THE EARLY-MODERN

3

The West and the Oceans

The maritime and the naval were to provide key aspects of the exceptional nature not only of Western power, but also of Western information. This chapter focuses on the importance of trans-oceanic Western activity in creating new information, and thus the pressure to understand and integrate it. After a review of the medieval background, the impact of the exploratory voyages of the fifteenth centuries is considered.

The Western legacy was not initially one to suggest that the West would be at the forefront of either trans-oceanic exploration or of developing intellectual responses to the resulting information. The Vikings had sailed to North America via Iceland and Greenland; but this was the sole Western trans-oceanic episode prior to the voyages of the late fifteenth century. Although their effectiveness is controversial, the Vikings apparently used crystal sunstones to navigate their ships through foggy and cloudy conditions. These sunstones, a gemstone found in Norway, establish the Sun's position as they enable the detection of polarisation, the properties displayed by rays of light depending on their direction, which is not visible to the human eye.[1] Iceland was reached by the Vikings in about 860, Greenland was settled from 986 and, in about 1000, a small settlement was established in Newfoundland.

The numbers involved were small, certainly in comparison with those who took part in conquests within Europe. Beyond Iceland, Viking expansion was very small-scale, and the failure to seek cooperation with the Inuit of Greenland was a major flaw, although there is also a theory that the Norse eventually intermarried and were subsumed by the Inuit. In addition to relations with the Inuit, hostile or friendly, disease, remoteness and the problems of global cooling in the high Middle Ages affecting an already harsh environment, probably brought the Greenland settlements to a close. That in Newfoundland had proved far more ephemeral. More significantly, these voyages did not substantially affect Western knowledge of the wider world.

All comparisons are problematic, but, in the period 400–1200, it would be difficult to feel that Western knowledge was more profound than that in China or the Islamic world. Possibly of greater importance was the lack of any advantage in the integrating of new material. Spiritual considerations played an important role in the West as elsewhere. The Bible was a significant inspiration in the West, not least in geography. There was interest in the location of places mentioned in it, and a wish to construct a geography that could encompass Eden; although these factors did not define geographical endeavour and cartographic information. At a different level, Christian symbolism influenced the composition and study of geometrical texts. Texts on geometry and surveying were understood as providing opportunities for meditation on spiritual subjects.[2]

Space and Time

The great *mappae mundi* (world maps) are significant means and repositories of the organisation of information in the medieval West. The maps conveyed geographical knowledge in a Christian format, offering a combination of belief and first-hand observation.[3] These maps employed a tripartite internal division, depicting three regions, divided between Noah's sons – Asia, Europe and Africa – all contained within a circle, the O, with the horizontal bar of the T within it seperating the regions representing the waterways differentiating Asia (the east in the top of the map) from the other two. This was not a case of separate continents, as all three were regions of one world to medieval Western thinkers.[4] These maps were full of religious symbolism. The T was a symbol of the Christian cross and Jerusalem came at the centre of the world, just as it was the inspiration of Christian pilgrimage.[5]

The Hereford *mappa mundi*, a copy of the map made in about 1290–1300 of what the cleric Richard of Haldingham (d. 1278) produced at Hereford,[6] has Christ sitting in Majesty on the Day of Judgement at its apex outside the frame. Christ in Majesty was a certainty above a Creation, the goal and nature of which were clear in God's purpose, but that man could only partly fathom; a pattern of thought that had psychological as well as intellectual consequences. There was an attempt to contain all knowledge within the cosmological construct of the Church. As the symbol of Creation, the circle acted to contain the ephemeral nature of human activity. It has been suggested that this map was hung as a centrepiece of a triptych, with painted panels of the Annunciation on either side, thus underlining the role of divine action and a power and purpose that were only partly knowable, and then knowable only through divine grace as much as the divine spark in every human. The use of Anglo-Norman as well as Latin in the map indicates that the information offered was for laity as well as clergy.[7]

Edward I (r. 1272–1307) had a world map, although it does not survive, and there was another map in English royal possession in the 1320s and 1330s.[8] The *mappae mundi* provided an account of the outer world that one might be tampted to treat as absurd, but they incorporated Classical information, namely Greek accounts of mythical peoples in distant areas, an aspect of the Classical assessment of the outside world.[9] These accounts, transmitted via Isidore of Seville's *Etymologies*, also influenced the Icelandic sagas, which included an encounter with a uniped in North America, another instance of mythical people.[10]

The *mappae mundi*, which were assemblages of ideas and information presented in an encyclopaedic manner, offered a key instance of the degree to which mapmaking provided ideas both about what lay beyond the confines of the known world and about how what was claimed as the latter could be interpreted. The Hereford map depicted the dog-headed Cynocephati, the Martikhora – four-legged beasts with men's heads – and the shadow-footed Sciopods. As further evidence for the wonder of the distant world, other maps presented, as facts, the mouthless Astomi, the Blemmyae, who had faces on their chests, the one-eyed Cyclopes, the Hippodes, who had horses' hooves, and the cave-dwelling Troglodytes. A one-eyed 'Monoculi' was still depicted, in West Africa, in Sebastian Münster's *Geographia Universalis* (1540).

Far from being uniform, the *mappae mundi* reflected the differing views of Christian theologians on the world, not least about whether Christian redemption would extend to all its monstrous races. All humans, the descendants of Adam, were to be evangelised by the Church, according to the Bible.[11] Mercy was not extended to everyone, however, and outsiders were often victims of what passed for 'information'. For example, in 1349, the Jews in Cologne were massacred on the grounds of the (totally false) report that the Black Death was due to their having poisoned the wells. Similar events occurred elsewhere; for example, in Brabant in 1350.

In the West, mankind was located in time as well as space in terms of the Christian story. The inherent connections between the Earth and salvation were aspects of a world in which God was present and active. In a universe bounded by the Fall (the expulsion of Adam and Eve from Eden) and the Apocalypse, time took on meaning in terms of redemption, and clerics, the educated members of the community, played a major role in ordering and explaining existence. Drawing on Christian Platonism, space also took on meaning as an aspect of God's creation. As a result, Christian models of space and time were necessarily schematic and, prior to the Second Coming of Christ, timeless. Indicating the centrality of the religious perspective, both the world and time became a stage across which revealed history occurred. The use of a circle as the frame for the Hereford map suggested the Wheel of Life

and Fortune, and also the movement of the heavenly spheres.[12] The schematic and timeless character of human existence prior to the Second Coming helps explain why medieval Christian thinkers reused Classical geographical ideas and terminology, even though these had been superseded by more recent information.

Presented in these terms, and treated in a jaundiced fashion, the West in the Middle Ages can resemble a place of deep Stygian unreason not too different from New Caledonia (see p. 47), but one that was to be overthrown by a secularising transformation in the shape of the Renaissance, the Age of Discovery and the Scientific Revolution, with the 'new monarchies' acting as assistants to change alongside printing and the rise of the middle class. The deficiencies of such an account, however, include not only a secular teleology that mistakenly defines the two periods as totally different, but also the related tendency to downplay the dynamism of medieval society, both in the West and elsewhere. There is also the issue of evidence. Alongside the Hereford *mappa mundi*, which is a magnificent, but not very original, presentation of a non-scientific geography, there is the cartographic character and purpose of the Gough Map, a practical map of Britain of about 1375 possibly produced for administrative use.

The dynamism of medieval society and its chronology are matters of controversy, but there were clearly major differences across the lengthy period of the Middle Ages. A greater measure of quantitative perception and application in the West by the fifteenth and sixteenth centuries was significant and looked towards future distinctive capabilities in science, technology and the arts.[13] Time, however, was also an important sphere of quantification and measurement in the medieval West, and a key source of information for locating human experience. There were many forms of time in the West including millenarian time, which dwarfed and qualified the human experience, not least the idea of the inauguration of the Last Times with the six-thousandth year of the world.[14] Alongside this apocalyptic tradition, there was also an important attempt to improve Paschal (Easter) calculations, which helps explain the significance of efforts to improve chronological understanding. The Council of Nicaea established Easter as falling on the first Sunday after the first full Moon after the vernal equinox, thus the Sunday closest to the first day of the year with twenty-four hours of light, twelve of sunlight and twelve of moonlight. As the lunar year consists of only 354 days, Easter does not fall on a fixed date. An intercalated lunar month of thirty days was added in seven of the years of a nineteen-year cycle. It was discovered in the year 457 that it would take 532 years for the series of Easter dates to repeat themselves. Medieval Christian *computus*, the calculation of the date of Easter, sought to balance scientific luni-solar cycles against theological traditions,

helping organise time in terms of a coordinated liturgical practice, centred on Easter, and a shared historical framework.[15] There are parallels here with some other traditions, including that of the Mayas of Central America.

