and when Maupertuis became the Academy's president in 1746.[101] The progress of Newtonianism in Italy was hampered by the disapproval of the Church, which a few decades earlier had silenced Galileo and in 1663 placed some of Descartes' writings on the Index of Prohibited Books. The Jesuit physicist Ruggiero Boscovich, an enthusiast for Newton's ideas and a friend of the enlightened Pope Benedict XIV, found that anyone who departed from the conventional Aristotelian account of nature was liable to be branded a heretic.[102] In parts of Italy, however, there was more intellectual freedom. Thus Laura Bassi, the second Italian woman to receive a university degree, lectured on Newtonianism at the University of Bologna from the 1730s to the 1770s.[103] The Greek cleric Nikephoros Theotokis published a book on Newton's physics at Leipzig in 1766–7, though he expressed himself cautiously for fear of conflict with the Orthodox Church, which still maintained that the sun went round the earth.[104]

The *Principia* inspired more than philosophers. Practically minded readers found in it much experimentally based information concerning

the motions of bodies and fluids that was valuable for engineers, and in due course made possible the profession of civil (as distinct from military) engineering.[105] More generally, Newton's picture of a divinely regulated order was recognized as a model not only for God's creation but for earthly monarchies. It applied particularly pleasingly to the limited monarchy consolidated in Britain after the Glorious Revolution of 1688.[106] The Huguenot émigré John Theophilus Desaguliers, whom Newton helped to become the Royal Society's experimental demonstrator in 1714, drew the analogy in *The Newtonian System of the World, the best Model of Government: An Allegorical Poem* (1728):

> That *Sol* self-pois'd in *Æther* does reside,
> And thence exerts his Virtue far and wide;
> Like Ministers attending e'ery Glance,
> Six Worlds sweep round his Throne in Mystick Dance,
> He turns their Motion from its devious Course,
> And bends their Orbits by Attractive Force,
> His Pow'r, coerc'd by Laws, still leaves them free,
> Directs but not Destroys, their Liberty.[107]

International trade was also imagined as a Newtonian balance of forces, composed of regularity and attraction.[108] More broadly still, Newtonian cosmology provided a model for concepts like the 'balance of trade' and the 'balance of power'. It is present even in the American Declaration of Independence, with its opening appeal to 'the Laws of Nature and of Nature's God'.[109] On all these grounds, Newton has been called the ' "prime mover" of all Enlightenment thought'.[110]

Newton's example had further momentous consequences. He confined himself to the observation and description of phenomena, without forming hypotheses about their ultimate causes. He showed that the force of gravity operated throughout the physical world, but he did not try to say what gravitation *was*. In a draft of the 'General Scholium' in the *Principia*, composed around 1712, Newton wrote: 'We do not know the substances of things. We have no idea of them. We gather only their properties from the phenomena, and from the properties [we infer] what substances may be.'[111] Natural philosophy thus separated itself from all approaches to reality that sought to ground knowledge in some underlying absolute truth. It differed from the theologians and metaphysicians, like Pascal and Leibniz, who thought there was an 'ultimate fact of the matter' to be discovered by religious or philosophical reflection.[112] It differed also from the eighteenth-century thinkers such as d'Holbach and La Mettrie whose materialism was really just as dogmatic as the theology they opposed.[113] And although

Newton's *Principia* contained the most advanced mathematics of his day, he did not assume, as Descartes had done, that mathematical axioms were the ultimate starting-point for the understanding of reality.

Newton's methodological modesty converged with that of the Dutch scientists of his time, notably Christiaan Huygens and Willem 'sGravesande, who likewise concentrated on exact observation and experimental research. Huygens in his *Traité de la lumière* (*Treatise on Light*, 1690)

> emphasizes that one cannot attain the same clarity in physics as is possible in mathematical demonstrations and inferences, and that there can be no intuitive certainty of the fundamental truths of physics. Physics requires simply a 'moral certainty,' which, however, can be raised to such a high degree of probability that for all practical purposes it is as good as a rigorous proof.[114]

On the other hand, the investigation of nature requires certain basic assumptions. We have to assume as an axiom that nature is uniform. But can that axiom itself be proved? 'sGravesande replies that 'this is not a strictly logical, but a pragmatic axiom; its validity does not lie in the necessity of thought, but in that of action'.[115] It is a working assumption.

