DAVID KNIGHT

VOYAGING IN STRANGE SEAS

THE GREAT REVOLUTION IN SCIENCE

'Elegant and engaging … the ideal book for those who seek an overview of the "long Scientific Revolution".'
—Frank James, The Royal Institution

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David Knight
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藏书章

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For Sarah, with thanks for fifty happy years;
and for Letsopa, Penelope, Laura and Hannah, beginning their lives

I could behold
The antechapel where the statue stood
Of Newton with his prism and silent face,
The marble index of a mind for ever
Voyaging through strange seas of Thought, alone.

William Wordsworth, *The Prelude* (1850)

The end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible.

Francis Bacon, *New Atlantis* (1627)

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CHAPTER 1

Voyaging in Strange Seas

In humble and reflective mood, the elderly Sir Isaac Newton (1642–1727) said: 'I don't know what I may seem to the world, but as to myself, I seem to have been only like a boy playing on the sea-shore and diverting myself in now and then finding a smoother pebble or a prettier shell then ordinary, whilst the great ocean of truth lay all undiscovered before me.'[1] His admirer William Wordsworth (1770–1850) wrote of Newton embarking upon that ocean as he remembered the view from his college bedroom in Cambridge of

> The antechapel where the statue stood
> Of Newton with his prism and silent face,
> The marble index of a mind for ever
> Voyaging through strange seas of Thought, alone.[2]

It seems natural to us to see the scientific life as a voyage of discovery, with its highlights when we can say, like ancient mariners: 'We were the first that ever burst/ Into that silent sea.'[3] It became so because the long revolution that gave us modern science began with the ocean voyages of the 1480s and '90s. Vasco da Gama (c.1469–1525) sailed round the Cape of Good Hope into the Indian Ocean, opening up a new and more efficient route to the riches of India, China and the East Indies; and in 1492 Christopher Columbus (1451–1506) set out

to reach them by going westwards, straight across the Atlantic Ocean. To his dying day, he believed that his landfall, the West Indies, was part of Asia. Discoverers often don't know quite what they have found; but the New World soon captured the imagination of Europeans, who began to think globally. Thomas More (1478–1535) set his Utopia on an island in the ocean, as did Francis Bacon (1561–1626), whose New Atlantis was run by an academy of sciences; the title-page of Bacon's *Instauratio Magna* (1620) shows ships sailing boldly through the Pillars of Hercules that bounded the Mediterranean into the open sea, and returning freighted with knowledge.

Nobody had suspected the existence of another continent, a brave new world to conquer literally and metaphorically. The Renaissance had seemed a recovery of the vast resources of ancient knowledge, and Aristotle (384–322 BC), Plato (427–347 BC), Ptolemy (c. AD 90–c. 168), Cicero (AD 106–43) and Pliny (AD 23–79) were adopted as authorities whose wisdom and style were to be emulated rather than questioned. Now their ignorance became apparent. When, in 1517, Martin Luther (1483–1546) launched what became the Reformation, he split the medieval Church, the other great source of legitimacy and certainty. Church teaching came to depend upon where you were. Nobody could any longer rely upon the old authorities. Luther translated the Bible into German, and William Tyndale (1494–1536) translated it into English, making the text available to be read and set against their own experience by those who were literate – a growing group. The Portuguese set up 'factories', trading stations and garrisons, in the East, and the Spaniards colonised Central and South America. The Dutch, French and British joined in. In 1620 the Pilgrim Fathers, Protestant refugees from England whose Church they thought insufficiently reformed, landed at Plymouth in what became in 1629 the Colony of Massachusetts; and it was here in 1775 that the first shots in the American War of Independence were fired. Our story ends in 1776 with the Declaration of Independence and the coming into being of the United States of America, whose first president, George Washington (1732–99), was inaugurated in 1789. Since that time, the course of science has moved gradually westwards, and the USA is now the leading scientific nation.

In the 1770s the project begun by the Portuguese and Spanish navigators of finding the limits of the habitable continents was essentially

completed by James Cook (1728–79) in his three great voyages of discovery. The interiors of all except Europe remained unmapped – a task for succeeding generations – but their outlines were known. This image can also be applied to science. There had been a huge change in the way the world was perceived and understood, and agreement that it could be improved: life could be less arduous and more comfortable. A new empirical attitude prevailed – active, optimistic, based upon observation, experiment and mathematical reasoning. Curiosity that had seemed childish became a virtue. Science and its fruits were perceived by governments to be vital. This book traces this development, crucial to the making of our modern world, which applied inherited knowledge and practical techniques, new and rigorous (if provisional) standards of classification and explanation, new devices for observation and measurement, and entailed the transformation of experience into experiment. Maps began to indicate how to get to Rome or America, rather than to Heaven. Clockwork brought a new sense of time, a fascination with machinery, and a new vision of the heavens, animals and humans. Printing made accurate texts available even to people like Copernicus (1473–1543), living far from the centre of things in Poland, and no less crucially, made the suppression of knowledge more difficult.

Gentry and professional men (clergy, doctors and lawyers) began to devote time to what we call science, and to take an interest in what craftsmen called their 'mysteries' – trade secrets. Associated with courts, universities and printing houses, at first in Italy, then further north, they formed groups that coalesced into societies and academies. There had previously been soloists like Leonardo da Vinci (1452–1519), but now there was a chorus to carry science forward. It became a profitable business. Science and navigation required better instruments and thus promoted new trades; gentlemen of science took the time and trouble to find out what artisans were doing, and themselves began to think with their hands; chemists learned, and improved, techniques used by craftsmen in metallurgy and dyeing; and medical sciences were transformed as first-hand study of anatomy and physiology augmented clinical experience, though at first with little therapeutic improvement. New industries promoted science and trade, bringing empire, prosperity and leisure. Astronomers, botanists and zoologists marvelled at the order and variety in the world which they

sought to classify; but God became for many a Clockmaker to be wondered at rather than prayed to.