Liturgical practice was central to Christian life under Charlemagne, the king of the Franks, who, in 789, ordered that *computus* be taught in schools. In 809, then emperor, Charlemagne called computists to a meeting at his capital, Aachen, to try to resolve issues to deal with competing methods of assessing the structure of time, methods that reflected the diversity of Western Christendom.[16] Concern about dating Easter explains the Church's support for astronomy, which was an aspect of the Christian purpose of investigating the natural world.[17] As with the settling of the Prime Meridian on Greenwich in 1884, this process reflected power and related aspirations to authority. Charlemagne's role proclaimed him as the leading Christian lay ruler, underlining his coronation as emperor by Pope Leo III in 800. The determination of Easter was a task that had to be accomplished for a formidable area and one that contrasted with the more limited needs of time calculation for the Islamic calendar.[18]

A sense of time as distinguishing present from past, and therefore creating new opportunities, while also regarding at least some of the past in terms of anachronism, was present in Western intellectual circles. This sense of separation between past and present became more apparent with the humanists and painters of Renaissance Italy.[19]

As part of the growing familiarity in Eurasia with mechanisms with moving parts,[20] the measurement and exposition of time became more sophisticated. Whereas China continued to employ the water clock, another form of gravity-driven mechanical timepiece, the weight-driven clock, was developed in the West, with the escarpment proving a key device as it translated the accelerating movement of a falling weight into a series of short movements of equal length. Western clocks continued to improve, with, for example, Richard of Wallingford, abbot of St Albans (1327–34), developing features such as a double-pallet escapement. His St Albans clock also had one of the earliest hour-striking mechanisms,[21] and is an instance of the precision and accuracy of much medieval technology.

The understanding, measurement and exposition of time involved a key concept in the use of information: fitness for purpose. For example, the knowledge of time required to deliver rent at a set period, or to impose night-time curfews on Venice's Jews, was different from the understanding required to determine Easter. Other spheres of activity, such as the law, had their own time requirements and conventions.

Although statistics and statistical indices were limited in this period, concepts of numerical value were significant. Thus, in the case of Western

thought on demographics, there were no concepts such as birth or mortality rates or population density; but, by the later Middle Ages, there was discussion of 'multitudes' in comparative terms and an ability to link the size of these multitudes to age of marriage, fertility and social consequences, such as dearth (shortage of food), poverty, and religious or political strength.[22]

A rationalist account of ideas and developments, in terms of emerging realism and fitness for purpose, should be complemented by an understanding that ideas of the period also reflected a holistic approach that provided an intellectual and moral coherence. Thus, Christian Platonism suggested a series of parallels, also seen in Indian (and other) thought, with the human body, the Church and the world, all microcosms of a divinely created universe. Moreover, revelation remained an important source of information, both in the West and elsewhere.

Maps and Exploration

Maps provide a good instance of the dynamism of medieval Western society. Although Christian models of space and time might be schematic and timeless, that did not prevent the provision of information in a far more specific fashion. Located in time and space, and recorded accordingly, information created a sense of identity that was important to the development of political consciousness. For example, the annals in the *Anglo-Saxon Chronicle* for the activities of King Alfred of Wessex in England in the 890s were important in linking events to places. Alongside the use of place names, there was an enumeration of distances and a citation of points of the compass.[23]

While, up to the mid-fourteenth century, the overwhelming use of Western maps appears to have been in scholarship and display, from that period onwards there was an increase in the number made for practical purposes or, looked at differently, *other* practical purposes. Local maps covering towns and some estates appeared, particularly in England, France, Germany and, most especially, Italy. These maps included drawings – for example, of buildings and bridges – indicating the extent to which elements of pictograms were featured. The visual was an important element of information, although written surveys remained common. The absence of modern surveying techniques ensured that the empirical element differed greatly from that of the current day.

Most local maps date from after 1400, suggesting that it was at this point that mapping began to play a role in local disputes as maps ceased to be novelties[24] and as people sought to demonstrate the boundaries of landholdings. Thus, the goals of government did not necessarily dominate. Nevertheless, official purposes were important. The Gough Map of Britain of about 1375 may have been intended to help officials. It provided an effective route map and

showed nearly three thousand miles of road, which transmitted goods, demands, information and innovation in an increasingly market-driven and economically sophisticated society.

Maps were an aspect of a growing infrastructure for both government and business, although other changes were more significant, notably improvements in roads, the building of bridges and the development of inns for trade. Information in other forms was also important and this information was used for new organisational devices. By the mid-fourteenth century in Italy, key elements of the modern economy had been created, including companies, shares, insurance, bookkeeping, cheques and business manuals. The money economy also became more sophisticated elsewhere: for example, in England.[25] Alongside this development and the growing demands of officials for precision with regard to locations, the idea of a district became less significant, notably legally, than that of more readily defined places, such as streets in the case of the notarial records of the French city of Marseille.[26]

Maps were also slowly adopted to delineate some Western frontiers from the fifteenth century. They helped to make the understanding of frontiers in linear terms, rather than zones, easier; and this understanding came to play a role in frontier negotiations. However, there were conceptual and methodological problems in comprehending frontiers, and in assessing and presenting them in these terms. As a result, a case law and literature developed. In his treatise *De Fluminibus seu Tiberiadis* (1355), Bartolo de Sassoferrata had to consider the difficulties of mapping meanders, changes of river courses and new islands in rivers.

A different form of cartographic information was provided by portolan charts, which supplemented sailing instructions by offering coastal outlines in order to help navigation. The charts were covered in rhumb lines: radiating lines resembling compass bearings. The use of the compass for navigation by Westerners had begun in the twelfth century, providing a new form of information. As with other innovations, for example astrolabes, which also became a navigational tool (and, later, steam engines and computers), the compass was not a one-stop change. Initially a needle floating in water, it became a pivoted indicator and, by the fifteenth century, there was compensation for the significant gap between true and magnetic north.[27] Moreover, portolan charts became more accurate with time. New discoveries could be incorporated into this format, a key element in any information system.[28]

At first, new geographical information was largely information arising from travel across Asia, such as the journey undertaken by William of Rubruck in 1253–5 on behalf of Louis IX of France to the court of the Mongol khan Möngke at his capital, Karakorum. In this case, the information was a mixture of accurate reporting, by William and other visiting friars, and of assumptions based

on the Bible and on apocalyptic prophecies about these non-Christian peoples. These assumptions affected the friars' reports.[29]

The friars were not alone in travelling across Asia. Marco Polo claimed to have left Venice in 1271 and to have reached the summer palace of Kublai, the ruler of China, at Shangdu four years later. In 1292, Polo was given, he claimed, the task of escorting a Mongol princess from China to Hormuz on the Persian Gulf, and from there he returned home in 1295. The veracity of his account has been challenged by some scholars, but it certainly had a major impact on Western knowledge about the Orient. His account also suggested the impact of the Mongol peace on facilitating journeys along the Silk Road.

By inaccurately assuming that he had travelled sixteen thousand miles from Venice to Beijing, instead of seven thousand, Marco Polo helped create a misunderstanding about the distance from Europe to China across the Atlantic, encouraging the idea that, by sailing west, it would be relatively easy to reach an Asia that was further east than is in fact the case. Polo was to be one of the sources for the 1492 globe by the Nuremberg geographer Martin Behaim which depicted only islands between Europe and China. Behaim also showed a large island called Antilla between Africa and China, an island that, since 1424, had been linked with the long-held and inaccurate belief that seven bishops and their flocks, fleeing the Moorish invasion of Portugal in the eighth century, had established seven islands, or cities, beyond the Atlantic horizon.