The claims of natural philosophy are thus relatively modest. Philosophers do not profess to reveal the ultimate nature of things. They willingly leave such inquiries to the theologians. But, within the domain of natural philosophy, there are agreed criteria of truth – not absolute truth, but truth good enough for all practical purposes – which are much firmer than any criteria theologians can find. Hence d'Alembert, in the 'Preliminary Discourse' to the *Encyclopédie*, prudently admits the need for revealed religion but strictly limits its domain to 'some truths to believe and a number of precepts to practise'.[116] Disputes about matters of fact can eventually be resolved through experiment, whereas disputes about theology drag on for centuries and are generally settled by dogmatic authority and/or *force majeure* – or forgotten when everybody has lost interest.

Precisely because its claims were modest, but feasible, natural science became the model for all knowledge. Cassirer quotes d'Alembert on the impact of scientific advances: 'from the earth to Saturn, from the history of the heavens to that of insects, natural philosophy has been revolutionized; and nearly all other fields of knowledge have assumed new forms'.[117] Natural philosophy – science – was not yet considered distinct from other fields.[118] When Diderot demands that philosophy should be intelligible to the people, his examples of unnecessary obscurity include Newton's *Principia*.[119] Thinkers informed themselves about natural science. Voltaire's exposition of Newton is the cardinal example, but he also twice submitted

scientific papers to learned academies. Having attended lectures on physics given by 'sGravesande in Leiden and studied chemistry, he sent the Académie des Sciences in 1737 an essay on the nature of fire, which the Académie published, though without awarding it a prize.[120] In 1746 he sent the Florentine Accademia della Crusca a paper on the prehistory of the earth's surface, for which the Accademia elected him a member.[121] Diderot wrote on many scientific subjects, including the laws of matter and motion;[122] the young Montesquieu dissected plants and animals in order to learn about their physiology;[123] Rousseau studied chemistry, and wrote on astronomy and cosmography.[124] Samuel Johnson performed chemical experiments as a hobby: Boswell, visiting his library, 'observed an apparatus for chymical experiments, of which Johnson was all his life very fond'.[125] Adam Smith wrote an essay on astronomy;[126] and Kant was the author of a serious and original, though little-noticed, study of astronomy and cosmology.[127]

Natural philosophers ranged widely in their interests. The great Russian scientist Lomonosov, having gained a broad introduction to the natural sciences at the famous school of mines at Freiberg in Germany, conducted pioneering experiments in physics and chemistry, drew up a catalogue of minerals, and studied the geological strata of the earth and the formation of icebergs. As an astronomer, he observed the transit of Venus across the sun in 1761 from his observatory in St Petersburg and was the first to discover that Venus had an atmosphere. He also wrote poetry, a grammar of the Russian language and a history of Russia.[128] A more famous polymath, Goethe, who wrote in almost every literary genre and devoted much of his life to studying geology, mineralogy, anatomy and the processes of organic development in plants and animals, is thus a characteristic, though still remarkable, product of the Enlightenment.

However, to speak of physics and chemistry in the Enlightenment risks anachronism, since, though the terms were much used, their respective areas within natural philosophy were still in the process of being demarcated. Chemistry (or 'chymistry') had been a recognized subject since the end of the sixteenth century, but was poised uneasily between natural philosophy and natural history.[129] 'Physics' often referred to 'the entire study of causes in nature'.[130] Some of the territory of physics was occupied by mechanics, i.e. the mathematical study of the motion and equilibrium of bodies and the action of forces, which built on Newton's discoveries. A very short and selective sketch of the progress of the physical sciences in the Enlightenment will, nevertheless, recall some of their achievements and indicate how the experimental method changed people's understanding of the world they lived in.

EXPERIMENTAL PHILOSOPHY

An educated man in the year 1700 still took for granted that the world consisted of the four basic elements described by Aristotle: earth, water, fire and air. (He might have known that Aristotle added a fifth, ether, which was supposed to fill the sky above the clouds.) He thought that most work had to be done by the muscle power of human beings, horses or oxen. Although he was familiar with watermills, he did not imagine that energy on a large scale could be generated by harnessing water, let alone steam or electricity (though the first steam engine would soon be invented by Thomas Newcomen, in 1712). He would not have used the word 'energy', which acquired the sense of 'quantifiable physical force' only in the nineteenth century. While he might not accept the biblical account of the creation of the world, he thought it unlikely that the earth was more than about ten thousand years old. And he took for granted that animal species had always existed in their present form. The idea that species might become extinct would, if it had occurred to him, have seemed absurd: why would God have created them only to let them vanish? Similarly, he thought it more likely than not that the other planets were inhabited, because God would hardly have created them to leave them unpopulated.

