INTRODUCTION

> This is the Age wherein (me-thinks) Philosophy comes in with a Spring-tide; and the Peripateticks may as well hope to stop the Current of the Tide, or (with *Xerxes*) to fetter the Ocean, as hinder the overflowing of free Philosophy: Me-thinks, I see how all the old Rubbish must be thrown away, and the rotten Buildings be overthrown, and carried away with so powerful an Inundation. These are the days that must lay a new Foundation of a more magnificent Philosophy, never to be overthrown: that will Empirically and Sensibly canvass the *Phaenomena* of Nature, deducing the Causes of things from such Originals in Nature, as we observe are producible by Art, and the infallible demonstration of Mechanicks: and certainly, this is the way, and no other, to build a true and permanent Philosophy . . .
>
> – Henry Power, *Experimental Philosophy* (1664)

Modern science was invented between 1572, when Tycho Brahe saw a nova, or new star, and 1704, when Newton published his *Opticks*, which demonstrated that white light is made up of light of all the colours of the rainbow, that you can split it into its component colours with a prism, and that colour inheres in light, not in objects.[1] There were systems of knowledge we call 'sciences' before 1572, but the only one which functioned remotely like a modern science, in that it had sophisticated theories based on a substantial body of evidence and could make reliable predictions, was astronomy, and it was astronomy that was transformed in the years after 1572 into the first true science. What made astronomy in the years after 1572 a science? It had a research programme, a community of experts, and it was prepared to question every long-established certainty (that there can be no change in the heavens, that all movement in the heavens is circular, that the heavens consist of crystalline spheres) in the light of new evidence. Where astronomy led, other new sciences followed.

To establish this claim it is necessary to look not only at what happened between 1572 and 1704 but also to look backwards, at the world before 1572, and forwards, at the world after 1704; it is also necessary to address some methodological debates. Chapters 6 to 12, which deal with the core period 1572 to 1704, constitute the main body of this book; Chapters 3, 4 and 5 look primarily at the world before 1572, and Chapters 13 and 14 at the world both somewhat before and somewhat after 1704. Chapters 2, 15, 16 and 17 deal with historiography, methodology and philosophy.

The two chapters of the Introduction lay the foundations for everything that follows. The first chapter briefly suggests what the book is about. The second explains where the idea of 'the Scientific Revolution' comes from, why some think there was no such thing, and why it is a sound category for historical analysis.

1
Modern Minds

> Bacon, of course, had a more modern mind than Shakespeare: Bacon had a sense of history; he felt that his era, the seventeenth century, was the beginning of a scientific age, and he wanted the veneration of the texts of Aristotle to be replaced by a direct investigation of nature.
>
> – Jorge Luis Borges, 'The Enigma of Shakespeare' (1964)[1]

§ 1

The world we live in is much younger than you might expect. There have been tool-making 'humans' on Earth[i] for around 2 million years. Our species, *Homo sapiens*, appeared 200,000 years ago, and pottery dates back to around 25,000 years ago. But the most important transformation in human history before the invention of science, the Neolithic Revolution, took place comparatively recently, between 12,000 and 7,000 years ago.[2] It was then that animals were domesticated, agriculture began, and stone tools began to be replaced by metal ones. There have been roughly 600 generations since human beings first ceased to be hunter-gatherers. The first sailing vessel dates back to 7,000 years or so ago, and so does the origin of writing. Those who accept Darwin's theory of evolution can have no patience with a Biblical chronology which places the creation of the world 6,000 years ago, but what we may term historical humankind (humans who have left written records behind them), as opposed to archaeological humankind (humans who

i I use 'Earth' for the modern, Copernican conception of the Earth as a rotating terraqueous globe, which is one of the planets; 'earth' for the pre-Copernican conception of the world we inhabit, being made up of the element earth, which is stationary at the centre of the universe.

have left only artefacts behind them), has existed only for about that length of time, some 300 generations. Add the word 'great' in front of 'grandparent' 300 times: it will fill just over half a page of print. This is the true length of human history; before that there were two million years of prehistory.