Behaim also drew on Ptolemy's *Geographia*, an instance of the way in which deep history played a role. Dating to the second century CE, Ptolemy's gazetteer provided latitude and longitude based on astronomical data. His *Geographia* was translated from Greek into Latin in 1406 and maps drawing on the coordinates from this translation appeared over the following decades, with printed versions being produced after 1475. There were errors, notably with the Indian Ocean being shown as enclosed, as a result of Africa below the equator appearing to stretch east to join a landmass that, in turn, stretched south from Southeast Asia. Moreover, the general practice of synthesis, of blending new information and ideas with traditional mapmaking processes, ensured that, in the fifteenth century, the Ptolemaic contribution was integrated with material and assumptions from portolan charts and *mappae mundi*.[30]

Nevertheless, the ideas Ptolemy expressed had considerable influence. His *Geographia* included material about three projections (representations on a plane surface of the curved, three-dimensional surface of the Earth) and thus encouraged the idea that the world could be presented through different projections, an important source of relativism. Moreover, Ptolemy's use of latitude and longitude furthered an emphasis on the mathematisation of location and, thus, on accurately measured data, recorded with reference to a graticule.

This grid was to become a central feature of Western mapping. Wider consequences of this emphasis on geometry included the application of mathematical proportionality to the known world and to what was discovered, as well as an objectification of the world, which was increasingly regarded as separate from humanity. The imposition of mathematical rules on representation lessened the sense of a spiritual connection with the Earth that had been seen in the T-O maps centred on Jerusalem.[31]

There were also consequences in the arts. The equivalent of the cartographic grid was the use of firm mathematical rules in order to produce a sense of accurate perspective in paintings and other visual arts. Some Italian Renaissance artists, such as Leon Battista Alberti (1404–72), author of *De re aedificatoria (On the Art of Building)*, and Piero della Francesca (c. 1415–92), author of *De Prospectiva Pingendi (On Painting Perspective)*, were mathematicians, and Urbino, a centre of the Italian Renaissance, was prominent for mathematical work. The new understanding of mathematics and infinity that was important to Renaissance art did not prevent a sustained engagement with sacred themes.[32] At the same time, perspective, in providing a method for organising spatial reality, offered a theory, at once visual, intellectual and spiritual, that engaged with the need to stabilise and reify perception in a manner not seen in Islamic visual theory, with its reluctance to embrace realistic depiction.[33]

Meanwhile, exploration and travel provided and confirmed new geographical information.[34] Some of the latter was a matter of clarifying information about lands already known by Westerners. Thus, in 1427, Claudius Clavus, a Dane who visited Norway, Iceland and southern Greenland, produced a map of northern Europe that supplemented Ptolemy's *Geographia*. However, it was lands to the south and east of Europe that attracted most attention. Stories reported by travellers, myth and history all played a role. For example, Prester John, a mythical Christian king, featured in many maps, being located in Ethiopia in Carignano's chart of about 1307, and in India in the Vesconte and Sanudo world maps of about 1320. The Catalan atlas of 1375, probably by Abraham Cresques, depicted Mansa Munsa, the legendary king of Mali in West Africa, who allegedly had dazzling quantities of gold. The maps are orientated to the north and feature compass lines, while the atlas also includes such details as tips for sailors to help them measure the passage of time at night and a table showing the movements of tides, an important form of information.

The dynamism evident for centuries in the extension of Christendom by proselytism and conquest, as well as in changing vegetation and land use by clearing woodland and introducing cultivation, was increasingly focused on trans-oceanic expansion. Interest in gold encouraged Portuguese explorers to sail south along the coast of West Africa, hoping to obtain goods without the

mediation of the North African Muslims. A map of 1413 by Mecia de Viladestes depicted the 'river of gold' that would apparently provide a trading route from the Atlantic into the West African interior.

Prince Henry the Navigator (1394–1460) was the major patron of Portuguese voyages of exploration. These voyages were designed not only to locate valuable goods, but also as part of a geopolitics of religious conflict. Henry sought Prester John, who would, he hoped, serve as an ally against Islam in the drive to reconquer Jerusalem. Similarly, papal grants of territorial rights arose from the desire to further the Church's universal mission.

The religious dimension of Henry's quest was minimised in most subsequent treatments, notably in the nineteenth and twentieth centuries, when a mercantilist, and essentially secular, account of the 'Age of Discovery' was offered; but there has been renewed interest in this aspect in recent years, interest that chimes with the recent theme of the 'clash of civilisations'. Both Christopher Columbus and Vasco da Gama wished to recapture the Holy Land, seeing it as a crucial preliminary to the Second Coming of Christ. Thus, time, as well as space, was at issue and exploration was a form of theology. Indeed, in his *Book of Prophecies*, compiled before his fourth voyage to the Caribbean, in 1502, Columbus argued that the end of the world would occur in 155 years, and that his own discoveries had been foretold in the Bible. By sailing west to discover a route to Asia, Columbus hoped to raise money to retake the Holy Land and, thus, redeem the Christian world.[35]

The Portuguese voyages led to a huge increase in information about African waters, which in turn resulted in improved mapping. Islands off Africa, Madeira, the Canaries, the Azores and the Cape Verdes, were sighted. Then, thanks to information obtained by further voyages, their number, correct orientation and true positions were all mapped. As a result, maps such as the Venetian Andrea Bianco's of 1448 offered a less stylistic and more realistic account than their predecessors had. A sense that it was necessary for the authority of the past to adapt to new information ensured that, from 1482, editions of Ptolemaic maps were updated to include recent discoveries. Furthermore, such new information was rapidly added. The manuscript book *Insularum Illustratum (Illustrated Islands)*, written in about 1490 by the Florence-based German cartographer Henricus Martellus, included, in both text and maps, information gleaned from Bartholemeu Dias's voyage rounding the Cape of Good Hope in 1488.

Drawing on the up-to-date geographical information of the period, Columbus set sail westwards in 1492, bound, he thought, for Japan. Using Ptolemy's maps as a guide, he had expected the voyage from Europe to be around 2,400 nautical miles. He would have had to travel about ten thousand to reach his Asian goal, but instead he found the West Indies. Information

about this New World – new to Westerners, at any rate – was rapidly disseminated. Columbus's pilot on his second voyage, Juan de la Cosa, is usually held to have produced the first map to show the discoveries, although it is possibly later than the traditional date given for it, 1500. The second voyage, that of 1493, was significant as it helped establish a viable and repeatable route.

News of the discovery of America spread. The St Thomas Altarpiece in Cologne, by the Master of Bartholomew's Altar, dates from 1495–1500 and portrays the 'wild' Mary the Egyptian, as well as three ships sailing towards the otherwise uninhabited coast where she lives. In 1502, a map aquired in Lisbon by the diplomat Alberto Cantino showed that knowledge was increasing: it revealed Columbus's discoveries as well as those in North and South America, the coast of Brazil being depicted rather vaguely, albeit illustrated with trees and parrots. The New World and Asia were clearly distinguished in this map.

Four years later, the map by the Italian Giovanni Contarini had a greater impact because it was printed. This indicated the variety of ways in which new information could be assessed and presented. Cuba and Hispaniola in the West Indies were shown, but Newfoundland and Greenland were inaccurately presented as parts of a peninsula stretching northeast from China. Between them and the West Indies, again inaccurately, lay a large body of water giving access between Europe and China, while South America was shown as a separate continent. This approach was also adopted in a map published by the Dutch cartographer Johann Ruysch in 1507 or 1508, although more detail was offered for Newfoundland, possibly reflecting the benefit of a voyage there. In 1520, Johannes Schöner's *mappa mundi* depicted the New World as a separate continent between Europe and East Asia, but, inaccurately, showed a marine route between North and South America. However, it was not until the 1534 map of the Fleming Gerhardus Kramer (1512–94, Latinised as Mercator) that the distinct names North and South America were used. The functional nature of nomenclature was seen in maps such as that of Gemma Frisius (1540), which referred to North America as Baccalearium, a reference to the Newfoundland cod fishery.