Experimental methods would change this picture of the world. The 'experimental philosophy', however, did not just mean conducting experiments in a laboratory or elsewhere and trying to verify one's findings by repeating the experiment. Experiments often required complex and expensive machinery. Repeating experiments was correspondingly difficult. Many branches of science, such as astronomy or geology, do not lend themselves to experimentation. 'Experimental' meant, much more broadly, the reliance not on authorities, but on careful observations, which in most cases could in principle, and often in practice, be verified by repetition.

Chemistry lent itself to experimental methods in the narrow sense. In the early eighteenth century, chemistry was widely seen as a branch of medicine. Many of its leading figures, such as Herman Boerhaave in the Netherlands, Georg Ernst Stahl in Germany, and William Cullen and Joseph Black in Scotland, were trained as physicians, and the subject flourished at universities with important medical schools, such as Leiden and Edinburgh.[131] The mechanical philosophy, being primarily concerned with quantitative measurements, treated the qualities of substances as secondary. Experimental methods made it possible to develop the science of chemistry and free it from its dependence on medicine, its subjection to the mechanical philosophy and its origins in alchemy. Previous inquirers into the

composition of matter had wanted to transmute metals by altering the proportions among their constituent parts, thereby producing gold from base metal, or discovering a universal solvent or 'alkahest' that could dissolve any substance into its constituents. Robert Boyle, author of *The Sceptical Chymist* (1661), still had great respect for alchemy, and hoped himself to find the philosopher's stone.[132] He also hoped, by putting his research on a firmly experimental basis, to confirm the claims of the mechanical philosophy that physical events could be explained in terms of matter in motion.

Early chemistry was hampered by lack of instruments. Boyle and his assistant, Robert Hooke, developed the air-pump, a globe from which air could be gradually removed, so as to observe the effects of its loss on objects inside the globe.[133] With this expensive and delicate instrument, Boyle performed some forty-three experiments, showing that air could expand, exert pressure and possess elasticity. Another important technical advance was the invention by Daniel Gabriel Fahrenheit in 1714 of the mercury thermometer, along with the temperature scale that bears his name. This enabled researchers to make precise use of heat in experiments, as well as opening up the whole subject of heat to systematic investigation.[134]

Many experimenters focused on the study of air: a sub-field called 'pneumatic chemistry'. At the beginning of the eighteenth century it was still assumed that air was a simple element, as Aristotle had taught. The Flemish chemist Jan Baptist van Helmont had noticed around 1640 that when he burned charcoal in a closed container, something escaped, leaving an unexpectedly small quantity of ash. He called this invisible substance a 'gas' (his Dutch pronunciation of the Greek *chaos*, meaning empty space). Eighteenth-century experimenters became interested in 'fixed air', air that, when trapped within a substance, lost its elasticity. Stephen Hales, an English clergyman and enthusiastic Newtonian, investigated 'fixed air' in order to substantiate Newton's argument that air contained both attractive and repulsive particles.[135] The Scottish chemist Joseph Black performed a series of experiments on heated limestone and magnesium carbonate, measuring the 'fixed air' that was gained or lost, and identified this air as something distinct from the ordinary air through which it was dispersed: it could not be breathed and it did not support combustion. He had thus discovered carbon dioxide and proved that air is a compound, not a simple substance.[136]

Subsequent researchers discovered yet more airs. Black's student Daniel Rutherford discovered nitrogen in 1772. In 1766 Henry Cavendish, a scrupulous experimenter who was often overlooked because he seldom published his researches, identified what he called 'inflammable air' and we call hydrogen.[137] The English Dissenter and polymath Joseph Priestley,

having already been awarded the Royal Society's Copley Medal for the discoveries recorded in his paper 'Observations on different kinds of air', announced in 1775 his discovery of oxygen, though he did not know that it had already been recognized by the Swedish chemist Carl Scheele.[138] And in 1778 the electrical researcher Alessandro Volta, applying an electric spark to the atmosphere near Lake Maggiore in northern Italy, found what he called 'inflammable air native to the marshes', now known as methane. It became clear 'that "air" was not a single element but a physical state that many chemical substances could assume and that atmospheric air was a mixture of several different chemicals in that same "vaporous", "gaseous" or "aeriform" state'.[139]