Gertrude Stein (1874–1946) said of Oakland, California, that there was 'no there there' – it was all new, a place without history.[3] She preferred Paris. She was wrong about Oakland: human beings have lived there for 20,000 years or so. But she was also right: the living there was so easy that there was no need to develop agriculture, let alone writing. Domesticated plants, horses, metal tools (including guns) and writing arrived only with the Spanish after 1535. (California is exceptional – elsewhere in the Americas the domestication of maize goes back 10,000 years, as far as any other plant anywhere in the world, and writing goes back 3,000 years).

So the world we live in is almost brand new – older in some places than others but, in comparison to the 2 million years of tool-making history, box-fresh. After the Neolithic Revolution the rate of change slowed almost to a crawl. During the next 6,500 years there were remarkable technological advances – the invention of the water-wheel and the windmill, for example – but until 400 years ago technological change was slow, and it was frequently reversed. The Romans were amazed by stories of what Archimedes (287–212 BCE) had been able to do; and fifteenth-century Italian architects explored the ruined buildings of ancient Rome convinced that they were studying a far more advanced civilization than their own. No one imagined a day when the history of humanity could be conceived as a history of progress, yet barely three centuries later, in the middle of the eighteenth century, progress had come to seem so inevitable that it was read backwards into the whole of previous history.[4] Something extraordinary had happened in the meantime. What exactly was it that enabled seventeenth- and eighteenth-century science to make progress in a way that previous systems of knowledge could not? What is it that we now have that the Romans and their Renaissance admirers did not?[ii]

ii Daryn Lehoux, in a thought-provoking book, asks: 'Are there differences between ancient and modern science? Of course there are. Are those differences fundamental? Did things change suddenly? Can we pinpoint some radically new way of doing things that emerged at some discrete point in history when we got something we call modern science? I think not.' (Lehoux, *What Did the Romans Know?* (2012), 15.) Lehoux thus makes the opposite case to the one made here.

When William Shakespeare (1564–1616) wrote *Julius Caesar* (1599) he made the small error of referring to a clock striking – there were no mechanical clocks in ancient Rome.[5] In *Coriolanus* (1608) there is a reference to the points of the compass – but the Romans did not have the nautical compass.[6] These errors reflect the fact that when Shakespeare and his contemporaries read Roman authors they encountered constant reminders that the Romans were pagans, not Christians, but few reminders of any technological gap between Rome and the Renaissance. The Romans did not have the printing press, but they had plenty of books, and slaves to copy them. They did not have gunpowder, but they had artillery in the form of the ballista. They did not have mechanical clocks, but they had sundials and water clocks. They did not have large sailing vessels that could sail into the wind, but in Shakespeare's day warfare in the Mediterranean was still conducted by galleys (rowed boats). And, of course, in many practical ways, the Romans were much more advanced than the Elizabethans – better roads, central heating, proper baths. Shakespeare, perfectly sensibly, imagined ancient Rome as just like contemporary London but with sunshine and togas.[7] He and his contemporaries had no reason to believe in progress. 'For Shakespeare,' says Jorge Luis Borges (1899–1986), 'all characters, whether they are Danish, like Hamlet, Scottish, like Macbeth, Greek, Roman, or Italian, all the characters in all the many works are treated as if they were Shakespeare's contemporaries. Shakespeare felt the variety of men, but not the variety of historical eras. History did not exist for him.'[8] Borges' notion of history is a modern one; Shakespeare knew plenty of history, but (unlike his contemporary Francis Bacon, who had grasped what a Scientific Revolution might accomplish) he had no notion of irreversible historical change.

We might think that gunpowder, the printing press and the discovery of America in 1492 should have obliged the Renaissance to acquire a sense of the past as lost and gone for ever, but the educated only slowly became aware of the irreversible consequences that flowed from these crucial innovations. It was only with hindsight that they came to symbolize a new era; and it was the Scientific Revolution itself which was chiefly responsible for the Enlightenment's conviction that progress had become unstoppable. By the middle of the eighteenth century Shakespeare's sense of time had been replaced by our own. This book stops there, not because that is when the Revolution ends, but because by that time it had become clear that an unstoppable process of transformation had begun. The triumph of Newtonianism marks the end of the beginning.