New information also entailed classification, and thus naming. In 1507, Martin Waldseemüller (c. 1470–c. 1522), a German theologian and cosmographer working at the monastery of St Dié des Vosges for Duke René of Lorraine, produced both a globe (the first known printed globe) and a large map of the world, printed from twelve woodblock engravings, in which he named the New World 'America' in honour of the Italian explorer Amerigo Vespucci, a French translation of the account of whose travels had been obtained by René. By depicting America, Waldseemüller also brought the Pacific, the ocean between America and Asia, to Western cartographic attention in a way that Behaim had not done in his 1492 globe. As an instance of the attempt to link

old and new, Waldseemüller also worked on a new edition of Ptolemy's *Geographia* designed to combine Ptolemaic and modern information: it was printed in 1513. As another instance of the endeavour to link old and new, there were attempts to relate ideas and conventions of the *mappae mundi* to Habsburg notions of the universality of their imperial interests.[36]

The first circumnavigation of the world, in 1519–22, begun by Ferdinand Magellan, also affected an understanding of its shape. Schöner's *mappa mundi* of 1520 had shown the Pacific as far smaller than was now realised to be the case. The Magellan expedition was the first (in late 1520) to round the southern point of South America and subsequently achieved the first recorded crossing of the Pacific, although Polynesian travellers had made long voyages across that ocean. The circumnavigation also exemplified how new information required new ways to display and consider it. It made the globe a more obvious tool, indeed the basic map, for understanding the world, and thus emphasised the need to give greater attention to the projections used in depicting that world.

Furthermore, new information clarified the amount of yet more information that had to be acquired, a situation that can be taken as a definition of modernity if the latter is presented as the practical understanding of continual change. As an intellectual system, the globe, and the graticule that covered it, had to be filled. Like the Classical Greeks, who had argued that the Earth was a sphere, the Western mapmakers, having proved this, were faced by the need to fill in the gaps that they were now certain existed. More specifically, by drawing attention to the size of the Pacific, the circumnavigation clarified not only the size of the Earth, but also how much remained to be mapped by Westerners: the larger the Pacific, the more extensive its shores.

Magellan's expedition had taken a route across the Pacific; it had not followed its shores, which would not have offered a practical route. The voyage also left open plenty of possibilities that landmasses lay to the north or south of the route. The latter seemed more plausible in order to help balance the greater known landmass in the northern hemisphere, a balancing that was (wrongly) assumed to be necessary. Indeed, despite not having actually been 'discovered' yet a southern continent was depicted on maps, even shown with a full set of place names.[37]

The sense of flux and uncertainty about the surface of the Earth was similar to that evident in the mapping of the sky. This was a mapping that was to be greatly challenged by new concepts and new information, in part thanks to the use of the telescope in the seventeenth century.

In another sign of the challenging onset of what can be presented as modernity, exploration led in the West to the overthrow of the authority of the Classical maps and geographers, and thus dealt a major blow to tradition as a source of information. Although Classical texts long continued to be cited in

accounts of Asia, Ptolemy's maps became curiosities or, at best, historical sources. The 1513 Strasbourg edition of Ptolemy's *Geographia* was the first to separate modern from ancient maps. In 1578, Mercator issued the Ptolemaic maps alone, without modern supplements, so that they could serve as an unrevised atlas of the Classical world. The latter was thereby detached from the present.

The mapping of the New World was the pre-eminent geographical novelty of the period. However, the arrival of Western voyagers in Asian waters led to major changes in knowledge about the Indian Ocean and East Asia. Some voyagers exploited pre-existing routes. Thus, Pedro de Covilham, a Portuguese explorer, sailed down the Red Sea in 1487, before travelling to India and, from there, down the east coast of Africa to Sofala in modern Mozambique, a port in the important Arab trading system in the Indian Ocean. Information from such voyages was a matter of repeating or incorporating knowledge about such journeys from non-Western societies.

In contrast, Bartholemeu Dias, who rounded the Cape of Good Hope in 1488, following a new route into the Indian Ocean, produced a map depicting the lands he explored. A fellow Portuguese navigator, Vasco da Gama, reached Calicut in 1498, at the end of the first all-sea journey from Europe to India. The Portuguese rapidly followed on from the Indian Ocean to China and Japan, establishing en route a series of bases, such as Malacca, conquered in 1511, that became the key points in a new naval-commercial empire.

The Portuguese also tried to systematise the accumulation of information. As a result, new maps were not only supplied by individual mapmakers. In Lisbon, a hydrographic office was established at the close of the fifteenth century in the Almazém de Guiné India (Storehouse of Guinea and the Indies) in order to control, as well as ensure, the flow of information. The office was responsible for the issuing of charts to pilots and for securing their return. It also oversaw the production of nautical charts and globes. In order to ensure quality, those deemed unacceptable were destroyed, and it was illegal to possess charts and globes that had not been approved. To improve accuracy, returning pilots were expected to submit their charts and logbooks for scrutiny. A navigation school was linked to the Almazém.

A similar process of trying to control access to information regarded as valuable was also seen with the Spanish government's response to the Americas. In 1508, a geographical department was established within the Casa de la Contratación de las Indias (House of Trade of the Indies).[38] These hydrographic offices have been called the West's first scientific institutions.[39]

Alongside functional benefits from the emphasis on globes, maps and charts, such works also offered powerful symbolic advantages. For example, spherical representations in the royal palace in Lisbon demonstrated

the aspirations of the newly rich monarchy to be a major world player. More generally, geographers served to imagine as well as record power. Atlas-making and mapmaking were linked to the writing of cosmographical poetry and pageantry as forms of cultural celebration. This celebration affirmed a global aspiration for Western power.

Western knowledge of South Asia rapidly expanded. In about 1502, India was recorded on the 'Cantino planisphere', a secret copy of the official register in Lisbon on which all Portuguese discoveries were noted. This register was an aspect of the melding of specific skills, techniques and knowledge in order to create an integrated and usable information system.[40] Such an integration was not easy, and posed issues of intellectual authority and experience, as well as of verification and consideration of new material and concepts. This ability, and its grounding, whether institutional or entrepreneurial, or intellectual or cultural, was to be important to the West's development of an information capability that was at once more dynamic and grounded than those elsewhere.

The Contarini map of 1506 showed the coast of Africa with considerable detail, although there was less accuracy in the coverage of South Asia. In 1513, the Waldseemüller atlas included a less inaccurate account of South Asia than that based on Ptolemy, although the depiction of the coast to the east of India was still full of error. Thereafter, mapping of South Asia improved, especially in Portuguese cartography. In 1518, Pedro Reinel, the leading Portuguese chart-maker with official status, was responsible for a map of the Indian Ocean in which he drew on the Portuguese expedition to the Moluccas five years earlier. The charts of the Indian Ocean produced by Sebastião Lopes in his portolan atlas (Lisbon, c. 1565) reflected a growing awareness of the coastline, for example of Sumatra, with which the Portuguese traded, although the Philippines, which were beyond their commercial zone, were still only poorly understood. But the Philippines were soon to become part of the Spanish zone, with a major base established at Manila. Voyages between Manila and Acapulco provided both an important link in the developing Western commercial system and the basis of new information about the Pacific.

As an instance of another process that was to be important to the diffusion as well as accumulation of Western knowledge, colonial centres where information was processed developed. The Portuguese base of Goa in western India became a centre of mapmaking.

Considering the World

Within the Western world, the publication and translation of travellers' accounts spread knowledge. Thus, the account of Jan Huygen van Linschoten, who had been a secretary to the bishop of Goa, an account that included a good map of

South Asia, was published in Dutch in 1596. In 1625, Samuel Purchas published in England the rutter (advice for pilots) of João de Castro, describing the routes he took in the Red Sea in 1541. Three years earlier, the publication of the history of Ethiopia by the Spanish Jesuit missionary priest Pedro Páez (1564–1622) provided up-to-date information that helped resolve disputes about the size of Ethiopia and the source and course of the Nile. Whereas earlier ideas about Ethiopia were derived from the Classical and medieval world, Páez's information provided the foundation for more realistic mapping, not least refuting earlier views about the great size of Ethiopia. Nevertheless, older ideas about Ethiopia and Africa, some based on symbolic cosmography, persisted, especially concerning the Mountains of the Moon and King Solomon's mines. Moreover, in contradiction of the notion that knowledge is always incremental, some erroneous ideas – for example, about a major lake in central Africa – were fostered by information obtained during sixteenth-century exploration. Some of this information was accurate, notably about the coastline, including river mouths, but there were also many rumours as well as mistaken speculations based on it.