Black's work on carbon dioxide, and Priestley's identification of new 'airs', provided a starting-point for Antoine-Laurent Lavoisier, often called the founder of modern chemistry. He analysed the composition of carbon dioxide and refined the understanding of oxygen as 'breathable air'. To explain the nature of gases, he put forward a new theory of combustion, showing that combustion, the production of fire and light, required the combustible body to be surrounded by oxygen. By showing that the burning object absorbs the air in which combustion takes place, and that its increase in weight corresponds to the weight of the air it has absorbed, he put paid to the long-standing idea that when an object burns it releases phlogiston (though, as we have seen, this conclusion had already been reached by Lomonosov in 1756).[140] Lavoisier was also the first person to realize that water, previously thought to be an irreducible element, is a compound substance formed from hydrogen and oxygen, just as carbon dioxide is formed from a combination of carbon and oxygen. In *Traité élémentaire de chimie* (*Elementary Treatise on Chemistry*, 1789) he published a list of chemical elements, divided into gases, metals, non-metals and earths, which laid the foundations of chemistry as a scientific discipline. Sending a copy of his book to Benjamin Franklin in 1790, Lavoisier wrote that he had avoided theory, 'in order to follow as much as possible the torch of observation and experiment'.[141]

Research on gases had highly visible effects, notably the invention of the hydrogen balloon. The first manned flight with a balloon filled by hydrogen was made by its designer, the chemist Jacques Charles, who had studied the work of Black and Cavendish, and his assistant, Nicolas-Louis Robert. They started from the Tuileries gardens in Paris and landed two hours later 22 miles (36 km) away, having reached a height of 1,800 feet. The hot-air balloon, pioneered at the same time by the Montgolfier brothers, was based on the tendency of air to rise when heated. Both alternatives were immediately discussed at the Académie des Sciences,

with Lavoisier prominent in the debate: he favoured the hydrogen method despite its greater expense.

The advance of chemistry not only illustrates the success of the experimental method. It also shows the emancipation of a discipline, both from its more primitive predecessors and from some of its own working assumptions. Lavoisier finally separated chemistry from alchemy. By showing that water was not a simple element, he disposed of the classical theory of four elements. And by showing that combustion required oxygen, he gave the venerable but increasingly threadbare phlogiston theory an empirical refutation. In the course of its development, chemistry also separated itself from the mechanical philosophy. The mechanical philosophy 'gave no advantage for explaining chemical properties such as acidity, alkalinity, metallicity, salinity, and the chemical operations of combustion, fermentation, and distillation'.[142] Black's teacher, William Cullen, pointed out to his students that mechanics could account only for the quantitative aspects of their subject. Chemistry, however, was principally concerned with qualitative matters, such as the changes that occur when water boils or freezes.[143] From being a helpful working model, the mechanical philosophy now became irrelevant to some areas of research and could be quietly discarded.

Physics traditionally meant the study of the entire physical world. Thanks to the mathematical advances of Newton and Leibniz, it came to focus on those aspects that could be studied quantitatively and moved into some areas formerly considered part of mathematics, such as mechanics and optics. Mathematics, previously a predominantly practical subject particularly required for military engineering, expanded as a field of study and was pursued by figures of international repute, such as the Encyclopedist d'Alembert and the Swiss Leonhard Euler, who spent most of his career in St Petersburg and Berlin and contributed to almost every branch of mathematics and mechanics. Mechanics was virtually a branch of mathematics with next to no experimental basis.[144] By 1800 physics was confined to the study of the inorganic world, using experimental and quantitative methods and assisted by instruments such as the air-pump and the thermometer.[145]

Just as the mechanical philosophy was not disproved by a frontal attack, but quietly sidelined, so some concepts in physics were allowed to fade away when they were no longer empirically useful. This applies to the concept of 'subtle fluids', which was introduced into physics around 1740. It was intended to resolve something Newton had left unclear: whether gravitation and similar forces acted at a distance (which to many seemed counterintuitive) or were transmitted through some intervening medium. Such a medium might be ether, a term used by Aristotle to denote

the upper atmosphere above the clouds, and now adopted to describe an imperceptible medium supposed to fill the spaces between particles of air. It seemed necessary to hypothesize such a medium to explain not only gravitational pull but also magnetism and the transmission of heat and light. If subtle fluids varied in density, it would be possible to weigh them and thus quantify these phenomena. Eventually, however, the hypothesis of subtle fluids turned out to be unhelpful and dispensable:

> Just as Newton discovered that he could describe the phenomena of gravitation mathematically without supposing any ether, so did the physicists of the late eighteenth century discover that they could quantify physical concepts such as temperature, specific heat, charge, and capacitance without assigning any specific subtle fluid to them.[146]