§ 2

In order to grasp the scale of this Revolution, let us take for a moment a typical well-educated European in 1600 – we will take someone from England, but it would make no significant difference if it were someone from any other European country as, in 1600, they all share the same intellectual culture. He believes in witchcraft and has perhaps read the *Daemonologie* (1597) by James VI of Scotland, the future James I of England, which paints an alarming and credulous picture of the threat posed by the devil's agents.[iii] He believes witches can summon up storms that sink ships at sea – James had almost lost his life in such a storm. He believes in werewolves, although there happen not to be any in England – he knows they are to be found in Belgium (Jean Bodin, the great sixteenth-century French philosopher, was the accepted authority on such matters). He believes Circe really did turn Odysseus's crew into pigs. He believes mice are spontaneously generated in piles of straw. He believes in contemporary magicians: he has heard of John Dee, and perhaps of Agrippa of Nettesheim (1486–1535), whose black dog, Monsieur, was thought to have been a demon in disguise. If he lives in London he may know people who have consulted the medical practitioner and astrologer Simon Forman, who uses magic to help them recover stolen goods.[9] He has seen a unicorn's horn, but not a unicorn.

He believes that a murdered body will bleed in the presence of the murderer. He believes that there is an ointment which, if rubbed on a dagger which has caused a wound, will cure the wound. He believes that the shape, colour and texture of a plant can be a clue to how it will work as a medicine because God designed nature to be interpreted by mankind. He believes that it is possible to turn base metal into gold,

iii Since the typical well-educated European was male, I use masculine pronouns when writing about the early modern period; I do not do this when writing about our own intellectual life. Similarly, I use 'mankind' when describing early modern views; 'humankind' when expressing my own views. Women were denied membership in all early modern learned societies, but there were a number of significant female scientists, particularly astronomers (Schiebinger, *The Mind Has No Sex?* (1989), 79–101) and alchemists (Ray, *Daughters of Alchemy* (2015)). It has been claimed that Maria Cunitz's *Urania propitia* (1650), a volume of astronomical tables, is 'the earliest surviving scientific work by a woman on the highest technical level of its age' (Swerdlow, '*Urania propitia*' (2012), 81); the book included a foreword by her husband assuring readers that this really was a woman's work, implausible though this must seem. See also below, 28n, 226, 234n, 474 and 569.

although he doubts that anyone knows how to do it. He believes that nature abhors a vacuum. He believes the rainbow is a sign from God and that comets portend evil. He believes that dreams predict the future, if we know how to interpret them. He believes, of course, that the earth stands still and the sun and stars turn around the earth once every twenty-four hours – he has heard mention of Copernicus, but he does not imagine that he intended his sun-centred model of the cosmos to be taken literally. He believes in astrology, but as he does not know the exact time of his own birth he thinks that even the most expert astrologer would be able to tell him little that he could not find in books. He believes that Aristotle (fourth century BCE) is the greatest philosopher who has ever lived, and that Pliny (first century CE), Galen and Ptolemy (both second century CE) are the best authorities on natural history, medicine and astronomy. He knows that there are Jesuit missionaries in the country who are said to be performing miracles, but he suspects they are frauds. He owns a couple of dozen books.

Within a few years change was in the air. In 1611 John Donne, referring to Galileo's discoveries with his telescope made the previous year, declared that 'new philosophy calls all in doubt'. 'New philosophy' was a catchphrase of William Gilbert, who had published the first major work of experimental science for 600 years in 1600;[iv] for Donne, the 'new philosophy' was the new science of Gilbert and Galileo.[10] His lines bring together many of the key elements which made up the new science of the day: the search for new worlds in the firmament, the destruction of the Aristotelian distinction between the heavens and the earth, Lucretian atomism:

> And new Philosophy cals all in doubt,
> The Element of fire is quite put out;
> The Sunne is lost, and th'earth, and no mans wit
> Can well direct him, where to looke for it.
> And freely men confesse, that this world's spent,
> When in the Planets, and the Firmament
> They seeke so many new; they see that this
> Is crumbled out againe to his Atomis.
> 'Tis all in pieces, all cohaerence gone;
> All just supply, and all Relation:

iv The first since Ibn al-Haytham's *Book of Optics* (1011–21). For discussion of Gilbert, see below, pp. 61, 157–8, 304, 315 and 328–9.

Prince, Subject, Father, Sonne, are things forgot,
For every man alone thinkes he hath got
To be a Phoenix, and that then can bee
None of that kinde, of which he is, but hee.