The long Scientific Revolution had by the 1770s established its foundations, but this was not yet the modern world. We define 'science' narrowly; our forebears did not. They had no word for scientist, and there were no such people in the modern sense. They lived in a different world, foreign to us, where few people could devote themselves to science, but where there was a new spirit of curiosity about the natural world and how it worked – a spirit of progress. Projectors boldly schemed to improve the world, mitigating the biblical curse upon Adam and Eve by labour-saving devices, new crops, and better understanding of and treatments for disease. From the start, what we call science and technology were intertwined, inosculating and inseparable, and science was about power, wealth and usefulness as well as sociable and intellectual activity. But they remained unspecialised and, except for medicine and mathematics, there was no clear educational route into them: would-be practitioners relied on patronage, informal apprenticeships, and (most importantly) joining the societies and academies that began to proliferate.

For science cannot be done on its own, and its growth depended not only on its heroes (Galileo, Newton, Linnaeus) but also on the presidents, secretaries and treasurers of scientific societies, the craftsmen who made apparatus, the printer-publisher-booksellers who turned scientific discoveries into public knowledge, and the editors who invented the scientific journal: all of them interesting, if unsung, people. We have distorted the picture by too much concentration upon geniuses. This book emphasises, then, as crucial to the development of modern science its institutions (academies and societies) and its international character, promoted by travel and printing but also greatly by wars and persecution which led to the migration of well-educated refugees, notably to Britain and the Netherlands, and then later to the fledgling USA.

Many of these conflicts were so-called 'wars of religion', but in contrast to the popular idea of science as developing in warfare with religion, this book traces their complex engagement, with the mutual support they provided being as important to the outcome of the Scientific Revolution as the battles they fought. Certainly, the variety, order and beauty being

revealed in the world increased wonder and respect for the Creator, who, however, seemed increasingly remote from a world that ran itself like a great clock. Science did not – and does not – answer all questions. To know what disease a person has, and what the prognosis is, is one thing; but the question 'why is this happening to me?', and how that person can best live with their condition, is quite another. And the eighteenth century saw not only the rise of Enlightenment Deism, with its remote First Cause, but also of Methodism and other pietist movements. On my reckoning, the Scientific Revolution coincides with what historians call the Long Reformation, from Luther to John Wesley (1703–91), with its emphasis upon private judgement and experience, unmediated by a priesthood. The phenomena are not unrelated.

The book sets chemistry, with its long tradition of laboratories, experimentation and useful knowledge, and natural history, with its classifications and its botanic gardens promoting agriculture and horticulture, at the heart of the Scientific Revolution – and considers medicine to be at least as important as astronomy and mechanics. In choosing voyages rather than publications as marking its limits, the book makes this period of 'revolution' or development even longer than other writers have done. But in so doing, it brings out the importance of seaborne empires (commercial as well as conquistador) in the rise of science, as well as of the new financial and statistical world that came into being with science. Because science is a social phenomenon, the book places it in contexts of war, wealth, crafts and industry, health and disease, publishing and communications, class, careers and leisure. It traces the slow build-up of broadly conceived science, subject to all sorts of contingencies and often poorly recognised and rewarded, becoming by the 1770s a key to understanding, power and wealth, unstoppable and ready for a real revolution in the Age of Revolutions.

For the chemist Humphry Davy (1778–1829), who was involved in that revolution, the great men of science, his predecessors, had all too often like Galileo (1564–1632) been

> despised or neglected; and great, indeed, must have been the pure and abstract pleasure resulting from the exercise of intellectual superiority and the discovery of truth, and the bestowing of benefits and blessings

> upon society, which induced men to sacrifice all their common enjoyments and all their privileges as citizens, to these exertions.[4]

For society, science was a road to riches, but not for all its practitioners individually. Davy, for whom science had been a rapid route to social mobility, was respected and honoured, and would be commemorated in Westminster Abbey. But others were less fortunate, as we shall see.

Above all, this is a story about people. European males occupy the foreground, because that it how it was, but they are not the whole cast. The people we shall meet on this voyage – or strange, eventful pilgrimage – are almost as varied in appearance, character and background as those whom early travellers reported that they had encountered in the Americas, in Africa and in the Indies. Institutions had their agendas, but because the progress of science depended upon individuals and groups, and was subject to the enthusiasms, whims and fortunes of powerful patrons, it was contingent: things could have been otherwise. This is a history with losers as well as winners: astrologers like John Dee (1527–1608) found their science passing out of favour, and skilled workmen were displaced by machinery or by changes in practice. Travel and family history can stimulate our historical imagination. The Second World War looks much less straightforward from Finland, Estonia, Romania or Hungary; and we may we find not only rogues among our ancestors, but others who, hindsight tells us, were on 'the wrong side': puritans, recusants, wheelwrights, farm labourers. They did not feel part of a triumphant course of history. The history of science is not all sweetness and light either; controversy is important in it, and so is priority, though this may be disputed or wrongly assigned. There are no silver and bronze medals in science: the perceived discoverer takes all the credit. Hatred and malice are not excluded from our story: Newton made enemies, and John Woodward (c.1665–1728), challenging another doctor to a duel, said that he would rather face his sword than his physic. Nor is sadness: in a fit of depression, Ralph Wood (d. 1726), who built the first railway bridge (1725/6), threw himself from it to his death.

But there are also many attractive characters who demonstrate the scientific virtues. Johannes Kepler (1561–1630) was certain that there must be simple mathematical laws governing the planets and worked out a

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