A particular source of fascination throughout the century, to scientists and the lay public alike, was electricity. Electrical experiments were performed for the Royal Society over many years. In 1729 the dyer and amateur physicist Stephen Gray discovered that certain materials, such as a brass wire, transmitted electricity, while others, such as a silk thread, did not. He had thus stumbled upon conductivity: all material bodies are either conductors or non-conductors. Gray was elected to the Royal Society in 1732, and was awarded its first Copley Medal for scientific achievement in 1731. On the Continent, it was discovered – accidentally – that it was possible to store electricity in an insulated glass container known as the Leyden jar. Pieter van Musschenbroek electrified water by the then-standard method of placing a jar on an insulating stand and running a wire from the prime conductor so as to fill the water with electricity. One then puts a finger on the prime conductor, whereupon a spark comes from the water. A visitor to Musschenbroek's laboratory incautiously took the water-filled jar in his hand and received a small electric shock. Musschenbroek repeated the experiment and found that if he used a globe instead of a jar, the shock was much greater: 'my right hand', he reported, 'was struck with such force that my whole body quivered just like someone hit by lightning'.[147] Thereby Musschenbroek had invented the condenser. Benjamin Franklin discovered the concept of the electric charge, which could be either positive or negative. By his experiment of flying a kite in a thunderstorm, he showed that lightning was electrical. He stood on an insulator and kept dry under a roof. Georg Wilhelm Richmann, who tried to repeat the experiment at St Petersburg a year later, omitted these precautions, caught a thunderbolt and was electrocuted.[148]

Electricity lent itself to spectacular demonstrations, often involving human beings. Gray suspended an eight-year-old boy by insulated cords

about two feet above the floor and applied a charged glass tube to his bare feet, whereupon the boy, being charged, attracted pieces of brass leaf from 10 inches away.[149] Later demonstrators showed the 'electric kiss': a woman was placed on an insulator and an unwary spectator was invited to kiss her, whereupon a spark issued from her lips and gave him a shock. Another popular trick was 'beatification': a person standing on an insulator, preferably in a dark room, held a wire attached to a prime conductor, so that fire seemed to spring from ears, fingertips and hair.[150] To show how far electricity could be transmitted, people might be asked to stand in a line holding hands; the free hands at either end were connected to a Leyden jar, whereupon all received shocks. In 1746 Jean-Antoine Nollet, who in 1762 became director of the Paris Académie des Sciences, gathered about two hundred monks into a circle about a mile in circumference, with pieces of iron wire connecting them. He then discharged a battery of Leyden jars through the human chain and observed that each man reacted at substantially the same time to the electric shock, showing that the speed of electricity's propagation was very high. He also shocked 180 gendarmes in the presence of the king.[151] Nollet was no mere showman, but an eminent scientist; after he had established his reputation with his six-volume *Leçons de physique expérimentale* (*Lectures on Experimental Physics*, 1743–8), Louis XV acknowledged his redefinition of the subject by creating for him a new university chair in experimental physics.[152]

Thanks to such performances, electricity was long considered a spectacular but relatively unimportant branch of scientific investigation. When Alessandro Volta displayed his condensers to the academies of Paris and London in 1782–3, he was thought more a performer than a serious researcher.[153] Near the end of the century, however, Volta, by then professor of experimental physics at the University of Pavia, invented the electric battery. Luigi Galvani, an anatomist at the University of Bologna, examined why a frog's legs twitched after its death, and attributed the twitching to electricity stored in the frog's muscles. Volta argued that the electricity was not internal to the frog but must come from outside. In 1799 he invented the Voltaic pile, a pile of silver and zinc discs, alternating and separated by cardboard discs soaked in brine. When the top and bottom of the pile were connected by a wire, the result was a steady flow of electric current. Henceforth electric current could be stored and turned on or off as needed (whereas the Leyden jar discharged its contents all at once).[154] This and his earlier inventions caused Volta to be called the Newton of electricity. Nobody, of course, could possibly foresee that the electric battery would become a mainstay of industrial civilization.

THE HEAVENS AND THE EARTH

Astronomy and geology presented distinctive challenges to proponents of the new methods of inquiry. Their subject matter – the expanse of the heavens, the recesses of the earth – were in obvious ways inaccessible. In addition, both proved increasingly hard to reconcile with the biblical narrative of the six days of creation and the Flood that supposedly engulfed the earth, destroying all animate life except for Noah's family and the pairs of animals sheltered in the Ark.