Páez's work was an aspect of a Jesuit body of knowledge intended to further understanding of the world, an understanding that would also contribute to missionary activity and thus to the glory of God and the reputation of the new and ambitious order. Indeed, this goal helped provide a purpose for the acquisition of new information.[41] Another Jesuit, Eusibio Kino (d. 1711), a missionary in northern Mexico who sent a compilation of his cartographic work to Rome in 1696, discovered in 1701 that California was attached to the continental landmass and not an island, although it continued to be depicted thus on maps for several decades thereafter. Individual careers displayed the far-flung nature of Western activity. Born in Trutnov in Bohemia in 1673, Samuel Fritz worked as a missionary along the upper Amazon River from 1686 to 1704, also producing four manuscript maps, one of which, drawn in 1691, was printed in Quito, a centre of Spanish colonial government, in 1707.

Illustrating the cascading nature of the Western information system, this map was reprinted, alongside Fritz's account of the missions among the Omagua Native Americans, in Paris in 1717 as part of the multi-volume French edition of works on the foreign missions of the Jesuits. In turn, this volume was reprinted in German in 1726. Moreover, indicating the availability of information from a number of sources, the 1691 map was brought to France in 1745 by the French explorer Charles-Marie de La Condamine, who reproduced the material in his own map of the Amazon, one based on the knowledge of longitude and latitude of the period.[42]

An emphasis on Western knowledge can lead to a failure to devote sufficient attention to the partial reliance of Western explorers and others on local sources of information. Vasco da Gama relied on Kanha, a Gujarati pilot, to guide him

across the Arabian Sea from East Africa to Calicut. João de Castro relied on the charts of Arab and Gujarati pilots. Similarly, in the East Indies, the Portuguese obtained copies of charts from native pilots, as with the 1511 expedition to Java and the Moluccas. Other explorers were also to profit from local advice. In the Pacific, James Cook was to benefit from local knowledge, with the Tahitian navigator Tupaia guiding him through Polynesia. It was not only guides who provided information. In Atlantic Africa, the Portuguese use of native interpreters gave them access to African views about their own societies.[43]

The capture of individuals also helped lead to the transmission of information, notably between Islam and Christendom, where there was a long tradition not only of using captives, but also renegades. Print spread the resulting information, as with Leo Africanicus's *La Descrittione dell'Africa* (1550).[44]

In the New World, the emphasis was on the mapping not only of coastlines, but also of inland regions and, more particularly, of settled areas under imperial control. The geographical department of the Casa de la Contratación de las Indias was instructed by the Spanish government to produce a *Padrón Real* (official royal chart), a work that was frequently updated to take note of new reports from navigators; the Portuguese equivalent was the *Padreo Real*. A manuscript map of the world that explorer Amerigo Vespucci's nephew, Juan, produced in 1526 survives and shows how Spanish knowledge of coastal waters rapidly increased. The successive estuaries on the coast of North America were recorded, while the outline of some of the American islands, especially Cuba and Hispaniola (but not Jamaica), was considerably more accurate than on earlier maps. It was, however, easier to give detailed shape to coastlines than to the interior of continents. Diego Gutiérrez's 1562 map of South and Central America offered a complete account of the coastline, which captured the general configuration, but the interior was only poorly covered.

The mapping of settled areas presented different problems, as it was necessary to come to terms with the native population, and for the latter to come to terms with Spanish rule.[45] In common with practices seen in the West, the Native American understanding of geography collapsed the boundary between space and time, recording mythic origins and symbolic power as part of space. This practice was changed as a result of Spanish conquest, not simply because Spain was now the imperial master, but also because the local population swiftly began to follow Spanish practices. They replaced hieroglyphs with alphabetic writing, which transformed the way in which information could be recorded.[46] Native maps thus became easier for the Spaniards to understand, which was important if they were to play a role in litigation. More generally, the landscape was increasingly understood in Western terms, with an abandonment of Mesoamerican abstraction in favour of the imagery and methods of Western illustrations and maps. The use of perspective spread.

At the same time, a mixture of native and Western mapping conventions and symbols reflected the syncretic character of Spanish imperialism, its ability – alongside the often brutal treatment of Native American society, which was seen as heathen and evil[47] – to adopt and adapt as part of its rule. This was a policy and practice observed also in the way in which, after a period of highly brutal destructiveness, native religious cults were given a place within Christianity.

The role of syncreticism in the gathering and presentation of information was seen in the 1570s when, in the latest instance of a process of gathering information about the New World, Philip II of Spain commissioned an extensive survey of his territory, which became the *Relaciones Geográficas de Indias* (Geographical Account of the Indies). The information, which was requested on a printed questionnaire sent out in 1577, was intended to reveal, describe and display what overseas territories had been seized by Spain, and to help support further expansion. There was interest in the political boundaries or tribute-reach of pre-Conquest states. As with many information-seeking projects, both across the past and in the present, it is possible to stress failure but also to note a measure of success. Philip entrusted the task to two prominent cartographers, Alonso de Santa Cruz and Juan López de Velasco, but neither visited the New World. Instead, they sent questionnaires to local officials, eliciting fewer replies than had been anticipated, which helped cause the abandonment of the mapping. On the other hand, the plan itself was impressive and also showed an ability to bridge cultures. Indigenous artists were in the main responsible for the maps sent from New Spain in response to Philip's commission.[48] Their role was part of a wider dependence on the indigenous population and the linked degree to which, however changed by conquest, indigenous communities continued to shape their colonisers' encounters with landscape in colonial times.[49] Information gathering was a shared project.

The mass of information received from trans-oceanic voyages, and the need to order and use it, encouraged a rethinking of the world by Westerners. The standard focus in the literature is on navigation and mapping and, indeed, as a result of the voyages of discovery, Westerners produced and used a projection, the Mercator projection, that made most sense for compass work, pilotage and navigation, especially in mid-latitudes. However, it is also pertinent to note the impact of the information produced by discoveries on land. Indeed, the extent to which the New World challenged established ideas has led to the claim that the Scientific Revolution began with the Spanish response to their new lands.[50] In particular, as an aspect of the process by which far-reaching state systems extended human interactions with the environment,[51] the Spanish crown's interest in profiting from its new territories encouraged the exploration of nature there. Demands for information were part of the process.

Demands for information were more necessary because of the lack of Classical exposition to give guidance, and this lack meant that the New World not only provided new knowledge, but also the need for a new classification of knowledge in order to give it meaning. The Lost Tribes of Israel were discerned in America, but biblical guidance could be problematic. Thus, the claim that the New World was the Ophir and Tarsis from where King Solomon had obtained bullion and ivory, and more specifically that Peru was Ophir, was dismissed in part on the grounds that there were no elephants in the New World.[52] Furthermore, animals and plants not known to Classical (Western) writers were discovered, including avocados. Indeed, there was concern about the impact of unfamiliar New World food on Western colonists.[53]

Discoveries from the trans-oceanic world were not the sole cause of challenges to existing understanding, but they encouraged a different development from that based on the textual collation and correction of Classical sources.[54] Some of the arguments of Classical writers were disproved: for example, Aristotle's claim that it would be too hot to live in the tropics. However, Classical literature provided pertinent models, Roman expansion serving as a reference point for its Spanish successor.[55] Moreover, Aristotelian principles remained important. Thus, Andrea Cesalpino's *De Plantis* (1583), a major text in the development of botany, owed much to Aristotle, notably in the classification of plants.

Nevertheless, the lack of Classical sources for the Americas was part of a broader reconceptualisation of the nature of authority, with the stress on eyewitness accounts and contemporary experimentation proving important to the process by which America was understood by the Spaniards and thus, as it were, 'invented'. Not only new knowledge, but a different classification of knowledge were offered. The emphasis on reports from eyewitnesses, the news of the current day, ensured that mythographic literature became less significant as a way to consider geography and, indeed, to set a context for the reporting of contemporary history.[56] Moreover, the Neoplatonic and occult aspects of Renaissance thought provided no practical guidance on how to interpret the new information.