Donne went on to mention the voyages of discovery and the new commerce that followed from them, the compass that made those voyages possible and, inseparable from the compass, magnetism, which was the subject of Gilbert's experiments.

How did Donne know about the new philosophy? How did he know that it involved Lucretian atomism?[v] Galileo had never mentioned atomism in print, although some who knew him claimed that, in private, he made clear his commitment to it; Gilbert had discussed atomism only to reject it. How did Donne know that the new philosophers were seeking new worlds, not only by thinking of the planets as worlds but also by looking for worlds elsewhere in the firmament?

In all likelihood Donne had met Galileo in Venice or Padua in 1605 or 1606.[vi] In Venice he had stayed with the English ambassador Sir Henry Wotton, who was busy trying to obtain the release of a Scotsman, a friend of Galileo, who had been imprisoned for having sex with a nun (a crime that was supposed to carry the death sentence). Perhaps Donne met and talked with Galileo, or with Galileo's English-speaking students; he certainly seems to have met Galileo's close friend Paolo Sarpi.[11] In England he may well have met Thomas Harriot, a great mathematician who was evidently attracted to atomism,[vii] and Gilbert too.[12] As well as, or instead of, Galileo's *Sidereus nuncius*, or *Starry Messenger* (1610), he may have read Kepler's *Conversation with Galileo's Starry*

v Lucretius (*c.*99–*c.*55 BCE) claimed that the universe has no design but is the result of the random interaction of unalterable and indivisible atoms, and that the present universe will eventually be destroyed and replaced – it is just one in an unending sequence of randomly generated universes. Lucretius's poem *On the Nature of Things* was lost during the Middle Ages; it was rediscovered in 1417 and first published in 1473 and there was no complete English translation in print until 1682. Lucretius was a follower of Epicurus (341–270 BCE). We use the word 'Epicurean' to mean someone who seeks physical pleasure but, in the Renaissance, Epicureans were materialists and atheists and consequently unable to acknowledge any good other than physical pleasure.

vi Galileo was living in Padua but frequently visited Venice; equally, Donne, when in Venice, would surely have visited Padua, where there was a significant English and Scottish community.

vii Harriot independently discovered what we now call Galileo's law of fall, and also what we now call Snell's law of refraction, but he never published. See also below, pp. 32, 91, 212, 215, 218, 220–1 and 302.

Messenger (1610), which contained lots of radical ideas about other worlds that Galileo had carefully avoided discussing.

There is another answer. Donne owned a copy of Nicholas Hill's *Epicurean* (which is to say Lucretian) *Philosophy* (1601).[13] That copy – now in the library of the Middle Temple, one of the Inns of Court in London – had previously been owned by his friend and Shakespeare's, Ben Jonson. It had originally been purchased by a fellow of Christ's College, Cambridge – its binding bears the college badge.[14] Its first owner had planned to study it with care, perhaps to write a refutation or a commentary, for it was bound with alternate blank pages on which notes could be made. The pages remained blank. Was it given to Jonson, or did he borrow it and keep it? Was it given to Donne in turn, or did he borrow it and fail to return it? We do not know. We know only that no one took Hill seriously. His book, it was said, was 'full of mighty words and no great matter'. It was 'humorous [i.e. whimsical] and obscure'.[15] The early references to him (in, for example, a satirical verse by Jonson) have more to do with farting than philosophy.[16] At some point before 1610 Donne composed a catalogue of a courtier's library; this was an extended joke, listing imaginary, ridiculous books, such as a learned tome by Girolamo Cardano, *On the Nothingness of a Fart*.[viii] The first entry is a book by Nicholas Hill on the sexing of atoms: how can one tell male from female? Are there hermaphrodite atoms?[ix]

Donne would have learnt from Hill about the possibility of life on other planets, and of planets circling other stars; he would also have learnt that these strange ideas derived from Giordano Bruno.[17] If he read Galileo's *Starry Messenger*, with its account of the moon as having mountains and valleys, Donne would surely have responded exactly as the great German astronomer Johannes Kepler did that spring when he read one of the first copies to arrive in Germany – he saw a remarkable vindication of Bruno's perverse theory that there might be life elsewhere in the universe. If Donne read Kepler's *Conversation* he would have found the link with Bruno spelled out.[18] Jokes about farts were now beside the point. The gathering recognition was too late for Bruno,

viii Brown, '*Hac ex consilio meo via progredieris*' (2008). The Elizabethans took farting very seriously: the Earl of Oxford allowed a fart to escape him when bowing to Queen Elizabeth; mortified, he went abroad for seven years, only to be greeted on his return by the Queen with the words: 'My Lord, I had forgot the fart.' (Trevor-Roper, 'Nicholas Hill, the English Atomist' (1987), 9.)

ix Having discussed with my neighbour in the country the difficulty of sexing her ducklings, I now know, as Donne surely did, that sexing can be far from straightforward.

who had been burnt alive by the Roman Inquisition in 1600; it was probably too late for Hill too, who, according to a later report, committed suicide in 1610, eating rat poison and dying blaspheming and cursing. He was in exile in Rotterdam: he had been caught up in a treasonous plot to prevent James VI of Scotland from succeeding Elizabeth I to the throne of England in 1603 and had fled abroad.[19] Then the death of his son, Lawrence, to whom he was devoted, made further living seem pointless. In 1601 he had chosen to dedicate his only publication not to some great man (there was rather a shortage of great men who wished him well) but to his infant son: 'At my age, I owe him something serious, since he, at his tender age, has delighted me with a thousand pretty tricks.' Hill may not have lived to know it, but suddenly in 1610 Epicurean philosophy had become 'something serious'. A revolution was beginning, and Donne, who only a few years before had mocked the new ideas, who had read Gilbert, Galileo and Hill and perhaps knew Harriot, was one of the first to understand that the world would never be the same again. So by 1611 the revolution was well under way, and Donne, unlike Shakespeare and most educated contemporaries, was fully aware of it.

But now let us jump far ahead. Let us take an educated Englishman a century and a quarter later, in 1733, the year of the publication of Voltaire's *Letters Concerning the English Nation* (better known under the title they bore a year later when they appeared in French, *Lettres philosophiques*), the book which announced to a European audience some of the accomplishments of the new, and by now peculiarly English, science. The message of Voltaire's book was that England had a distinctive scientific culture: what was true of an educated Englishman in 1733 would not be true of a Frenchman, an Italian, a German or even a Dutchman. Our Englishman has looked through a telescope and a microscope; he owns a pendulum clock and a stick barometer – and he knows there is a vacuum at the end of the tube. He does not know anyone (or at least not anyone educated and reasonably sophisticated) who believes in witches, werewolves, magic, alchemy or astrology; he thinks the *Odyssey* is fiction, not fact. He is confident that the unicorn is a mythical beast. He does not believe that the shape or colour of a plant has any significance for an understanding of its medical use. He believes that no creature large enough to be seen by the naked eye is generated spontaneously – not even a fly. He does not believe in the weapon salve or that murdered bodies bleed in the presence of the murderer.

Like all educated people in Protestant countries, he believes that the

Earth goes round the sun. He knows that the rainbow is produced by refracted light and that comets have no significance for our lives on earth. He believes the future cannot be predicted. He knows that the heart is a pump. He has seen a steam engine at work. He believes that science is going to transform the world and that the moderns have outstripped the ancients in every possible respect. He has trouble believing in any miracles, even the ones in the Bible. He thinks that Locke is the greatest philosopher who has ever lived and Newton the greatest scientist. (He is encouraged to think this by the *Letters Concerning the English Nation*.) He owns a couple of hundred – perhaps even a couple of thousand – books.

Take, for example, the vast library (a modern catalogue runs to four volumes) of Jonathan Swift, the author of *Gulliver's Travels* (1726). It contained all the obvious works of great literature and of history, but it also contained Newton, the *Philosophical Transactions* of the Royal Society for the Advancement of Natural Knowledge (the second scientific journal, the *Journal des sçavans*, began publication two months earlier), and Fontenelle's *Entretiens sur la pluralité des mondes* (1686). Indeed, Swift, for all his antagonism towards contemporary science (to which we will return in Chapter 14), was sufficiently familiar with Kepler's three laws of planetary motion to use them to calculate the orbits of imaginary moons around the planet Mars; his hostility was grounded in extensive scientific reading.[x20] His world was one in which the culture of the elite was much more sharply distinguished from the culture of the masses than it had been in the past but also one in which science was not yet too specialized to be part of the culture of every educated person. Even in 1801 we can still catch Coleridge resolving that 'before my thirtieth year I will thoroughly understand the whole of Newton's works.'[21]

Between 1600 and 1733 (or so – the process was more advanced in England than elsewhere) the intellectual world of the educated elite changed more rapidly than at any time in previous history, and perhaps than at any time before the twentieth century. Magic was replaced by science, myth by fact, the philosophy and science of ancient Greece by something that is still recognizably our philosophy and our science, with the result that my account of an imaginary person in 1600 is

x Swift thought scientific research was a waste of time because it never led to any practical applications, a view forcefully expressed in Part III of *Gulliver's Travels* in his account of the airborne island of Laputa.

automatically couched in terms of 'belief', while I speak of such a person in 1733 in terms of 'knowledge'. The transition was of course still incomplete. Chemistry barely existed. Bleeding, purges and emetics were still used to cure disease. Swallows were still thought to hibernate at the bottom of ponds.[xi] But the changes of the next hundred years were to be far less remarkable than the changes of the previous hundred years. The only name we have for this great transformation is 'the Scientific Revolution'.

§ 3

On the evening of 11 November 1572, soon after sunset, a young Danish nobleman called Tycho Brahe was looking at the night sky. Almost directly above his head he noticed a star brighter than any other, a star that ought not to have been there. Afraid his eyes were playing some sort of trick on him, he pointed out the star to other people and established that they too could see it. Yet no such object could exist: Brahe knew his way around the heavens, and it was a fundamental principle of Aristotelian philosophy that there could be no change in them. So if this was a new object it must be located not in the heavens but in the upper atmosphere – it could not be a star at all. If it *was* a star then it must be a miracle, some sort of mysterious divine sign whose meaning urgently needed to be deciphered. (Brahe was a Protestant, and Protestants maintained that miracles had long ceased, so this argument was unlikely to persuade him.)

In all history, as far as Brahe knew, only one person, Hipparchus of Nicaea (190–120 BCE), had ever claimed to have seen a new star; at least, Pliny (23–79 CE) had attributed such a claim to Hipparchus, but Pliny was notoriously unreliable, so it was easy to assume that either Hipparchus or Pliny had made some sort of elementary mistake.[xii] Now

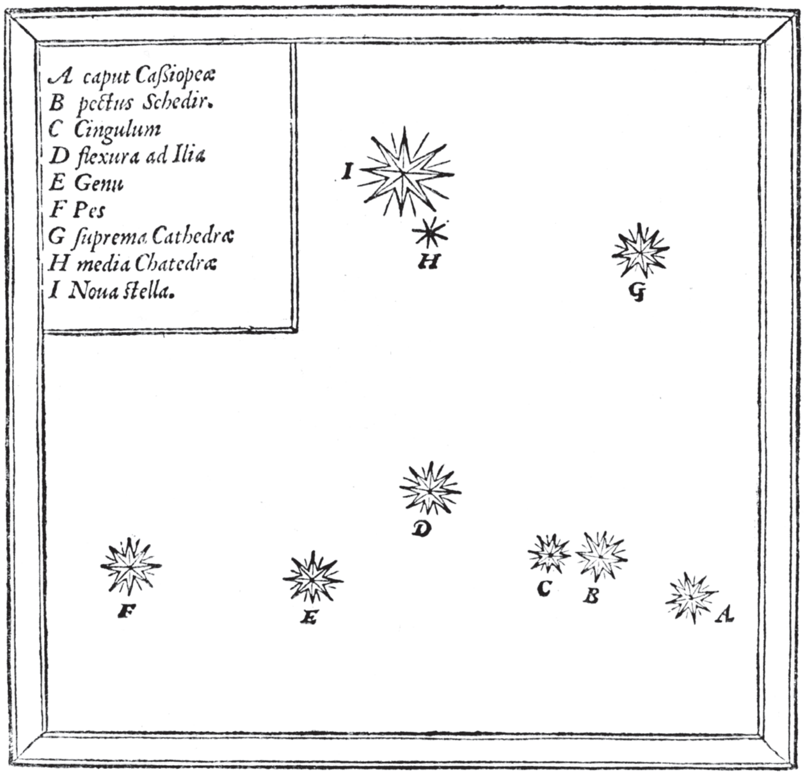
xi Towards the end of the century the great naturalist Gilbert White was still in two minds on the vexed question of migration versus hibernation: White, *Natural History* (1789), 28, 36, 64–5, 102, 138–9, 165, 167, 188. For a summary of a book which White cites (144), Carl D. Ekmarck's *Migrationes avium* (1757), see Griffiths, 'Select Dissertations from the *Amoenitates academicae*' (1781): Ekmarck held that some birds migrate but that swallows overwinter in ponds. His views are commonly attributed to Linnaeus, who examined his dissertation.

xii Brahe did not count the star of Bethlehem as a true star, for the Gospel of Matthew describes it as moving in the heavens. There had been an even brighter supernova in 1006, but there was no mention of it in the books known to him.

Brahe set about proving that the impossible had in fact occurred by showing, using elementary trigonometry, that the new star could not be in the upper atmosphere but must be in the heavens.[xiii] Soon it became brighter than Venus, and was briefly visible even by daylight, and then it slowly faded away over the course of sixteen months. It left behind a flurry of books in which Brahe and his colleagues debated its location and significance.[22] Also left behind was a research programme: Brahe's claims had caught the attention of the king of Denmark, who supplied Brahe with an island, Hven, and what Brahe later described as a ton of gold to fund the building of an observatory for astronomical research. As a result of his sighting of the new star Brahe was convinced that, if the structure of the universe was to be understood, much more accurate measurements must be made.[23] He designed new instruments, capable of an exquisite precision. When he realized that his observatory shook slightly in the wind, making his measurements imperfect, he moved his instruments into underground bunkers. Over the course of the next fifteen years (1576–91) Brahe's researches at Hven turned astronomy into the first modern science.[24] The nova of 1572 was not the cause of the Scientific Revolution, any more than the bullet which killed Archduke Franz Ferdinand on 28 June 1914 was the cause of the First World War. Nevertheless, the nova marks, quite precisely, the beginning of the Revolution, as the death of the archduke marks the beginning of the war. For the Aristotelian philosophy of nature could not be adapted to incorporate this peculiar anomaly; if there could be such a thing as a new star, then the whole system was founded on false premises.

Brahe had no idea what he was starting as he fretted over the new star that is now named after him – 'Tycho's nova' – and which can still be located in the constellation Cassiopeia, although only with a radio telescope. But since 1572 the world has been caught up in a vast Scientific Revolution that has transformed the nature of knowledge and the capacities of humankind. Without it there would have been no Industrial Revolution and none of the modern technologies on which we depend; human life would be drastically poorer and shorter and most of us would live lives of unremitting toil. How long it will last, and what

xiii Thomas Kuhn thought that, but for Copernicus, Brahe would not have been able to grasp that the new star was in the heavens (Kuhn, *Structure* (1970), 116), although Copernicus had nothing to say about supralunary change, and Brahe was no Copernican. Kuhn's claim is at odds with his broader argument that scientists can identify anomalies, but it is significant that Brahe lived in a culture in which long-established certainties (in religion, for example) were being questioned and overthrown.



Star map of the constellation Cassiopeia, showing the position of the supernova of 1572 (the topmost star, labelled I); from Tycho Brahe's *The New Star* (1573).

its consequences will be, it is far too soon to say; it may end with nuclear war, or ecological catastrophe, or (though this seems much less likely) with happiness, peace and prosperity. Yet although we can now see that it is the greatest event in human history since the Neolithic Revolution, there is no general agreement on what the Scientific Revolution is, why it happened – or even whether there was such a thing. In this respect the Scientific Revolution is quite unlike, for example, the First World War, where there is general agreement on what it was and a fair amount of agreement on why it happened. An ongoing revolution is a nuisance for historians: they prefer to write about revolutions that happened in the past – when, in reality, this one is still continuing all around us. As we shall see, much of the disagreement on this subject is the result of elementary misconceptions and misunderstandings; once they are cleared out of the way it will become apparent that there really is such a thing as the Scientific Revolution.