Since astronomy depends on combining calculation with observation, it demanded well-equipped observatories and instruments of the utmost possible precision. The Paris Académie des Sciences founded in 1667 an observatory at Faubourg Saint-Jacques, to the south of Paris, and invited foreign astronomers to study there. For forty-five years it was directed by Giovanni Domenico Cassini, who observed four new satellites of Saturn, the cleavage between its rings, the red spot on Jupiter and the white spots at the poles of Mars. In Britain, the Greenwich Observatory and the office of Astronomer Royal were founded in 1675. The first Astronomer Royal, John Flamsteed, managed to compile a catalogue of some three thousand stars, all visible from Greenwich. His successor, Edmond Halley, among many other achievements, established the periodicity of comets. Having observed the comet of 1682, Halley noticed resemblances to reports of comets from 1531 and 1607; his theory, that they were the same comet, returning at intervals of approximately seventy-five years, was confirmed after his death when the comet, henceforth called Halley's Comet, reappeared in 1759.

The telescope, invented in the Netherlands in 1608 and used by Galileo for his discovery of the moons of Jupiter, was continually refined throughout the eighteenth century. Telescope technology reached its peak with William Herschel, a native of Hanover (then in personal union with the British crown) who settled in England, practised astronomy as an amateur, and in 1781 discovered a new planet. He wanted to call it the Georgian star after his royal patron, but continental astronomers insisted that it should, like the other planets, have a mythological name, and called it Uranus (after the father of Saturn). Herschel's largest telescope, completed in 1789, had a mirror 49.5 inches in diameter and a tube 40 feet long; Herschel designed and built it with the aid of a royal grant of £4,000 and an army of skilled workmen. With it he promptly discovered two hitherto unknown moons of Saturn. His sister Caroline assisted him in his work and made her own independent discoveries, including a new star and eight comets.

Astronomers were concerned with the earth as well as the heavens. Their

observations could have important implications for navigation, and therefore attracted support from governments. When Newtonianism was introduced into France, one of the points of conflict with the reigning Cartesian orthodoxy was the shape of the earth. Descartes had argued that the earth must be elongated at the poles, and measurements made by Cassini seemed to confirm this view. Newton, however, had argued that the rotation of the earth on its axis should make it bulge at the equator and be flattened at the poles. Measurements made in 1672 near the equator had found that pendulums of the same length swung more slowly near the equator than in France; Newton explained that points on the equator were further from the centre of the earth and therefore the force of gravitation was weaker. To settle this dispute, measurements must be made at the equator and the poles. Two kinds of measurements were possible. One could compare the speed with which pendulum clocks moved at different latitudes. Or one could measure lengths on the ground and correlate them with astronomical observations: the lengths were determined with the help of triangulation, in which the length of a single side of a triangle enables the other lengths to be calculated – but the vertices must be at prominent points, preferably mountain-tops.[155]

The French crown financed two expeditions. One, the French Geodesic Mission, went in 1735 under the leadership of Charles-Marie de La Condamine to South America. Access to Spanish territorial possessions required official permission, so this could claim to be the first international scientific expedition. Condamine's account of his travels, drawn from the journal he kept assiduously, records endless hardships.[156] Some were natural, such as earthquakes, volcanic eruptions, hurricanes and floods, in which important papers were soaked. Others were man-made: the observation points that the academicians erected were blown down by storms or damaged by thievish natives; workmen were negligent; communications with Europe were slow; when the travellers ran out of money, Condamine went from Quito to Lima to use some bills of exchange, only to be accused on his return of transporting contraband. Having again run short of money, Condamine made his return journey by crossing the Andes and sailing down the Amazon, reaching the Atlantic in 1743 and Paris only in 1745.

Meanwhile Maupertuis, the chief advocate of Newtonianism in France, set off in 1736 with his associate Alexis Clairaut and several astronomers for Lapland. Their base was Torneå (now Tornio) at the head of the Gulf of Bothnia. To find an elevation high enough for triangulation, they had to place their instruments on mountains, which they reached by struggling through trackless forests and swamps.[157] Their observations proved that the earth was an oblate spheroid, and, moreover, that aspects of Newton's theories could be confirmed experimentally. However, this

conclusion found general acceptance only after a long and bitter dispute with Cassini, who was unwilling to accept that his calculations could be empirically corrected.