Instead, what can be considered anthropological ideas and information developed. This process can be seen with the Spanish response to the New World. Alongside a destructive contempt for native cultures,[57] there were also attempts to understand them. The career of the Spanish Franciscan Bernardino de Sahagún (c. 1499–1590) is instructive in this regard. Sent to Mexico to act against 'idolatry', he came to appreciate Aztec culture and the Nahuatl language, documented many texts and created his own research methodology.[58] More generally, in each of the stages of acquiring, transmitting and processing information – observation, description, dissemination and comprehension – basic

assumptions were tested as new ways of thinking focused on empirical data came into conflict with established ones.

At the same time, traditional ideas could be employed to help shape information about the New World. The capacity for human fall from grace was already present from the biblical story. This capacity was offered anew by human behaviour that was apparently similar morally to that of animals; and this categorisation was then applied to natives who were presented as irrational. Given that rationality was seen as the main distinction between humans and animals, and that the soul was presented as moral as a consequence of humans' God-given reason, the capacity to process information and acquire knowledge was an aspect of the divine plan as well as a means to distinguish among creation.[59]

More specifically, the growing complexity of racial classification posed by intermarriage became an issue, notably in Spanish America, where such intermarriage was large-scale.[60] There and elsewhere, racial categorisation was deployed as a way to cope with otherness, such as skin colour. Whiteness was fixed as both origin and norm in Renaissance Western theories of blackness.[61]

Christian purpose overlapped with cartography, for, aside from concern with the geography of the Holy Land – the key element of *geographia sacra*, which was an important aspect of Western geography – maps in part were designed to encourage consideration of God's work.[62] That process did not preclude an attempt to understand and represent change. Different projections were devised in response to the extension of Western knowledge about the physical shape of the world. Thus, Peter Apianus (1495–1552), a German humanist who became the official cosmographer to Emperor Charles V, devised in 1530 the first cordiform (heart-shaped) map to be printed.

In 1569, drawing on the work of Erhard Etzlaub,[63] Mercator produced a projection that treated the world as a cylinder, so that the meridians were parallel, rather than converging on the poles. In this projection, the poles were expanded to the same circumference as the equator, although, in 1569, Mercator produced a separate, fanciful map of the Arctic, presenting it as a rock surrounded by a large body of water from which four channels crossed a continent, dividing it into four islands. Beyond that, there was a continuous ocean to the north of the various continents.

The maps that utilised Mercator's projection greatly magnified the temperate landmasses at the expense of tropical ones. Taking into account the curvature of the Earth's surface, Mercator's projection kept angles, and thus bearings, accurate in every part of the map. A course of constant bearing (loxodrome) could thus be charted as a straight line across the plane surface of the map, a crucial tool for navigation. This was a huge achievement, unmatched by the

Arab traders of the Indian Ocean, who were unable to use a grid of latitude and longitude in order to create practical navigation charts.

To achieve the navigational goal, the scale was varied in the Mercator projection, and thus size was distorted. Mercator's projection affords negligible distortion on large-scale detailed maps of small areas, but relative size is markedly misrepresented on Mercator charts because of the increased poleward separation of parallels required to straighten out loxodromes. This was not a problem for Western rulers and merchants keen to explore the possibilities provided by exploration and conquest in the middle latitudes to the west (America) and east (South Asia). Indeed, by providing a way to understand and overcome distance, the projection highlighted the imperial world of Portugal and Spain, and was an appropriate accompaniment to the success of Philip II of Spain (r. 1556–98), son of Charles V, in creating the first global empire, the first on which the Sun literally never set.

The Philippines, named by the Spaniards after Philip, demonstrated another characteristic of imperial power: appropriation through naming. The frequent use of saints' and other religious names as the basis for place names added another dimension to this appropriation. The Mercator projection also underlay the idea of the Earth as habitable and open to communication, as opposed to the Classical idea of four continents, the inhabitants of which could not communicate with each other.[64] Mercator's work, therefore, was part of the process by which maps provided crucial conceptual information to help Westerners cope with the new shape of their known world.[65]

A Mercator projector need not necessarily include more of the northern hemisphere than the southern, nor place Europe at the top centre. However, Mercator placed Europe, which to a Westerner seemed both most important and the easiest to map, at the top centre of his world map, thus highlighting Portugal and Spain as the source of activity. He gave the northern hemisphere primacy not only by treating the north as the top, but also by giving the southern hemisphere less than half the map.[66]

Mathematics and Geography

Mercator's work can be linked not only to Western power, but also to intellectual enquiry and commercial opportunity. Intellectual enquiry was seen in the wish to offer accuracy and to reduce error due both to lack of information and to the distortion arising from the problem of providing a two-dimensional representation of the three-dimensional curved globe. This issue of how best to represent the Earth on a map was an instance of the autonomous and significant nature of practical problems, as opposed to an emphasis on information as serving simply to further power, the latter an approach that

it is all too easy to adopt.[67] The problem that a straight line on a plane chart was not a straight course because of the curvature of the Earth had been highlighted by Pedro Nunes (1502–78) in his *Tratado da Sphera* (Treatise of Spheres) (1537), a work that introduced new methods and instruments in navigation.[68]

Mercator looked back to Ptolemy in employing coordinate geometry as guarantee and means of a mathematically consistent plan and logically uniform set of rules. The combination of the grid of latitude and longitude with perspective geometry proved a more effective way to locate places, and thus to adapt to the range of new information, than the Spanish template map, the *Padrón Real*, which was a portolan chart, without projection, grid of latitude and longitude, or common scale. Instead, portolan charts, which were essentially directional guides based on analogue rather than digital methods, had a variety of scales and units of measures, and the rhumb lines on different charts did not coincide. As a result, these charts were more personalised than maps based on a projection. Disputes over how to correct the *Padrón Real* led to it slipping into disuse in the 1560s.

Intellectual enquiry also encouraged the development and improvement of a range of measuring devices, notably in the sixteenth century.[69] Mercator, a mathematician who was skilled in producing globes as well as maps, also made mathematical instruments for which the commercial opportunities were enhanced by the widespread interest in cartography. The emphasis on mathematics reflected the currency of that knowledge and the role of its practitioners in promoting a concept and practice of mathematics not as an insular subject focused on abstractions, but as a developing system of information and method capable of being applied and of respecting problems.

Indeed, there was, with the Dutch mathematician Simon Stevin (1548–1620), his English counterpart Thomas Harriot (1560–1621) and other mathematicians, a use of the rhetoric of geographical discovery in order to present mathematicians as explorers of the structure of geometrical figures. The rhetoric of geographical voyages of discovery was applied to the search for truth in the natural world as well as to personal relationships and the development of the printing press. The theme of new discoveries in the accounts of voyages of exploration encouraged a call for new discoveries on the part of experimental philosophers, and with these discoveries grasped through experience. In short, knowledge was not to be referential to the past, but to be focused on the new. Francis Bacon (1561–1626) explicitly compared both forms of discovery. Similarly, John Dee and Harriot supported voyages of exploration and made mathematical advances. Dee's *General and Rare Memorials Pertaining to the Perfect Art of Navigation* (1577) argued for England's position as an Atlantic power.[70]

The link between navigation and mathematics epitomised that between practice and theory that was so important to what would be termed the Scientific Revolution. The need for mathematical knowledge in navigation and cartography joined the voyages with the pursuit of truth in mathematics. Prominent mathematicians such as Harriot and Edward Wright (d. 1615) were engaged in both voyages of exploration and mathematical research and writing. Wright provided a mathematical rendering of Mercator's projection, calculating the position of parallels, and helped to disseminate the necessary information by publishing a table of meridian parts for each degree. As a result, mapmakers could produce accurate projections. Jodocus Hondius (1563–1612), who also offered his own version of Mercator's work, relied heavily on Wright.[72]

The experience of exploration has been linked to the development in the seventeenth-century West of the method of mathematical indivisibles. Whereas Dee offered a deductive mathematics based on Euclid's *Elements*, the key Classical model, Harriot took a bolder line towards the geometrical continuum, adopting an atomistic approach that anticipated the development of calculus. Dee's presentation of geometry as the divine alphabet of nature was challenged by Harriot's concern with the mathematics of the inner structure of physical reality, an approach that lent itself to an engagement with knowledge as a developing field for intellectual application.[71] In place of the classic Euclidean proof, relying only on rigorous deductions from first principles, came an attempt to look into the inner structure of geometrical figures. Thus, in contrast to the scholasticism of traditional mathematics, in which conclusions are implicit in the assumptions, and geometry is focused on relations between apparent features, there came an emphasis on scrutiny and exploring hidden secrets, a thesis advanced in Bonaventura Cavalieri's *Geometria Indivisibilibus* (Invisible Geometry) (1635). The mathematical indivisibles, the objects of discovery, led directly, later in the century, to the calculus of Isaac Newton and Gottfried Leibniz.[73]

A demand-driven interest in maps was a distinctive feature of Western cartography. Alongside the role of government came a desire to have and to use maps that was important to the particular trajectory of Western mapmaking. Maps were scarcely projects simply for the depiction of space and distance on the Earth or in the cosmos. They also served important political and religious ends.[74] Nevertheless, the ability to discuss and interpret spatial issues rose with the development of geography both as an intellectual subject and as a sphere of publishing. Geography offered a new ideal of science as a tool for understanding and controlling nature. In addition, exploration and the information it produced posed problems for classification.[75]

Service of the state fostered the use of cartographical imagery to glorify rulers[76] and also strengthened an interest in mathematical geography, while descriptive geography encouraged readers to regard the world as a source of

wondrous tales and new goods. The incremental nature of enhanced geographical knowledge looked towards the empirical nature of scientific advances, while the emphasis on utility was to be more generally pertinent for the governmental response to new information.[77] At the same time, the development of geographical writing, like the Mercator projection, was a response to the great amount of new information coming into the West. The key element was not the arrival of the information itself, but rather the related late Renaissance desire to structure the flood of information.[78]

In England and other Western maritime states, there was a relationship between the study of geography and the development of ideas of national power and imperial growth.[79] A sense of maritime destiny was pressed in England in a number of publications, including Dee's *General and Rare Memorials Pertaining to the Perfect Act of Navigation* (1577) and Richard Hakluyt's *Principal Navigations, Voyages, Traffiques and Discoveries of the English Nation* (1598–1600). Such accounts were also important in fixing knowledge of exploration. In contrast, societies that lacked such a print culture found that information was not fixed. For example, knowledge of the voyage of Semen Dezhner around the coast of Siberia in 1648 was largely lost in Russia.

Carto-literacy increased greatly in the West with the production of large numbers of maps and atlases. Moreover, the changes coming from new discoveries created a sense that knowledge was dynamic. William Shakespeare, in his play *Twelfth Night* (1602), has the duped Malvolio 'smile his face into more lines than is in the new map with the augmentation [addition] of the Indies' (III, ii). That map contained more information than its predecessors, and Shakespeare's London audience was expected to appreciate the fact.

At the same time, it is important not to neglect the extent to which a specialised trade in printed maps developed only slowly, certainly in London prior to 1640. Moreover, maps continued to reproduce earlier information without any or much alteration, which both captured the degree of continuity in city shapes and images, and also led to inaccuracies. William Cunningham's map of Norwich, published in 1559, was the basis for all maps of this major English city produced until 1696.[80] A tradition of religious allegorical cartography also continued.[81]

The ability of explorers to provide new information helped to enhance a sense that the Western world-view was correct and should shape the world, although this ability also created problems about how best to integrate this information with existing material. Furthermore, many of the additions were inaccurate, sometimes because they included material from explorers who had not understood what they saw. An important example occurred in 1524 when Giovanni de Verrazano, a Florentine explorer in the service of Francis I of France, followed the coast of North America from Georgia to Nova Scotia. He thought, when sailing off the Outer Banks of North Carolina, that he was

seeing a long isthmus between the Atlantic and the Pacific, and this was shown in the world map of 1529 by his brother Gerolamo de Verrazano. The erroneous idea was adopted by other mapmakers.

The New World was the cause of much error. In his *Universale*, or world map, of 1546, Giacomo Gastaldi, who in 1548 became the official cartographer of Venice, captured the eastern seaboard of the Americas and the western seaboard of South America (the location of the Spanish colony of Peru) with some accuracy, but he had Asia and North America as a continuous landmass, with the join between the main sections no mere land bridge but as wide as Europe. This was an influential model for other maps of the period, although growing knowledge of North Pacific waters, in particular as a result of voyages from the Indian Ocean to Japan, where the Portuguese and Dutch established trading outposts, led to an abandonment of the land link in many Western maps by the late sixteenth century.

Moreover, as a valuable admission of a lack of information, and therefore of the expectation that more would be obtained, it was possible to leave the coastlines of the North Pacific blank, as with Edward Wright's map of the world published in the second edition of Richard Hakluyt's *Principal Navigations* (1599). However, it was not until Vitus Bering's voyages in the early eighteenth century that the idea of a land link between Asia and North America would be conclusively rejected. This was not the only area of error. There was also the idea of a large northwest passage between Canada and an Arctic landmass to the north. And, there was the long-standing belief, referred to above, that California was an island.

The nature of the information available was related to the extent and means of Western power. As a result, the emphasis was on coasts rather than interiors. In Amsterdam in 1614, the visiting Prince Johann Ernst of Saxony was impressed by the large chart in the meeting room of East India House in which 'the Asian navigation with all winds and harbours was depicted, beautifully drawn on parchment with pen and partly painted'. The East India Company had no need for similar maps of overland routes in Asia; this was true for other mappers too. The focus was on areas of Western settlement. For example, French cartographer Etienne de Flacourt's map of Madagascar (1666) was largely accurate for the southeast of the island, where the French had established Fort Dauphin in 1642, but not for other parts. Similarly, the map of India in the Dutch mapmaker Joan Blaeu's *Atlas Major* (French edition 1667) included many errors for the interior, including highly inaccurate alignments of the Ganges and Indus rivers, the incorrect location of the hills of the Western Ghats far inland and a failure to mark in the mighty Himalayan range of mountains. On the other hand, Blaeu's twelve-volume atlas contained nearly six hundred maps, an indication of the amount of cartographic information that was available in the West.

This quantity reflected the accumulative nature of cartographic information. Thus, Ortelius's *Theatrum Orbis Terrarum* (*Theatre of the World*, 1570) was expanded in the 1584 edition to include a map of the Azores by the Portuguese mapmaker Luis Teixeira, while the 1595 edition contained a map of Japan based on his work. Similarly, Blaeu's *Atlas Major* showed China relatively accurately because of the influence of the atlas of China and Japan compiled by Martinus Martini, a Dutch Jesuit who had resided in Beijing and been captured by the Dutch East India Company, which had made a translation of his work. Martini's information corrected that derived from Marco Polo, an indication of the extent to which Western knowledge of China was limited and, for long, had not been updated.

Thanks in part to the Jesuits, who had their headquarters in Rome, the information about the natural world accumulated through the voyages of exploration helped make the Italian city an intellectual epicentre, and one that had to deal with the shock of the new in a way that no other religious centre had to do. In 1622, the Sacred Congregation for the Propagation of the Faith was established in Rome not only to coordinate all missionary activities, but also to centralise information on foreign lands, much of which was gathered by missionaries.

Printed works also served to incorporate material from manuscript maps. Vincenzo Coronelli's map of North America, published in his *Atlante Veneto* (1691), provided new information on the western part of North America based on a recent manuscript map by Diego Dionisio de Peñalosa, who had sought to interest Louis XIV of France in mounting an expedition against New Spain: France and Spain were then engaged in the Nine Years' War (also known as the War of the League of Augsburg or King William's War). This use of the manuscript map was an instance of the more general process of manuscript material strengthening that available in print.

The translation of atlases increased their impact. Moreover, the very concept of a map-book or atlas represented an important development. The idea of maps systematically produced to a common purpose fused utility and the consequences of the technology of printing, including predictability and quantity. In addition, an atlas could be perceived as having an authority that surpassed that of individual maps. Like Mercator, Ortelius also captured the idea of mapping as a continuous process, rather than representing the proclamation of a supposedly complete body of knowledge. Thus, his *Theatrum* made reference to the sources used for its maps, a practice that carried with it the implication that new information would lead to new maps. Mercator was similarly committed to using new sources rather than familiar images, and his range of correspondents extended to the cartographic centre of Goa in India.

A parallel pattern of assembling information through continuous accumulation from a number of sources, with the process aided by publication, could

also be seen with tides. A 1684 mercantile report of the Tonkin tide, unusually a daily, not a twice-daily, one, affected Newton's theory of tides.[82]

Thanks to the accumulation of information, the West knew far more about the world than did other cultures, both the world as a unit and distant parts of the world. In particular, a synergy existed between overseas expansion, navigation and mapping. In the case of the Dutch East and West India Companies, ships' pilots began to keep logbooks and to produce reconnaissance charts employing sheets of paper with pre-drawn compass lines. Company ships were provided with navigation instruments, and an East India Company mapmaking agency was established in Amsterdam from 1616. The Companies also regarded surveys with information on crops and town plans as essential instruments for management and planning. The Blaeu publishing firm produced maps for the East India Company and also used information the Company provided for its publicly sold maps.

Similarly, in Dutch Brazil and elsewhere in the territories of the two major Dutch trading companies, engineers and land surveyors were present to map, plan and remodel fortresses, settlements and agricultural areas. In every settlement founded by the Dutch West India Company, a land registry was established where large-scale cadastral (property) maps and ledgers were updated regularly. Moreover, oral information obtained from sources such as the native population, material from reconnaissance expeditions, and the mapping of settlements and plantations was integrated into medium-scale topographic maps of the Dutch colonies. Thus, a map of Surinam (Dutch Guiana) was printed in 1671, and a new survey of all plantations there began in 1684.[83]

This was information gathering and presentation for economic benefit, a process also seen with other Western colonies and a major theme in Western activity. Cartography provided an opportunity to understand and assess the success of overseas territories and was thus linked to efforts in metropoles to develop tools of national accounting.[84] More generally, geographical information was an adjunct, if not an enabler, of imperial power, and this information was fed through to plans for colonisation.[85] The gathering of plants served to provide items of medical and educational interest, notably for the physic garden created at the University of Leiden between 1587 and 1594.[86] Uses were found for products new to the West, such as guaiac wood, which was employed as a cure for syphilis.

Plants and animals from overseas were illustrated, which provided a way to disseminate information.[87] In turn, the gathering of plants posed problems for compilations and classifications, as the quantity of specimens continued to grow, while Dutch overseas activity ensured that Amsterdam became the centre of the Western trade in exotic animals, and these were used to advance

comparative anatomy. Similarities between the bodies and, even more, brains of monkeys and humans challenged the physical basis for the traditional argument of a clear divide between humans and animals. This had consequences both for the discussion of slavery and for the background to the consideration of evolution. The continual discovery of new species posed challenges for zoological classification and for the Aristotelian legacy, as part of the process by which the expansion of the West, physically and conceptually, led to the acquisition of much more information and, correspondingly, to issues of how best to compile, arrange and explain the new surfeit of facts.[88]

Economic benefit was not the only theme in accumulating information. The directors of the East and West India Companies also ordered highly decorative charts and maps to demonstrate their new position as actors on the global stage. There was, moreover, a wider public dimension. Maps were purchased by citizens of the United Provinces (Dutch Republic) who were interested in the global dimension of Dutch trade and the struggle with Spain, which lasted from the mid–1560s to 1609 and from 1621 to 1648. The maritime role of the United Provinces enhanced Amsterdam's position as a centre for information, both for the development of newspapers and for mapping. This information contributed to the sophistication and profitability of the Amsterdam markets for commodities and stocks.[89] The Dutch also played a leading role in shipbuilding, notably in constructing efficient cargo ships, and were also prominent in the publication of works on the technology and techniques of navigation.[90]

The relative lightness of regulation, both political and economic, was also key to the vigour of Dutch financial and mapping activities. Each was a sphere in which, by contemporary Western standards, entrepreneurship was little constrained by the need to seek governmental permission or to operate only within the boundaries set by guilds. As a result, entrepreneurs were able to respond to the demand for information. Dutch production of maps was dominated by competing publishing houses, especially those of the Blaeu and Hondius families. In their bids to outdo one another, they drew on maps from any source they could, benefiting from the absence of any real sense of copyright; their rivalry helped to ensure a constant process of updating. Thus, maps of the East Indies by Portuguese mapmakers were published by the Dutch. The commercial context was often made readily apparent. The map of the East Indies designed by Petrus Plancius and published by Cornelis Claesz in 1592, which ranged east to include New Guinea and the Solomon Islands, drove home the idea of the region's economic value by adding pictures of nutmeg and sandalwood. The West alone saw plentiful mapping intended to help merchants develop trade networks. This was a divergence from non-Western practice that was well-established prior to the eighteenth century.

The West in the World

This was a world in which the gap between the achievements of humans and the capabilities of far-ranging animal species was growing rapidly. As far as humans were concerned, the oceans were increasingly serving Western purposes, while Westerners were able to derive economic benefit from pillage and commerce in a range of environments. That, however, did not mean that overseas trade was necessarily under Western control, or that non-Western cultures could not reach viable accommodations with capitalist opportunities[91] and different environments. Although China lacked formal market and financial institutions, such as commercial courts, and did not succeed in raising *per capita* income or experience significant urbanisation,[92] and the Islamic world arguably was held back by legal and institutional factors,[93] there was considerable energy at play on the part of some non-Western interests. For example, the ability of native shippers, mostly from the East Indies and Gujarat, to evade Portuguese attempts at blockade helped ensure that part of the spice trade to the Ottoman empire and the West returned to overland routes through the Near East, rather than being controlled by the Portuguese and conducted by sea.

If, in the 1590s, China and Korea fought Japan over the waters round Korea, rather than looking further afield, so the focus in the struggles between Western powers was also local, centring on control in Europe rather than taking a more global approach. Thus, in 1585–1604, the war between Britain and Spain centred not on the Caribbean, but on the Low Countries, Ireland and European waters and coasts. Yet, there was also a major contrast between the West and the Asian powers. Conflict between the latter did not range as widely as did the wars between the Dutch and Portugal or the Dutch and Britain in the mid-seventeenth century.

Moreover, there were no comparable developments in attitudes towards the trans-oceanic world. After the Chinese refused in the 1590s to accept any equality of status, Japan saved face in part by restricting its diplomatic links in the seventeenth and eighteenth centuries largely to Korea and the conquered kingdom of Ryukyu,[94] although information about China was valued. This drawing-in was also seen with a marked curtailing of Japanese relations with Western powers. The Portuguese were expelled from Japan in 1639, and links with the Dutch were greatly reduced in 1641. Having developed Western-style shipping that traded widely in Southeast Asia, Japan now did not persist with this shipping.[95]

Meanwhile, Mughal India and Safavid Persia did not develop significant naval power. The Ottoman Turks, in contrast, did, but most of their naval activity was in the Mediterranean. Fleets were sent into the Indian Ocean, to

India in 1538 and to Hormuz in 1552, but both were defeated. Moreover, in 1589, the Portuguese ended the Ottoman advance along the Swahili coast of East Africa by defeating their force at Mombasa. The Manchu, who conquered Ming China in the 1640s–50s, were not a naval power and, although they pressed on to seize Taiwan in 1683, did not develop a long-range naval capability. Non-Western societies did not have an equivalent to the Americas to exploit, both for their own benefit and in fostering global trade. Looked at differently, whatever their economic strength, these societies did not develop a policy of trade-orientated development or an intellectual engagement with understanding the world as a dynamic process.

To Western commentators, convinced that their oceanic reach was providential proof of their purpose and superiority, the inability of the non-West to match this capability was evidence of failure, an approach that, in certain respects, prefigures some modern commentary. In the sixteenth and seventeenth centuries, this approach brought together evidence of Western success, notably the conquest of the Aztecs and Incas, with Christian providentialism and the ability to grasp the future in millenarian terms. The account of the non-West as primitive, and therefore deserving of exploitation, could be placed alongside the idea that the West had progressed from an anachronistic medieval past, and that the Classical tradition, while exemplary, was only a point of reference. This approach fixed both the Western past and the non-Western present as limited at best, and primitive and redundant at worst.[96] In each case, there was a sense of Western development, both absolute and relative, although it was presented differently in Protestant and Catholic cultures.

The complex relationships between social structure, political culture, international activity and intellectual resources will be considered in chapter five, but, first, it is necessary to discuss other aspects of the search for, and ordering of, information, including the Scientific Revolution. The background, as this chapter has indicated, was one of a West adapting to an unprecedented flow of new information stemming from a global range not matched by any other culture.