Scientists were prepared to devote years of their lives, and encounter innumerable discomforts and dangers, in order to make discoveries. More such challenges were issued in the 1760s, when there were opportunities for observing the transits of Venus across the sun's disc in 1761 and 1769. These transits occur in pairs, eight years apart, followed by intervals of over a century. The previous transit had been in 1639, and the next would not occur until 1874. By measuring the transit with the utmost attainable precision, it would be possible to establish the distance between the earth and the sun, and, by treating this measure as the basic astronomical unit, to work out the exact dimensions of the solar system.[158] It was necessary to make the observations from numerous different points across the globe, because calculations had to allow for the rotation of the earth; because the duration of the transit would differ when seen from different points; and because some attempts at observation were sure to be frustrated by cloud cover. The observations made in 1761 were inconclusive, so the 1769 transit was awaited with intense excitement. Many nations sponsored far-flung expeditions staffed by scientists. Spain, which normally denied foreigners access to its American possessions, was persuaded to allow a French astronomer to observe the transit from the tip of the Baja California peninsula. Catherine the Great ordered the Imperial Russian Academy to make observations from points in Siberia, the Urals and the Arctic, and German and Swiss astronomers were invited to help. King Christian VII of Denmark and Norway invited the Jesuit astronomer Maximilian Hell to travel from Vienna and make observations from Vardö in the extreme north of Norway.[159] And the British crown helped to finance the Royal Society's expedition, led by Captain James Cook, to the newly discovered island of Tahiti. (The government was further motivated by hopes for new commercial opportunities and, above all, for the discovery of the great southern continent which, it was still thought, must exist as a counterweight to the Eurasian land-mass, and which it would be important to colonize before another European power – notably the Spanish with their base in South America – reached it.[160]) Altogether, some 150 observations of the transit were made, from California and Tahiti to Manila and Yakutsk, and though they did not reach an altogether conclusive result, they greatly reduced the range of probable measurements.

These journeys could be extremely arduous, and success was far from guaranteed. Cook and his companions were away for three years. Guillaume Le Gentil spent eleven years travelling in Asia; when he tried to

observe the transit from the French fort of Pondicherry, a cloud suddenly blocked his view at the crucial moment.[161] Hell was almost shipwrecked off the Norwegian coast. Very often the astronomers had to build their own observatories. However, they acquired new knowledge in many fields besides astronomy. The Cook expedition included the naturalists Joseph Banks and Daniel Solander (the latter a pupil of Linnaeus), who were to investigate the natural history of these unknown lands. Hell and his assistant whiled away the Arctic winter by studying the languages of the Lapps and Finns, discovering that they resembled Hungarian and thus belonged to what later philologists would call the Finno-Ugric language group. Le Gentil made a study of ancient Hindu astronomy by examining the calculations, carved on stones that he believed to be older than the Flood, made by the Brahmins so that (in his opinion) they could overawe the people by predicting eclipses of the sun and moon.[162]

The study of the earth was, if anything, more difficult than the study of the heavens. The orthodox assumption was that the history of the earth was reliably recounted in the Book of Genesis. The best attempt at a more precise chronology was considered to be that presented by James Ussher, archbishop of Armagh, in his *Annales Veteris Testamenti* (*Annals of the Old Testament*, 1650), which gained added authority when Ussher's dates were included among the notes to a new edition of the King James Bible in the 1650s. This was a work of historical scholarship, comparing and trying to reconcile information about datable events, including astronomical events such as the appearance of comets, in Latin, Greek and Hebrew sources. Ussher dated the Creation to the eve of 23 October 4004 before the Christian era.[163] It was assumed that human life must be as old as the earth, not only because Genesis tells of the creation of Adam and Eve, but also because it would have seemed pointless for God to create the earth without humans to inhabit it.

Biblical chronology faced two difficulties. One was that other cultures offered alternative – and sometimes much longer – chronologies: those of Egypt, Babylon and China. The other was the existence of fossils. Were they inorganic rock formations that happened to resemble organic objects? Or were they organic in origin? But if so, how did they come to be found on hillsides?

To answer these questions, the new science of stratigraphy, the study and relative dating of rock layers, came hesitantly into being. Its seventeenth-century progenitor, Niels Stensen, known as Nicolas Steno, examined fossils found in the stratified rocks of Tuscany, and argued that fossils were the remains of living beings trapped and petrified within layers of rock that had been deposited as sediment on the ocean floor.[164] Their

presence on hillsides he attributed to some kind of subterranean upheaval. Steno's theory was developed by John Woodward, who in his *Essay toward a Natural History of the Earth* (1695) argued that fossiliferous strata dated from the Flood, and the fossils they contained were living beings from the period before the Flood. The earth had been churned up and arranged in various strata.[165] Thus it became possible to understand strata as sequential deposits.

Leibniz developed this idea in *Protogaea* (written in 1694, published posthumously in 1749), which was intended as part of the history of the Guelf dynasty, including his employers, the dukes of Brunswick-Lüneburg, which he was commissioned to write in 1685.[166] He maintained that the earth had originally been an incandescent mass, the surface of which had cooled and solidified, leaving the crust on which we live around a global core of fire, which is manifested occasionally in volcanic eruptions. The fire pushed humidity into the air, which condensed and filled the larger cavities on the earth's surface with seas and lakes. The seas were afterwards reduced by evaporation, at which point a sequence of strata containing fossils was laid down. Leibniz intended his explanation to be compatible with Genesis: 'the separation of light from darkness indicates the fusion caused by fire; and the separation of wet from dry signifies the effects of inundations'.[167]

It hardly seemed possible, however, that such processes had occurred within a period of a few thousand years. In the first volume of his *Histoire naturelle* (*Natural History*, 1749) Georges-Louis Leclerc, Comte de Buffon, accepted the conventional chronology, arguing that existing physical processes sufficed to explain all the geographical changes indicated by the position of fossils on land.[168] Later, however, in *Les Époques de la nature* (*Epochs of Nature*, 1778), Buffon accepted the speculations by Leibniz and others that the earth had been originally hot and had cooled down. Buffon tried to put Leibniz's speculation about the earth's central fire on an experimental footing. He experimented with heating and cooling iron balls in a cellar remote from solar heat. From their rate of cooling, he extrapolated the length of time the earth would have taken to cool from incandescence, and calculated that the earth had taken 74,832 years to reach the temperature of the present, though he also admitted that a million or more years might have been required.[169] To make his theory compatible with the seven days of creation in Genesis, Buffon interpreted the 'days' of Genesis as seven epochs, or long periods of time.[170] The seventh epoch, the world as it is now, followed six epochs of gradual creation, which lay outside biblical chronology, so that the historical chronology of biblical events need not be questioned.

The *philosophes* were mixed in their responses to these arguments. Voltaire did not like the idea that the world might have undergone great

changes. In the paper he sent to the Accademia della Crusca in 1746, he challenged the view that changes of the earth's surface could be inferred from fossils. There was no good reason, he asserted, to suppose 'that the ocean ever covered the habitable earth for a long time, and that human beings once lived where today there are porpoises and whales'.[171] Nor need one imagine that seashells had been carried up into mountains by violent upheavals; he suggested instead that ammonites or serpent stones were really petrified snakes, and that small shells found in the mountains of France and Italy had been dropped by pilgrims and Crusaders.[172] He also affirmed that all species had remained the same. (After all, if, as Voltaire seems to have believed, the world had been wisely constructed by a God who subsequently left it alone, why and how could it have been drastically changed?) Diderot was more open-minded. Since individuals passed through a cycle of growth, decay and death, why should not entire species do the same? But if species were not constant, and had not, as the Bible assured us, been created in their present form, could there be any natural science? Could philosophy say anything valid about a natural world that was in continual flux?[173]

Most thinkers in the late eighteenth century were prepared to accept that the earth might be far older than biblical chronology suggested, though Buffon's 75,000 years remained the upper limit that could easily be imagined. They found it difficult to accept that species might become extinct. Neither the divine economy nor that of nature could permit such waste. Hence Thomas Jefferson thought that since mammoth bones had been found in America, mammoths must still exist in unexplored regions to the north: 'Such is the œconomy of nature, that no instance can be produced of her having permitted any one race of her animals to become extinct; of her having formed any link in her great work so weak as to be broken.'[174]

The Enlightenment view of a stable earth created as a home for humanity received its death blow from the zoologist Georges Cuvier. His starting-point was the evidence that species had become extinct. In a paper of 1796, 'On the species of living and fossil elephants', Cuvier compared the skeletal anatomy of different specimens and demonstrated that the Indian and African elephants were distinct species and that both were different from the fossil elephant or 'mammoth' found in Siberia.[175] He pointed out that the fossilized bones of existing species were found mainly in recent rocks, while deeper strata contained the bones of creatures now extinct. Besides, the more ancient deposits were askew and fractured, thus bearing witness to some elemental violence which had hurled them there. In his best-known work, he summed up his argument that the earth had undergone a series of violent upheavals involving floods: