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3 TRICKSTERS AND CARTOGRAPHERS: MAPS, SCIENCE AND THE STATE IN THE MAKING OF A MODERN SCIENTIFIC KNOWLEDGE SPACE

Two of the major themes pursued in this book are the way knowledge spaces are created out of the messy motley of practice, and the 'great divide' between science and other knowledge traditions. Nowhere are these two themes better exemplified than in the synergistic relationship of science and cartography. That relationship is now so self-evident and yet so complex that it is best explored by going back to basics and asking what maps are, what they do and how they come to be so embedded in modern consciousness. The seemingly trite question, 'what is a map'? is hard to answer because maps are the paradigmatic examples of the kind of spatial knowledge that is produced in the knowledge space we inhabit. Not only do we create spaces by linking people, practices and places, thus enabling knowledge to be produced, we also assemble the diverse elements of knowledge by spatial means. Unpacking such a transparent, lived-in, dual spatiality necessitates a fairly difficult reflexive exploration since it involves the attempt to understand the spatiality of knowledge from within the knowledge space that has been coproduced with that knowledge.

In this chapter I revisit the great divide to set up the possibility of recognising other ways of assembling knowledge, thereby gaining the perspective of an alternative space. Some of the recent discussions about the spatiality of knowledge then open up a discussion of the socio-historical origins of our knowledge space in early attempts by the state to assemble cartographic knowledge in sixteenth-century Iberia. While these were ultimately unsuccessful, they were a precursor to the knowledge space that came with the integration of the state, science and cartography that began with the French national survey in the eighteenth century. Because all this raises profound reflexive difficulties, I have adopted the role of the jester—an approach suggested by the Fool's Cap Map, one of the most revealing of cartographic images.

Being a Trickster

Although the author and origin are unknown, the Fool's Cap Map (see Fig. 14) dates from the late sixteenth century, probably post-1587,

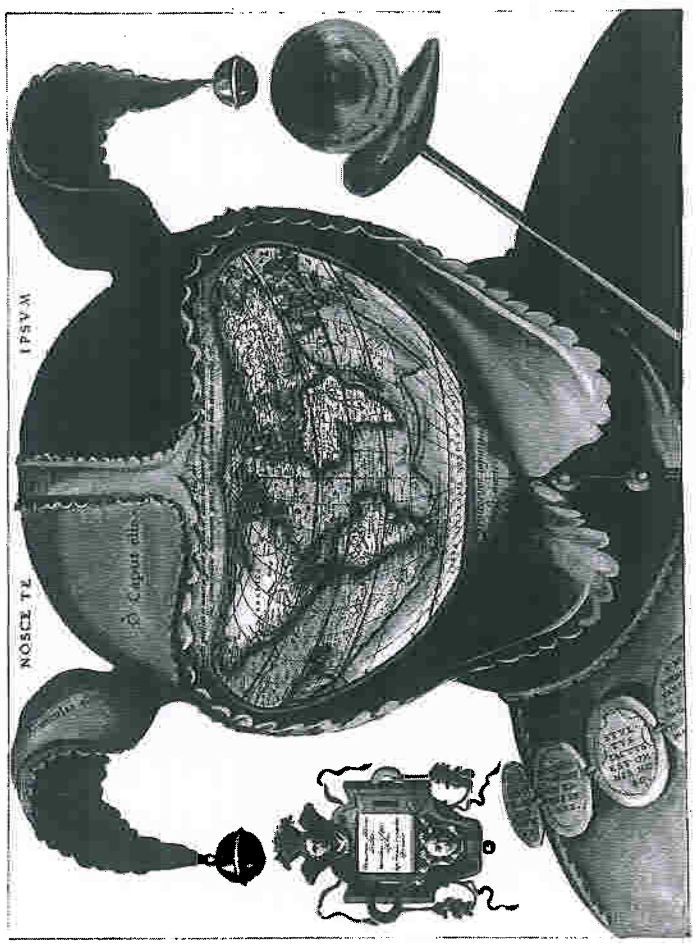

Figure 14 'Fool's Cap' Map, anon c. 1590. The main title translates as 'Know thyself', the subtitle as 'Tis folly to be wise'. The cartouche suggests it was drawn by Epicthonius Cosmopolites, translated as 'Everyman indigenous to himself'. By permission of the Bodleian Library, University of Oxford, Douce Portfolio 142 no 92.

given the Ortelius map projection. It is referred to in Burton's *Anatomy of Melancholy* where it is suggested that the author is Epicthonius Cosmopolites. The left-hand cartouche claims Democritus laughed at it, Heraclitus wept over it and Epicthonius Cosmopolites portrayed it. Rodney Shirley, having failed to identify any personage of that name, translates it as 'everyman indigenous in this world of ours'.[1] The title is roughly translatable as ''tis folly to be wise'. There are several variants of this image but they all bear the Delphic injunction 'know thyself'. One way of reading the image would suggest that all seemingly universal truths, all apparently trustworthy knowledge or authoritative maps, are partial and untrustworthy in that they conceal a hidden social ordering. This may be seen in the analogous role of the jester who confirms the king's power through mocking him. The jester's costume is of course the origin of the term motley. Just as the jester's motley is an assemblage of heterogeneous components, so, too, is our mapping of the world. The moral is that we need to remind ourselves of the role of the jester or the trickster in order to avoid taking our knowledge for truth—thus becoming victims of our own folly.

But the jester is also the trickster, a mythological figure in a vast range of cultures: the monkey god in India; the spider in Africa; the coyote in America; Loki in Scandinavia are some examples. The trickster is the spirit of disorder, the enemy of boundaries. The function of the trickster myth, according to Kerényi 'is to add disorder to order and so make a whole, to render possible within the fixed bounds of what is permitted, an experience of what is not permitted.'[2] A classic example of the kind of ordering through the establishment of boundaries is the 'great divide' between 'us and them', 'then and now',[3] the 'we' who use and make maps, and the 'they' who don't, the 'then', when maps were relatively uncommon and the 'now', when they are taken for granted. The trickster warns us to be wary of such boundaries and divides. The trickster is also a performer and should remind us that history telling is also a performance; we in the academic West make too much of representation and neglect the performative side of knowledge making and knowing the world. We who purport to be historians, sociologists, or cultural critics, are also tricksters.[4]

Maps as the 'Hard Case'

Maps are indeed important representational devices that have changed modes of thought. Internally, through the spatial arrangement of information, maps allow for enhanced connectivity. Externally maps allow for the assemblage of information at centres of calculation.[5] However, maps are the important 'hard case' since they appear to provide a counter to the claim that knowledge spaces are the result of contingent assemblage. Maps are often taken as emblematic of scientific knowledge; just as, scientific theories are often taken as inherently maplike.

In attempting to explore what maps are and why they appear to be so fundamental to our thinking, we need to go back to what has sometimes been called the cartographic revolution—the complex socio-historical processes beginning around 1600 whereby the state, science and cartography became so strongly intermeshed that in effect they coproduced one another. Modern cartography is the product of joint processes of cognitive and social ordering resulting in the establishment of the knowledge space within which scientific knowledge is assembled and the state is organised, as is now taken for granted in Western culture. It is from an examination of that 'taken-for-grantedness' that I want to work my way backwards.[6]

I argue that there has not been an 'epistemological break' or 'cartographic revolution'. Instead there has been a rather heterogeneous, locally contingent process in which maps have become integrated with science and the state. In that process the space that we have taken for granted has been produced. Space is a contingent assemblage, though we find this hard to see because we live in a knowledge space in which maps are a mimetic reflection of external objective space. But just as there is more than one way to navigate, there are many ways of mapping; different cultures, different periods and different groups within a given culture have produced differing knowledge spaces or ways of assembling knowledge which have simultaneously shaped those cultures, eras and people.

The Pacific is where the single best example of radically different ways of assembling knowledge and space can be found; in the next chapter I shall look at the navigation system of Pacific Islanders. But it was in Portugal and Spain that the first attempt to assemble cartographic knowledge scientifically took place. Explaining why this first effort was ultimately a failure leads me to look at the French national survey and the social labour involved in producing the knowledge space we now inhabit. But first I want to examine our modern map consciousness.

Maps and the Modern Mind

We are largely unconscious of the centrality of maps in contemporary Western life precisely because they are so ubiquitous, so profoundly

constitutive of our thinking and our culture. We are bombarded by maps in our newspapers, on our televisions, in our books, and in our getting around in the modern world. The cartographic trope is all pervasive. We talk of cognitive maps, mental maps, genetic maps, or of mapping the mind and mapping the human genome. Minds, languages, cultures, laws and social environments are described as maps.[7] Postmodernists constantly resort to the cartographic figure in their explorations of the contemporary landscape.[8] A salient example is a recent newspaper article that portrays the scientific description of the grammatical structure of English as a process of mapping comparable with the mapping of the world's flora and fauna into phyla and species.[9] Ludwig Wittgenstein indirectly invoked the cartographic metaphor to characterise the whole philosophical enterprise when he said 'A philosophical problem has the form "I don't know my way about."'[10]

The cultural theorist Stephen Hall claims that if there is one thing that best represents the ways in which we as human beings perceive, represent, measure, know and understand reality, it is the map.[11] This cogent suggestion is but one which, in its universalising assertion, focuses on much of what I want to investigate. The mode of perceiving, representing, measuring, knowing and understanding reality that best represents contemporary Western technoscience is indeed the map. Our 'form of life' is so intensely cartographic that it is tempting to accept Denis Wood's description of modern Western society as 'map immersed'.[12] However, whilst scientific maps predominate they have not yet provided one universal form of knowledge space.

The past twenty years have seen a vast increase in the range of spatially portrayed domains.[13] Scientists are currently mapping everything from the cosmos to the atom, from the brain to society, from physical objects to the laws of physics. At the same time there are moves to expand our linear, individual and causal explanations to include spatial, relational and systemic explanations. This transition to spatial explanation has occurred not only in the physical and biological sciences, as Hall's *Mapping the Next Millennium* so amply illustrates, but is also underway in the social sciences:

> Understanding how history is made has been the primary source of emancipatory insight and practical political consciousness, the great variable container for a critical interpretation of social life and practice. Today, however, it may be space more than time that hides consequences from us, the 'making of geography' more than the 'making of history' that provides the most revealing tactical and theoretical world.[14]

So comprehensive is this spatialisation of knowledge that it is now possible to dream of the ultimate archive in which all knowledge can be brought together as a 'fuzzy cognitive map'.[15]

Maps as Scientific Theories

However, just as we have come to expect in this ever more reflexive world, there is also a concomitant transformation in progress reshaping both what it is we take maps to be and what we take science to be. One of the most important themes that has emerged in the revised understanding of cartography and science was proposed by Brian Harley, whose extensive but unfortunately curtailed writings have displayed the ways in which maps are texts that can be deconstructed to reveal their concealed power.[16] Denis Wood in his iconoclastic and penetrating book *The Power of Maps* has gone even further to argue that maps are 'weapons in the fight for social domination.'[17] Similar themes are of course prevalent in the sociology of scientific knowledge. Joseph Rouse argues that 'the experimental and theoretical practices of science are themselves forms of power'.[18] Likewise Bruno Latour holds that science's power and domination is to be explained through the examination of the practice of scientists and technologists in constructing and elaborating social networks.[19]

An essential step in this exploration is to reconsider the ways in which maps are equated with scientific knowledge. Scientific theories and their 'maplikeness' have been commented on by such philosophers as Michael Polanyi, in whose view 'all theory may be regarded as a kind of map extended over space and time',[20] and Thomas Kuhn, who extended the point:

> ... as a vehicle for scientific theory, the paradigm functions by telling the scientist about the entities that nature does and does not contain and the ways in which those entities behave. That information provides a map whose details are elucidated by mature scientific research. And since nature is too complex and varied to be explored at random, that map is as essential as observation and experiment to science's continued development. Through the theories they embody, paradigms prove to be constitutive of the research activity. They are also, however, constitutive of science in other respects ... paradigms provide scientists not only with a map but also with some of the directions essential for map making. In learning a paradigm the scientist acquires theory, methods, and standards together usually in an inextricable mixture.[21]

But it is between cartography and science conceived as total systems of knowledge that there is an especially powerful symbiotic and symbolic synergy. Not only is the commonest image of scientific knowledge or theories that of the map, but the strongest theme running through the history of cartography is that of maps becoming increasingly scientific and ever more accurate mirrors of nature. The development of 'scientific maps' has come to be identical with a progressive, cumulative, objective and accurate representation of geographic reality, synonymous with the growth of science itself.[22] Hence, the map/science relationship is not simply metaphoric. Through the process of knowledge assemblage we have created a naturalised space amenable to being mapped; we now equate scientific knowledge with maps. (see Fig. 15).

An instance of the ways in which the processes of science and mapping are jointly embedded is the concept of 'discovery' and 'exploration'. Territorial discovery and scientific discovery are both conflated with, and mediated by, maps and have often been used to create the classic example of the great divide between the oral and literate cultures. A recent example of this genre is David Olson's *The World on Paper.* He quotes approvingly Walter Ong:

> Only after print and the extensive experience with maps that print implemented would human beings, when they thought about the cosmos or universe or 'world', think primarily of something laid out before their eyes, as in a modern printed atlas, a vast surface or assemblage of surfaces ready to be 'explored'. The ancient oral world knew few 'explorers', though it did know many itinerants, travellers, voyagers, adventures and pilgrims.[23]

Thus Olson builds his great divide between the scientific explorers with maps and the indigenous voyagers without. 'The Inuit map serves only as a mnemonic for the already known; the world map of Columbus or Cook served as a theoretical model for thinking about the unknown.'[24] Olson agrees with Skelton on the other divide that 'Cook's may without exaggeration be called the first scientific voyages of discovery. They mark an epoch no less in the mapping of the world than in its exploration.'[25] His conclusion is that:

> The paper world, therefore, did not simply provide a means for accumulating and storing what everyone knew. Rather it was a matter of inventing the conceptual means for coordinating the bits of geographical, biological, mechanical and other forms of knowledge acquired from many sources into an adequate and common frame of reference. This common frame of reference became the theoretical model into which local knowledge was inserted

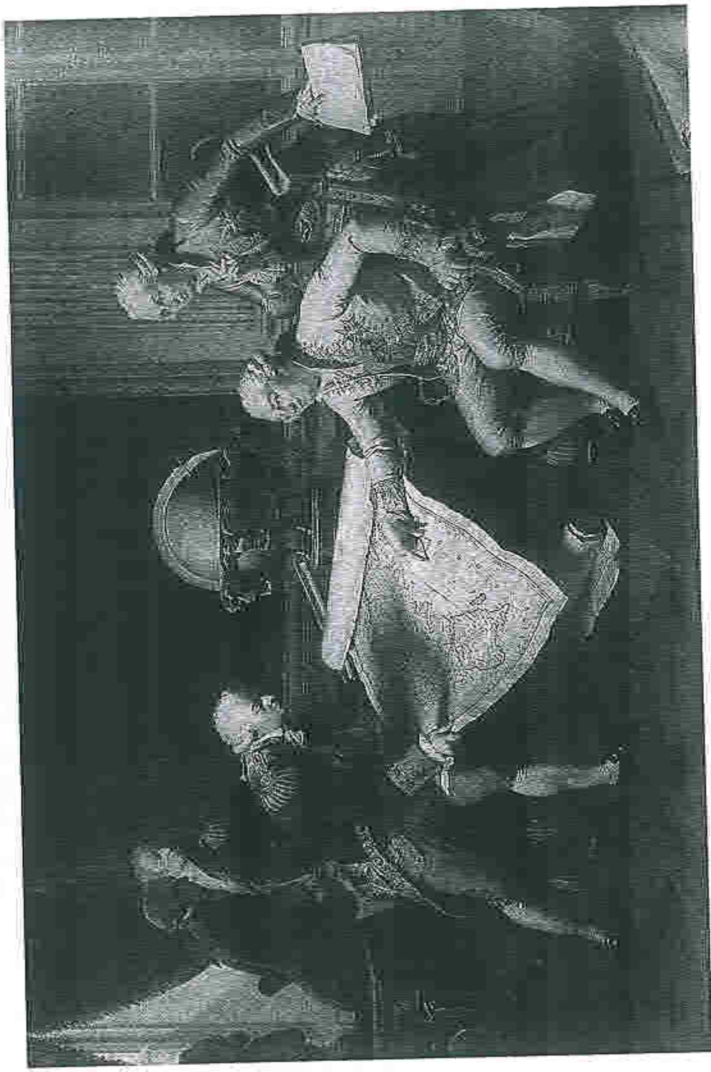

Figure 15 Louis XVI giving instructions to La Perouse. By permission of the Musée National du Château de Versailles.

and reorganised. This is the sense I believe in which Western science of that period acquired the distinctive property of being theoretical science.[26]

Captain Cook and the supposed difference between accidental and deliberate voyages is a key issue in the consideration of Pacific Islander navigation in the next chapter, but for the moment I want to focus on the relationship between cartography and science.

The Suppressed Question

Thirty years ago, Marshall McLuhan made a claim while simultaneously throwing out a challenge:

> Maps are a prime vehicle for repositioning, reframing, rethinking science because theories are maps, maps are science instantiated, without maps science would not have been possible.
>
> The art of making pictorial statements in a precise and repeatable form is one that we have long taken for granted in the west. But it is usually forgotten that without prints and blueprints, without maps and geometry, the world of modern science would hardly exist.[27]

In order to meet McLuhan's challenge and rethink the self-evident rationality of science and the map/science relationship, we jesters need to ask, 'what is it that we are disposed not to question about maps'? We must be especially careful to bear this question in mind when such cartographic theorists as Robinson and Petchenik ask 'what can there be about the map which is so profoundly fundamental? Why should a representational system for space be so basic?' For their answer to their own question is, 'the problem in analysing maps as communication is that the universal metaphor turns out to be the *map* itself' because 'maps are surrogates of space'.

> As we experience space, and construct representations of it, we know that it will be continuous. Everything is somewhere, and no matter what other characteristics objects do not share, they *always* share relative location, that is spatiality; hence the desirability of equating knowledge with space, an intellectual space. This assures an organisation and a basis for predictability, which are shared by absolutely everyone. This proposition appears to be so fundamental that apparently it is simply adopted a priori.[28]

The geographers Chorley and Haggett claim a common link in language to argue that 'it is characteristic that maps should be likened to language and scientific theories.'[29] Malcom Lewis, an historical geographer, has similarly argued for an evolutionary relationship between language and spatial consciousness.[30] Denis Wood finds a Piagetian development in mapping paralleling the cognitive development of children.[31] Michel de Certeau locates the centrality of space in human consciousness in the more pedestrian but no less vital role of walking in our everyday lives.[32] Much of the essence of these sorts of claims is summed up in the view of the anthropologist Robert Rundstrom in his work on Inuit maps, that 'mapping is fundamental to the process of lending order to the world'.[33] Wood agrees that mapping, in the sense of deploying mental maps, is a common human trait but argues that it is not the same as mapmaking, which for him is largely restricted to societies with a high degree of social complexity.[34]

A claim for the most fundamental role of maps in our understanding comes from recent work in neurophysiology, which suggests that the role of the human neocortex is to create and store memories as maps.[35] The ethologist Talbot Waterman even goes as far as to argue that many animals, birds and insects have a 'map sense'.[36]

Such claims, while seemingly attractive, are more likely to reflect the pervasiveness of the map metaphor in our scientific culture and in questions we are not, therefore, disposed to ask, than the existence of maps in animal or human brains. Whatever the aetiology of the spatial in our knowledge, these researchers all assume the metaphysically self-evident spatiality of knowledge. This assumption seems to capture the essence of why it seems so natural to think of knowledge in terms of maps. Robinson and Petchenik's position suggests an argument that might be sketched out along the following lines: maps are surrogates of space; knowledge is in some sense spatial in virtue of its being structured; organised knowledge or theories are therefore like maps. Likewise Lewis' claims for a link between spatiality and linguistic structure are extremely suggestive. However, both arguments fail to pose the question of how we came to accept our modes of spatiality because they cede too much to another seemingly plausible self-evident intuition; that the underlying reality is the topographical relation of objects, that they '*always* share relative location'. It is this taken-for-granted understanding of objects, their relations, and our ability to represent those relations that in part constitutes the forms of life underlying Western contemporary thought and science. Indeed our representations of spatial relations are coproduced with our understanding of what spatial relations consist in. Given this dialectic how do we break into the apparent circle?

Maps as Lies

In order to render visible, vocalisable and questionable that which is otherwise transparent, silent and unquestioned in regard to spatial representation, it is necessary, as Shapin and Schaffer suggest, to bring into focus the hidden labour, social organisation and discursive formations that make the mode of knowledge production map-like. One way to do that is to focus on the contradictions inherent in maps as representations. Maps suffer acutely from such contradictions in so far as they claim accuracy, scientificity and authority. Of necessity, they cannot avoid the use of some mode of representation which is not itself also a representation, that is to say maps are inherently conventional in that they employ arbitrary symbol and classification systems. Equally, they cannot achieve a full one to one correspondence with what they represent, that is to say they are necessarily selective. Whatever pragmatic resolution of these problems is adopted it is bound to be incompatible with total truth preservation and consequently, as Monmonier has pointed out, all maps are lies.[37] For analogous reasons, as we saw in Chapter 1, Nancy Cartwright argues that the laws of physics are also lies.[38] The problem is that explanation and truth, the joint aims of scientific inquiry, cannot be simultaneously satisfied.[39] This trade-off between explanation and truth can be seen as a dynamic tension and the source of change,[40] but more typically the potential for incoherence that it generates is handled by suppression of the conditions under which a given representation, explanation or truth claim is produced.

At one level the selectivity and conventionality of maps are non-problematic: we all accept that we cannot represent everything at once and that some mode of representation is necessary. But at another level we are seldom aware of the ways in which our views of the world are ordered by suppressed social constructs. We are blind to the processes by which the social is naturalised. Maps have boundaries, frames, spaces, centres and silences which structure what is and is not possible to speak of.[41] Maps are the product of such transparent processes as 'compilation, generalisation, classification, formation into hierarchies, and standardisation of geographical data.'[42] We are in danger of being 'prisoners in [their] social matrix. For cartography as much as for other forms of knowledge, "all social action flows through boundaries determined by classification schemes."'[43] Escape from the prison of such seemingly natural boundaries is problematic since they are taken for granted. But as soon as the social construction of such boundaries is made apparent, what were once bars become potential sites of resistance.

The generally suppressive effects and silences of cartographic representations have been brought out by Jose Rabasa, for whom 'the effect of universality or totality is only achieved through blindness to the subjective reconstitution of the fragments. The map is a palimpsest subject to ironic reconstitution through bricolage.'[44] Similarly Michel de Certeau critiques the map as a 'totalising device' and argues that the application of mathematical principles produces 'a formal ensemble of abstract places' and 'collates on the same plane heterogeneous places, some received from tradition and others produced by observation.' The map is, in effect, an homogenisation and reification of the rich diversity of spatial itineraries and spatial stories. It 'eliminates little by little' all traces of the 'practices that produced it.'[45]

De Certeau's characterisation of the map as a homogenised assemblage that eliminates the local practices that produce it is extremely apposite. But why is it held that a scientific representation of the world needs to be abstract and geometric? According to the French historian of cartography Christian Jacob:

> Maps allow the assemblage of a multitude of heterogeneous inputs in order to subject them to the same mathematical logic and to erase their differences through the coherence of the visual codes. They delocalise knowledge, and thus render it accessible, in a condensed and synoptic form, to future generations of unknown researchers, who can reproduce it according to the same design.[46]

Thus, it is claimed that in the pursuit of the aims of accuracy and objectivity all locations need to be rendered equivalent and connectable in a mathematiseable framework; subjectivity and error can be eliminated and all new information about the world can be accumulated systematically.

Put this way the self-evident necessity of abstract geometrisation seems quite compelling and there appears to be a natural coincidence of internal logics between science and cartography. However, there are three broad kinds of considerations that militate against that compulsion. Firstly, there are alternative ways of creating geographic assemblages. Secondly, such modes of representation cannot be achieved purely scientifically, for large amounts of social work are involved in creating the connections between the heterogeneous elements. Without such work those elements have no natural relationship; self-assembly

cannot be achieved by logic or structural necessity. Finally, the connections that maps establish with the social life in which they are embedded are also not natural or self-evident and have power effects that pervade the whole society. Indeed, it is through the social work of creating the assemblages that science and society co-produce each other.

Was There a Cartographic Revolution?

These three considerations can be approached by addressing the question: what brought about the cartographic transformation in sixteenth-century Europe? How were local knowledge, people and practices assembled to produce the 'universal' and objective knowledge that we now equate with science and cartography? This is the second focus of this chapter, to try to disassemble the apparent naturalness of the 'science is a map' metaphor.

It has been noted by many historians of cartography that there was a marked increase in map production and use in the last half of the sixteenth century. Buisseret, for example, claims that around the year 1600 maps suddenly start to be 'essential to a wide a variety of professions'.[47] Skelton and Harvey see a sudden dramatic increase in maps after 1550 and argue that 'the maplessness of the Middle Ages is hard for us to grasp',[48] hence the temptation to label this apparent transformation of epistemological break as a 'cartographic revolution' and to see in it the origins of modern map consciousness. Such a Kuhnian inclination is, I think, to be resisted.

Though map usage increased rapidly at this time, the use of maps was by no means uniform or ubiquitous.[49] (see Fig. 16) The adoption of mapping as a mode of knowledge assemblage was a local and contingent matter and was not uniform in, for example, estate management and land transfer, where one might have expected its universal adoption. Alain Pottage points out that in the case of English estates:

> ... what mattered were the economic qualities of the estate, and not its geometric extent ... the technology of cartography was not rapidly or wholeheartedly embraced by the agencies of land transfer, so that the traditional scheme of narrative description survived the extension of 'linear' space for longer than it might otherwise have done.
>
> [It was] in the course of the nineteenth century, [that] maps, and in particular the model of what was described as a 'cadastral' map did come to be

Figure 16 Late fifteenth-century local estate map, Inclesmoor, Yorkshire.

> seen as somehow 'obvious' or indispensable ... A cartographic description was seen as the perfect measure of the identity of land. To some, it seemed that the certainty of property could be assumed only by delineating 'land' on a proper surface of description.[50]

Certainty that could only be achieved by reference to a common standard provided by the technology of the Ordnance Survey. Previously, property had been irredeemably uncertain but nonetheless unproblematic, a contractual construct embedded in literary and oral practices for assembling local knowledge, social expectations, trust and memory. What property was and how it was known was the product of a different knowledge space from the one with which we are now familiar.

The question of property maps is also particularly interesting because Peter Barber locates the first use of sketch plans in legal disputes in England at about 1400, when they were used to 'illustrate and when possible to clarify, disputes over rights, ownership and jurisdiction'.[51] This indicates how very variable the use of maps can be, even within a fairly restricted domain such as land ownership, reflecting the different contexts for establishing conditions of trust and knowledge assemblage.

By contrast, as we saw in the last chapter, the use of architectural drawings in the building of cathedrals seems to have developed around the mid-thirteenth century at the zenith of the Gothic cathedral construction era, and sketch plans were almost certainly used from at least the twelfth century. While the building of such complex and innovative structures was thus possible without detailed plans, the very process of construction created a knowledge space within which the role of the mason evolved into that of the architect and plans began to be used as control documents. In the context of naval shipbuilding and the massive Dover harbour project the use of accurate plats or plans was only taken up in the late sixteenth century. Shipbuilding and fortification, like the Gothic cathedrals, had a long history of large-scale, complex projects without the use of detailed drawings. The reason for their introduction seems to have lain in the facility of maps for bringing together otherwise disparate techniques, interests and needs for control by the state.[52]

The integration of cartography with the affairs of state gained some of its impetus from the political revolutions of the 1530s. According to Peter Barber, 'maps were to become one means by which Cromwell's (and later, Burghley's) objective of enhancing royal authority could be achieved, and it was thus that they made their most profound contribution to Tudor government.'[53] The military building program that brought about the modernisation and expansion of England's defences under Henry VIII was 'once and for all, to establish maps and plans as one of the English government's everyday tools in the formulation of policy and in the process of administration'.[54] However, this revolution was based, in Barber's view, on the 'humble and frequently inelegant manuscript plats'.[55] Though scales had started appearing on these plats by 1547,

> The sort of precision to be found in scale maps was often not required by decision makers who could make do perfectly adequately on most occasions with rough and ready picture or position maps lacking scale or standardised conventional signs. These continued to be produced and used for decades and centuries to come.[56]

Hence it may be that the kind of calculative rationality we associate, thanks to Weber, with the modern state is a matter of degree of complexity. Wood, for example, argues that mapmaking

> ... characterises a degree of organisation in society which is not just a function of size but of differentiation and hierarchical integration ... the need to keep written records occurs when control of the social process in rapidly expanding groups is at stake ... The state in its pre-modern and modern forms evolves together *with* the map as an instrument of polity to assess taxes, wage war, facilitate communications, and exploit strategic resources.[57]

He concludes that map use did not come about through the renaissance discovery of Ptolemy, the scientific revolution, painterly realism, rationalised land management, or the emerging nation state. Projections, realism, and quantification were secondary: mapmaking 'emerges as a rationalising tool of state control during periods of relative prosperity in capitalist state economies' around the world.[58]

Wood's arguments, though cogent, are incomplete because they overlook the problem of assemblage. While maps did start to become important tools in government policy making during the Tudor period, the modern state and the scientific map did not emerge until appropriate modes of assemblage were created. In Tudor times maps, surveys, plans and plats were accumulated by individuals like Lord Burghley, Elizabeth I's secretary of state between 1550–1553 and 1558–1570.[59] Whenever he wanted to assemble his maps he took whatever was to hand, of whatever scale or dimension and simply had

them bound together; a classically messy motley. The first glimmerings of a need for a more formalised mode of assemblage was recognised with the establishment of the State Paper Office in 1610, but it had a turbulent beginning, with powerful individuals using it as an opportunity to pillage maps for their own private collections.[60] So, an increase in map making alone does not indicate a change in consciousness or a revolution. Many other things had to be set in place before maps were fully integrated with state and scientific knowledge making.

The First Attempt at Map Assemblage

An ideal site for a close examination of such processes is the very first attempt to assemble cartographic knowledge systematically in the interest of the state, which occurred in Spain and Portugal early in the sixteenth century when they established the Casa de la Contratación and the Casa de Mina. These Boards of Trade housed the first scientific institutions—hydrographic offices that held the Padron Real, a master template map, on which all the knowledge of the New World was to be assembled. This attempted assemblage was ultimately a failure. There is a complex of reasons for this, but a contributing factor was that the Padron Real and all the maps utilised by ship's captains were portolan charts. (see Figs 17 and 18). The most obvious feature of portolan charts is the network of rhumb lines which give them the deceptive appearance of having a fixed, mathematically determined grid. In fact the rhumbs are actually lines joining the named points of direction generated by drawing one or two large circles so placed as to cover most of the chart, each circle being subdivided into sixteen or thirty-two equidistant points. The ad hoc way in which these assemblages of geographical information were achieved is emphasised by the fact that the rhumb lines on different charts do not coincide, each chart having its own starting point.

The means of locating a port or coastal feature on portolan charts was not by reference to a mathematical grid but to distance and direction. Originally conceived in terms of wind direction and represented as a wind rose, it was later translated into a compass direction through subdivision of the horizon circle into thirty-two colour-coded but not numbered points. In short it was directionality—the attribution of direction to the observational and experiential phenomena in analogue rather than digital form—which allowed for the process of assemblage of the heterogeneous elements of the portolan charts. Portolan charts

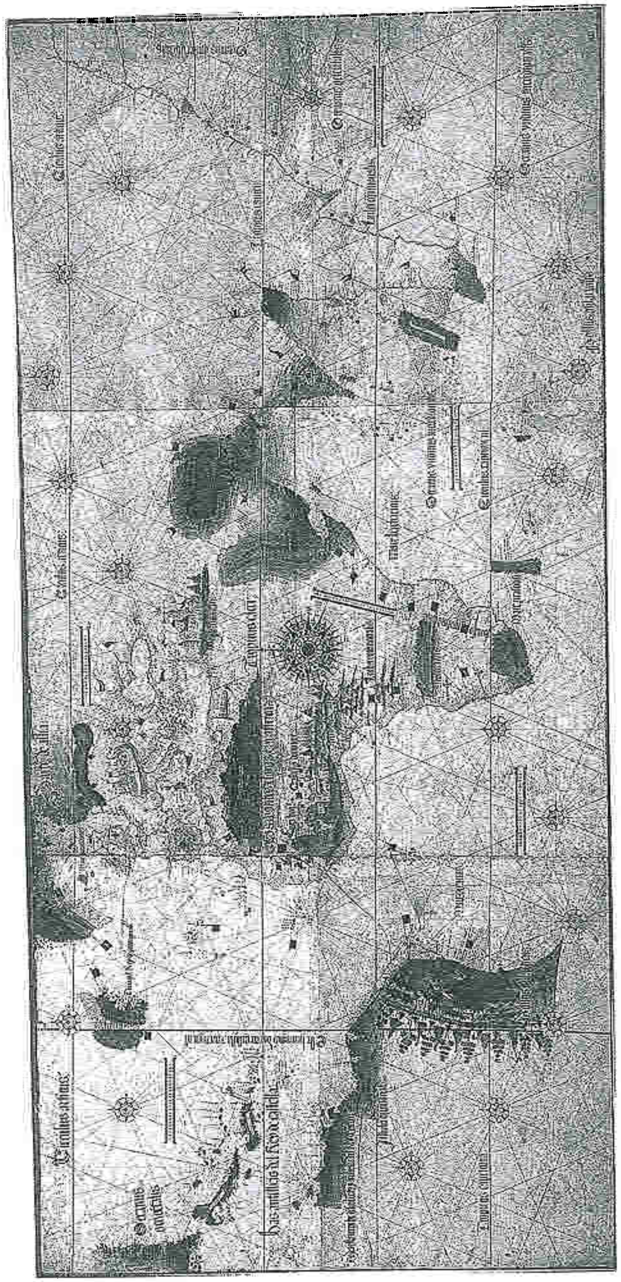

Figure 17 A portolan chart, the Cantino Planisphere, 1502. By permission of the Minestero per i Beni e le Attività Culturali.

were essentially 'catalogue[s] of directions to follow between notable points' and mnemonics for recalling lists of ports.[61] As we shall see in the next chapter, this way of ordering knowledge spatially is common to all early seafaring traditions, and enabled navigators as disparate as the Pacific Islanders and the medieval sailors of the North Sea to have a dynamic cognitive map in their heads. The problem for the state was not just that portolan charts lacked a grid, projection, or a common measure, but that they were rooted in a maritime tradition. That tradition enabled ships' masters to navigate autonomously, using their own experience and charts from a variety of non-official sources. Portolan charts were too local.

To bring all the knowledge of the new world together, the Iberian governments were attempting to construct a 'general system of metrication'[62] and to regularise the old nautical tradition, in a number of ways: by training and licensing the captains; encouraging the development and improvement of instruments including the compass and the astrolabe; commissioning new tables for calculating distances, giving latitudes and the sun's declination; and by establishing new techniques like latitude sailing and new forms of social organisation. In this way they hoped to be able to assemble and standardise all the new information by bringing it under one roof.

The Casa de la Contratación de las Indias was founded by Royal decree in January 1503. On August 8, 1508 a separate geographical or cosmographical department was created, 'perhaps the first Hydrographic Office in history'.[63] Within that office the government ordered that a master chart of the new territory, the Padron Real, be compiled under the supervision of a commission of pilots headed by Amerigo Vespucci, the Pilot Mayor. The Padron Real was a huge wall chart that embraced 'all the lands and isles of the Indies then discovered and belonging to the crown'. All pilots were instructed to trace on their charts 'every land, island, bay, harbour and other thing, new and worthy of being noted' and to report these findings after returning from their voyages.[64]

Disciplining the Master Map

However, the standardisation and accumulation of knowledge could not be achieved by decree or by representations alone. Keeping stable all the components of an assemblage or network—people, instruments, and data—required constant effort and discipline.[65] In order to stop their maps unravelling, the Casa had to establish the boundaries of the

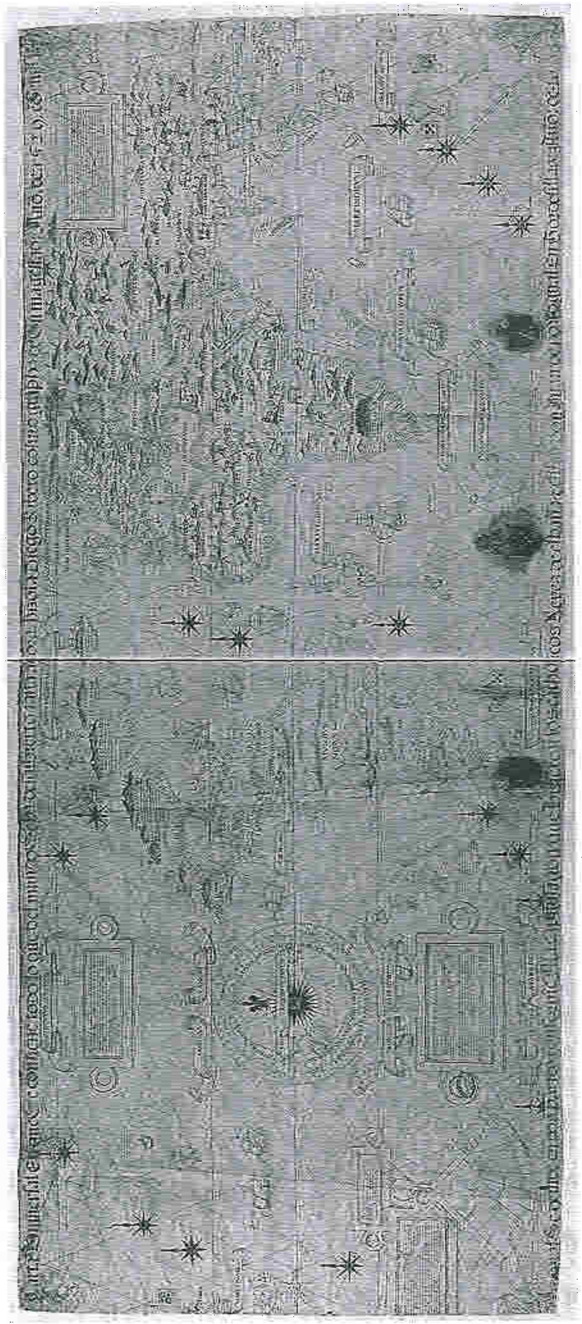

Figure 18 Diogo Ribeiro's Plansiphere 1529. With permission of the Biblioteca Apostolica Vaticana.

knowledge space and to police the inputs and outputs as they moved across the boundaries. What kinds of persons could contribute new knowledge, how that knowledge was to be expressed and evaluated, how it should be stored and reproduced, how disputes over conflicting evidence should be settled, and what were appropriate techniques for adjudicating ownership and control all had to be established. What was to count as knowledge was as much a political and moral problem as it was an epistemological one.

The social, moral and political nature of establishing the process of standardisation and stabilisation is reflected in a series of disputes focused on the Padron General. One such dispute reveals the basic difficulty of establishing 'the facts of the matter' in correcting the Padron General: who was the proper authority, what was the proper technique for determining which piece of information was correct in a case of disagreement? In 1543, the Pilot Mayor Sebastian Cabot and the cosmographer Alonso de Chaves went to court over corrections to the Padron.[66] Chaves complained that the instruments he was provided with were faulty and that the Padron was not kept up to date because pilots did not know how to collect data to give to the cosmographers. Other noted pilots also agreed the Padron was useless.

But what was an appropriate authority on which to resolve disputed claims? The visitor appointed by the Casa to hear the case was a good committee man who believed in consensus and argued that truth would be established by everyone agreeing to sign the Padron. Gutierrez, a chart and instrument maker, revealed that the form of his charts was determined by the demands of his customers. Cabot claimed that he did what was required by law. Others appealed variously to the authority of the crown and God. The visiting Portuguese cartographer Francisco Falero took the modern, but as yet unestablished, empirical position, and called for observation, description and experiment, while also pointing out the inherent flaws of the portolan charts' projectionless plane chart mode of representation.

In 1563 the Casa was still concerned about errors in the Padron and, in one of the earliest examples of sociological investigation, the pilots were given a questionnaire asking their opinion on how to correct it. The majority of respondents agreed that the charts were in error, but perhaps reflecting their adherence to the tradition of the portolan charts, they thought that the best solution was not to change it, but to let individual pilots carry on using whatever techniques they found best. Those who liked compasses should carry several, those who liked astrolabes could try bigger ones.[67]

The cosmographer Alonso Santa Cruz, who was initially employed along with Sebastian Cabot in the 1530s to try to resolve the difficulties the Casa had with the Padron, pursued similar sociological techniques, developing the plan to map the New World territories by questionnaire. The project, incomplete at his death, was taken over by Juan Lopez de Velasco, who proposed a solution to the key problem in assembling knowledge in space and time—longitude. No one at this point was able to establish with any accuracy where the New World was with respect to the old. In 1577 Lopez sent out instructions to local officials to observe the lunar eclipses of September 26, 1577 and September 15, 1578, from which he hoped to be able to work out the longitudes of each place. In addition to the eclipse measurements Lopez attempted to assemble more detailed territorial knowledge of the New World by sending out a questionnaire.[68] This questionnaire asked a large number of very detailed questions, including a request to each official to draw a map of his town and its adjacent area. Barbara Mundy has analysed the sixty-nine maps that were painted by Mayan officials and sent to Spain in response to this request.[69] The maps were left to the local artists, who used the opportunity to advance their own interests, blending their traditional modes of representation with those demanded by the Spanish:

> Far from providing the simple boundaries expected of them, they took the initiative of offering a territorial synthesis of their jurisdiction that conformed to local tradition by packing their maps with pre-Hispanic features.[70]

The resulting hybrid maps made Lopez' project impossible. The results of the questionnaire were equally incapable of assemblage. Many failed to answer; those that did often misunderstood the question or the instructions on making observations, or gave inaccurate responses. Lopez was unable to establish the conditions of simultaneity and homogeneity required to create his planned knowledge space. However, the maps resulting from the encounter, while not ethno-cartographically pure, do reveal a profound cartographic ability and engagement. The Mayans were able to graphically represent their interests and local knowledge, their sense of history, memory and place. Rather than being passive recipients of Western scientific cartography, they were agents of knowledge, and according to the French historian Serge Gruzinski, their 'maps became the basis of a new legality ... colonial geography was born of the fusion of notions of pre-Hispanic territory and Spanish occupation.'[71]

A Fifth Continent?

Ultimately the knowledge space that the Spanish tried to construct proved too hard to sustain. The navigational tradition of the portolan charts was immune to the state's demands. But just as the difficulties of controlling the inputs were proliferating, so too were the problems of controlling the outputs. There were other centres of calculation; Seville was only briefly a compulsory passage point. In Dieppe, for example, French cartographers under the leadership of the armateur Jean Ango set up a chart production house that had a network of informants sending information from all over the world.[72] (see Fig. 19). However, the Dieppe School also had difficulties with assembly of that information, as is evidenced by the so called 'Java la Grande' problem or the 'Portuguese Discovery of Australia.'

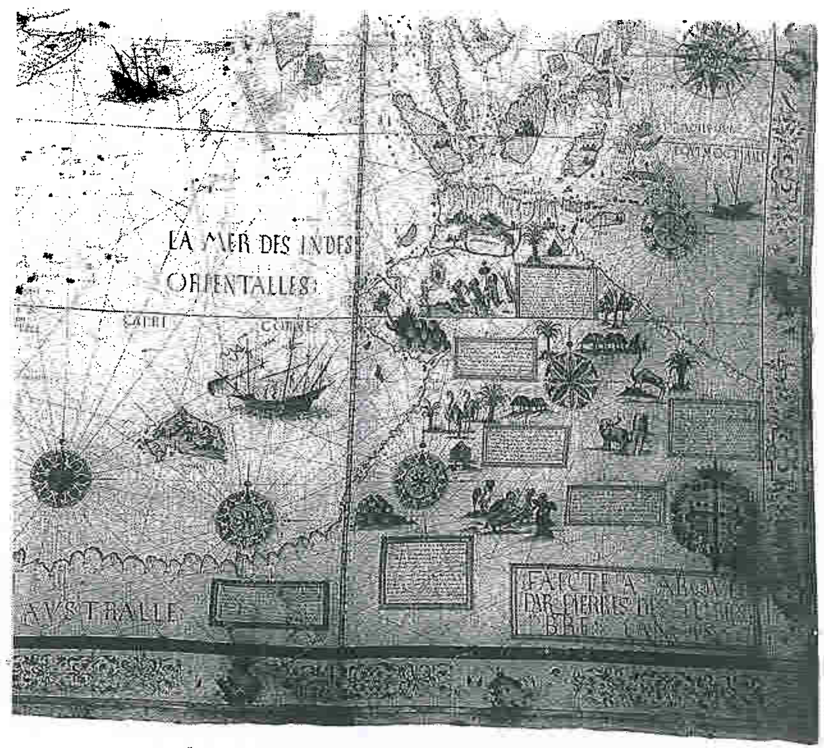

Figure 19 A section of a 'Dieppe' World Map showing Java La Grande. Pierre Descalliers, 1550. By permission of The British Library (Shelfmark: 1000008.011).

From the publication in 1547 of the Dauphin map, the first of the Dieppe series of world maps, charts started to show a fifth continent labelled Java La Grande. This emergent land mass has long intrigued historians of Renaissance cartography who are unable to decide whether it was 'a pseudo Borneo, or a misplaced and duplicated Java'.[73] Whether it might be partly Vietnam,[74] pure imagination or a hoax,[75] the claim that has attracted the most attention and the most criticism is that Java La Grande in fact represents Australia[76] and that the distortions of the outline are the consequence of a misassemblage, by the French cartographers at the Dieppe School, of charts drawn by the original Portuguese discoverers.

Jean Rotz' *Boke of Idrography* (1542) is the earliest surviving work of the Dieppe school, all the source materials—navigators' charts, journals, sailing directions and drawings—having been destroyed in the English bombardment of Dieppe in 1694.[77] Rotz was probably on Jean Parmentier's expedition to Sumatra in 1529–30. According to the historian of cartography, Helen Wallis, it was this Sumatra voyage which provided the opportunity for Rotz to obtain information on Christovao de Mendonca's ill-fated expedition to the south in 1521, from which only one of the three original caravels returned to Sumatra. Rotz took to Dieppe copies of the charts that Mendonca brought back to Malacca showing sections of the Australian coast.

An explanation, advanced by the proponents of the Portuguese discovery of Australia, for the peculiar shape of Australia on these maps is that the Dauphin map of 1536, the Rotz map of 1542, the Vallard Map of 1547 and the Desceliers map of 1550 are compilations from separate charts of what were taken to be sections of the Australian coast from Darwin to Tasmania. The difficulty for Rotz and the other French cartographers was how to assemble them. They had no direct experience of the voyage themselves, they had no grid, and no indication of scale or orientation. Hence, even though the charts had returned to a centre of calculation, something in addition to the inscriptions was needed in order to assemble them. Commenting on a similar misassembly in early Canadian cartography, W. F. Ganong remarked:

> Cartographically myopic as the first explorers often were, even blinder were the cartographers at home, who had to piece together and reconcile, without the slightest means of testing their conclusions, the diverse records and maps that explorers brought back.[78]

Bringing the World Back Home

Many of these difficulties in creating a knowledge space that could embrace the world are held to have been resolved with the advent of Mercator's projection of 1569. This projection provided a grid and the possibility of representing loxodromes, that is courses of a constant bearing, as a straight line. Its absence had previously been a severe drawback, as Pedro Nunes had pointed out, since loxodromes on plane charts as on portolan charts, though drawn as straight lines, were in fact curves. When perspective, geometry, and the grid of latitude and longitude were combined, it was possible to calculate accurately the location of any spot on earth. It was this calculative framework, this space within which to assemble knowledge that, according to some historians of the Renaissance and the scientific revolution, provided the essential precondition for the possibility of modern science.[79] Such a framework had, of course, been initially proposed by Ptolemy in his *Geographia*, which reached Europe by way of the Byzantine Empire in the thirteenth century, though it did not achieve wide circulation until its Latin translation in the fifteenth century. While it had the potential to contain the world and bring it to the desktop, considerable social and technical difficulties had to be resolved before a knowledge space of this kind could be fully established. Moreover, as late as 1753, Tobias Mayer published his state of the art 'Mappa Critica' of Germany, which portrayed the location of 200 places despite the fact that 'only 33 were fixed by astronomical determinations of latitude' and none were apparently well fixed by longitude'.[80] Mayer's map serves to show that cartographers were not completely dependent on fixed, mathematically determined spatial structures to assemble knowledge.

To achieve the integrated assemblage of geographical knowledge that we now take for granted, science, cartography and the state had to be aligned as they became, for the first time, through the process of the triangulated surveys of France and England. By the mid-seventeenth century the problem of the bureaucratic regulation and taxation of the French state had become recognised as one susceptible to cartographic solution, and the problem of assembling cartographical knowledge was treated as being essentially linked to the astronomical and geophysical sciences. The French Academie Royale was set up in 1666 with the explicit purpose of correcting and improving maps and sailing charts, in light of the recognition that the solution of the major problems of geography, chronology and navigation lay in astronomy. In 1667 work was begun on the Royal Observatory at Faubourg St Jacques.

The World on the Third Floor

As head of the leading French observatory, Jean Dominique Cassini was in correspondence with astronomers all over Europe and was deluged with astronomical data. He had to devise a new way to assemble it. Though he did use a map—his famous Planisphere Terrestre—it was a markedly different way of assembling data cartographically from that which we take for granted today. Cassini started by drawing a 24 foot circle on the floor on the third level of the west tower of the new observatory, which had been oriented by compass and quadrant when the foundations were laid. The map employed an azimuthal projection with the north pole at the centre, from which meridians radiated at ten degree intervals, with the prime meridian being drawn from the centre passing through the midpoint between the two south windows of the octagonal tower and with the parallels of latitude forming concentric circles.

This floor map attracted a great deal of attention and was considered a major achievement. James II and Louis XIV both came to see it. Being on the floor, it was subject to a good deal of wear and though it was restored in 1690, by the turn of the century it had become effaced.[81] What is striking is that Cassini's first impulse was like that of the Iberian monarchs, though somewhat more primal: to build a physical space in which to assemble knowledge. He felt that accurate assemblage of information about the world from different observatories could only be stabilised by being locked onto the world, by being given the same geophysical orientation. However, in 1682 Cassini transferred the determination of 40 locations onto a sketch map that was issued as an engraved world map in 1694.[82] (see Fig. 20).

Tying France Together

Arguably, if there is anything resembling a turning point in map consciousness, at least in the scientific community, it is marked by the abandonment of the Planisphere project. From that point on, the rational way to represent the whole world scientifically was on a sheet of paper, which was to be achieved not by bringing different astronomical sites into one central space but by the creation of a new space in which the distributed sites were linked with the invisible bonds of social labour.

But Cassini was not the only one with a problem. Until the late Middle Ages, French territory, as in England, was known in a 'literary

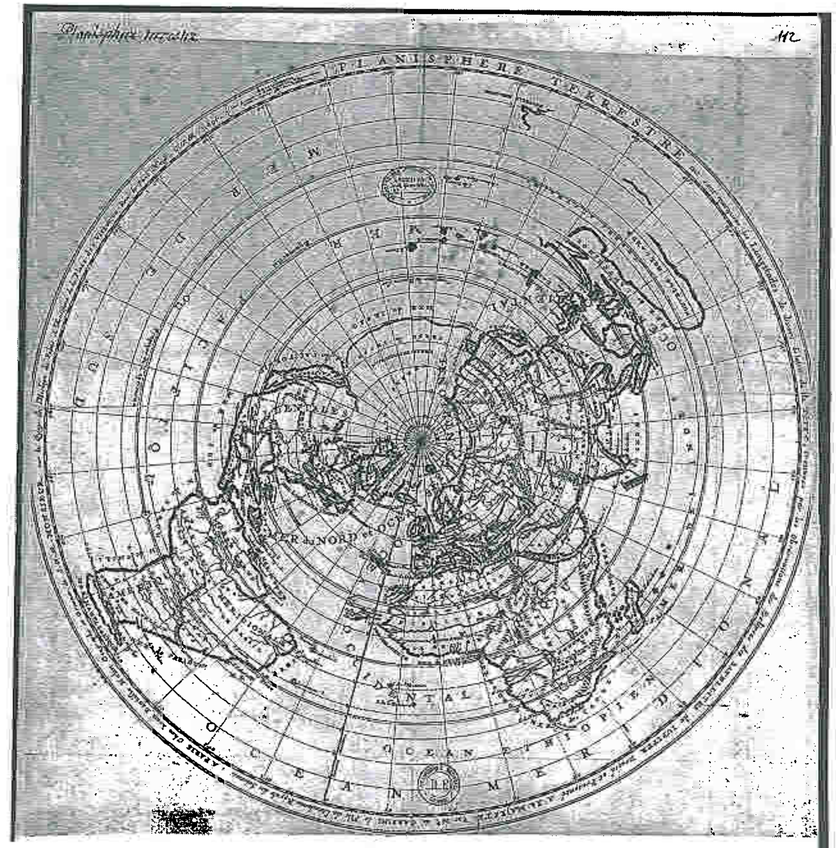

Figure 20 Cassini's Planisphere Terrestre 1696. Reproduced with the permission of Bibliothèque Nationale, Paris.

mode', through itineraries, journeys and lists; which assembled local knowledge in written descriptions.[83] The literary form of spatial knowledge began to prove less adequate to the needs of the state in the mid-seventeenth century, when it became the task of the secretary of home affairs, Jean Baptiste Colbert, to restore the floundering French economy and ensure an ever increasing income to provide for the lavish expenditures of Louis XIV. Colbert set out to develop the nation's resources and build an infrastructure of roads and canals, but he was stymied by the lack of a map of the whole of France which, like everywhere else in Europe at this time, was a country that operated almost entirely on local knowledge. All the systems of

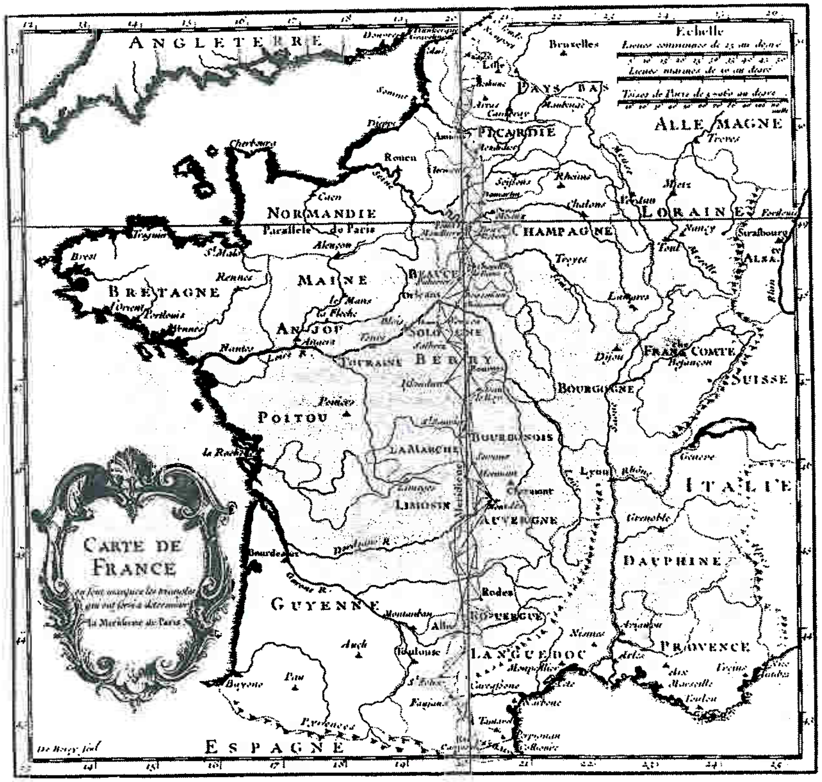

Figure 21 Triangulation of France with the base line running through Paris. Reproduced with the permission of Bibliothèque Nationale, Paris.

weights, measures and taxes were local, there was no centralised uniform system of mensuration, and there was virtually no collective topographical knowledge.[84]

The lack of an accurate, large-scale map of the kingdom prevented Colbert from gaining an overview of the extent and variety of the country's resources. His first attempt was to assemble all the provincial maps and ensure their commensurability through the use of a common scale and criteria of accuracy.[85] To this end he instructed the field commissioners of the provinces to evaluate their maps and send their amended versions to Paris, a discipline that was impossible to impose. That provincial maps already existed was not sufficient in itself to ensure their assemblage at a centre of calculation. To achieve such an assemblage two problems had to be solved: one social and one

technical. The Provincial administrators had to be persuaded to cooperate in a national project which they saw as organising their resources for the benefit of the King. At the same time all those provincial maps, as Colbert had recognised, could not be assembled unless and until they were rendered commensurable. In the face of these political and technical problems of assemblage the response of Cassini, Jean Picard and the Académie was to propose the creation of a network of surveyed triangles that would encircle the whole country and thereby enable the drawing of a unified map of the whole of France on one grid (see Fig. 21).

The network of triangles could provide a solution to the general technical problem of assembling all the separate topographic surveys of the whole of France. A centralised, Académie-based approach would also provide a political solution if the King could be sufficiently diverted from his military ambitions to fund the project. Ultimately the national map could only be achieved by bringing into line not only the King, but also the satellites of Jupiter, pendulum clocks, telescopes, surveying chains, trigonometry, quadrants, new printing techniques, all the provinces of France and the earth itself. In aligning all these places, practices, people and instruments a new space was created, a space that we now take for granted, but one which did not come into existence naturally or even easily, requiring as it did the physical and social labour of tying France together with surveying chains.

The first discussions of the project were held in 1683 and it was proposed that J. D. Cassini survey a line from Dunkerque to Barcelona. (see Fig. 22) This would have the co-dependent purpose of enabling the measurement of the circumference of the earth and providing the base line for all future surveying operations in France. A hitherto independent geodetic problem of the day concerned the sphericity of the earth. Was it a perfect sphere, a prolate spheroid elongated at the poles or an oblate one flattened at the poles and bulging at the equator? Once again the question arose that had bothered the Portuguese and Spanish navigators and cartographers for a century and a half, what is the length of a degree of latitude? Did it vary with distance from the pole and if so did it increase or decrease? Consequently, not only did the shape of Earth have to be aligned, so did French and English science. Newton's theory of gravity indicated an oblateness of the earth while French theory and early measurements seemed to indicate a prolate spheroid. The disagreement created yet more pressure for greater accuracy in measuring the length of a degree. Eventually Louis XV ordered a decisive test: two arcs were to be measured, one near the Equator, in

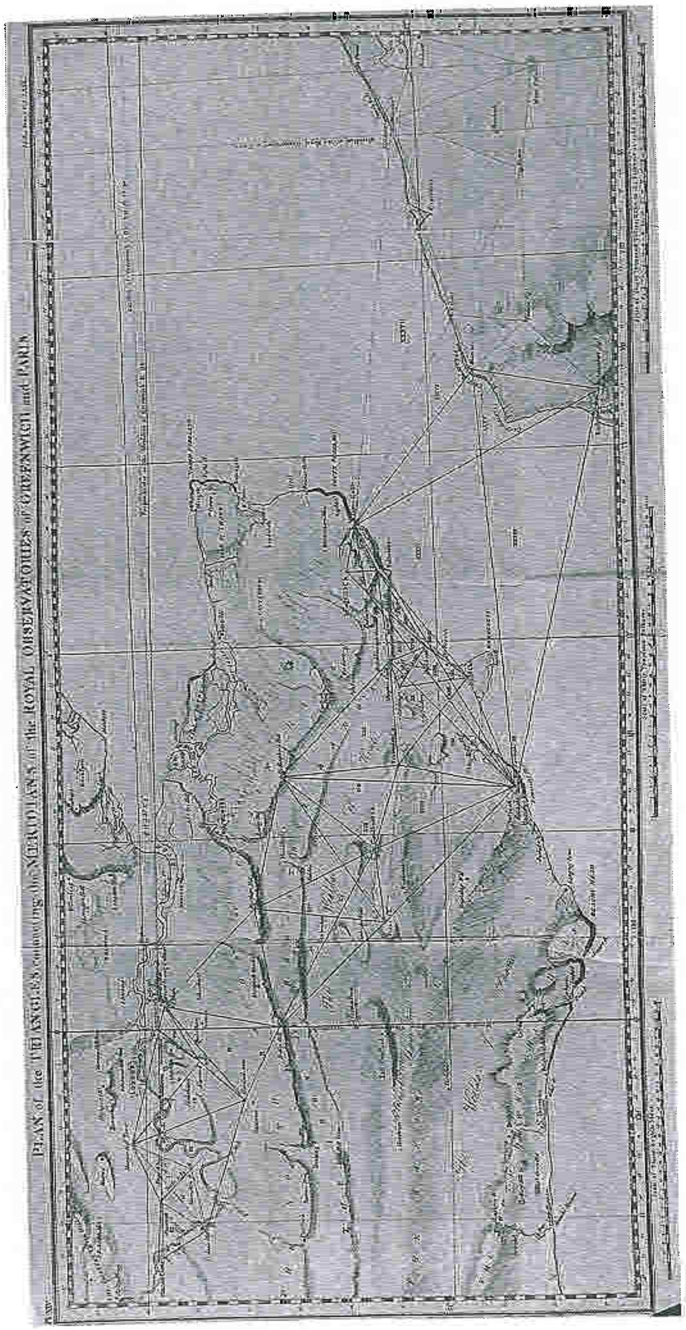

Figure 22 The 'Plan of the Triangles' linking the Meridians of Paris and Greenwich across the Channel. With the permission of the Ordnance Survey.

Peru (1735–1744) and one near the Arctic, in Lapland (1734–37).These 'tests' were the rationale for what were arguably the first purely scientific expeditions and involved vast amounts of work and commitment.[86]

By 1739 'France was enclosed by an uninterrupted chain of 400 triangles surveyed from 18 fundamental bases.'[87] In 1744 the first outline map was produced, but the complete topographic survey resulting in the publication of the *Carte de Cassini* was not finished until 1789.[88] Altogether it took 121 years of arduous labour by vast numbers of people at a cost of 700,000 *livres* to produce the first national map.[89] The *Carte de Cassini* was important historically not just because it was the first thorough topographical survey of a whole country—'it [also] taught the rest of the world what to do and what not to do.'[90] It established the practice, adopted in all national mapping projects ever since, of linking topographic surveys with a chain of great triangles. Just how difficult it is to achieve this enlightenment project of the ultimate survey is nicely revealed in Matthew Edney's account of the survey of India.[91] Edney found that the technological fix offered by triangulation served to intensify the Enlightenment's 'cartographic illusion' of the 'mimetic map'. But totalising archives are impossible in practice. The British could only make their general maps of South Asia by combining multiple surveys based on local knowledge and techniques within a framework of latitude and longitude—a motley assemblage just like the Padron Real.

France and England Bound as One

Similar social processes were also central to what, in 1783, was to be the first international cooperative mapping venture. The initial pressure for this transformation of international space did not come from either military or economic forces, as Wood has argued. Rather it came largely from the demands of a rapidly internationalising science. The technical problem was to measure precisely the difference in latitude and longitude between the Paris and Greenwich observatories.[92] (see Fig. 23) The English and French astronomers disagreed by a matter of 11 seconds of longitude and 15 seconds of latitude which, on the ground, amounts to roughly 500 metres.[93] Such technical questions are not, of course, *sui generis*, but are coproduced with the instruments and practices that make possible both their formulation and their solution. Concomitant with that process is the creation of the kind of homogeneous and unified space in which science's universalised forms of knowledge become

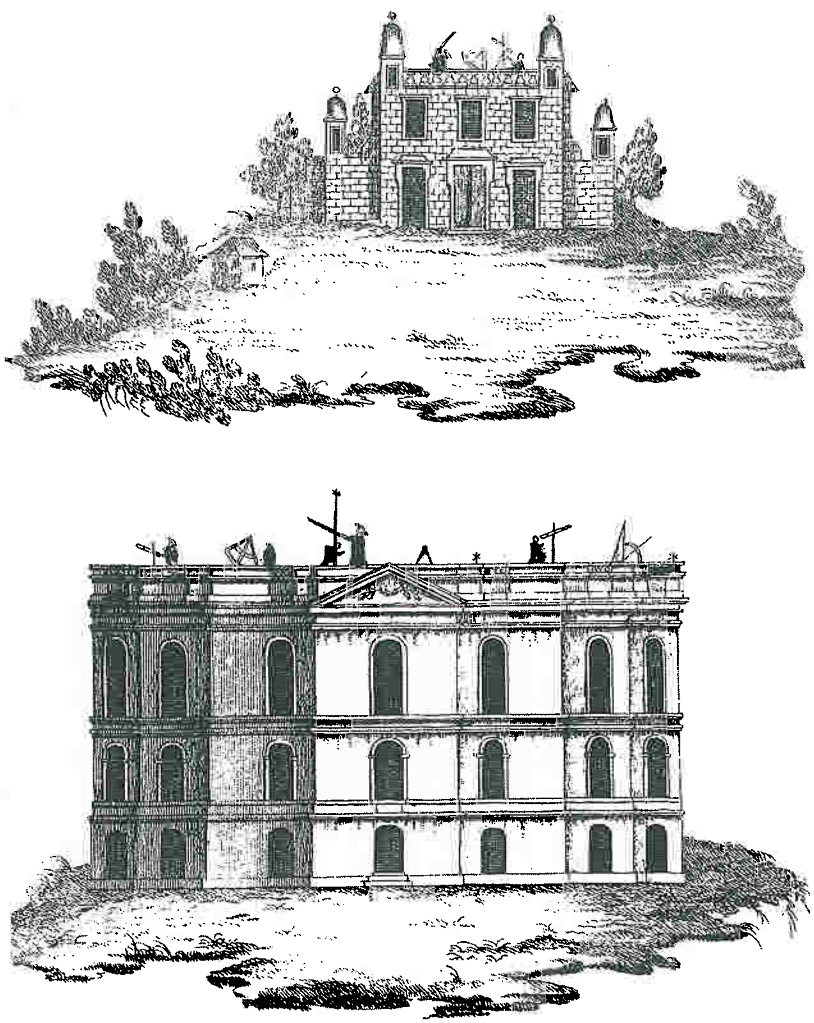

Figure 23 The Greenwich (above) and Paris (below) observatories, sketched in the eighteenth-century.

possible through the linking of local knowledge spaces. In turn, the creation of such a scientific knowledge space generates a different social space.

César François Cassini III suggested that the astronomical problem could be solved by a trigonometric survey from Greenwich to Dover and a triangulated connection to the French National survey, thereby

expanding the isolated spaces of the observatories into one homogeneous space. In 1787 England and France were invisibly but indissolubly linked. The connection between the two national spaces was established by trigonometric triangulation using lights and the new theodolite at night to span the Channel. However the problem of creating equivalences between all the pieces of heterogeneous information was not so easily resolved. It was necessary first of all to convert the French *toise* to the English league. Then, having established an agreed linear distance between the meridians of Paris and Greenwich, there were difficulties converting this value into degrees since, once again, this depended on agreement about the precise length of a degree and the shape of the earth. In addition there were problems in establishing the difference in clock time between the meridians. Only when social means could be found to solve these seemingly technical problems could the astronomers measure the differences between their observatories, thereby creating one unified knowledge space and hence a new international and political space. The establishment of this new international space would set in motion the process whereby the whole of the Earth's territory could be mapped as one, all sites would be rendered equivalent, and all localness would vanish in the homogenisation and geometrisation of space. To this day, the project remains incomplete; even though the international geoid system was accepted in 1980, the conversion of national surveys to this common reference surface still produces local difficulties. In Australia, for example, the Geodetic Datum is based on a local ellipsoid whose centre of mass differs from that of the internationally defined ellipsoid by 200 metres to the north east. All maps are having to be redrawn with details being changed by an average of 1 mm.[94]

Cook Adrift

What this journey through the sixteenth and eighteenth centuries has done is to put back the traces that have been erased and show that in order to achieve the kind of 'universal' and 'accurate' knowledge that constitutes modern science and cartography, local knowledge, personnel, and instrumentation have to be assembled on a national and international scale. This level of organisation is only possible when the state, science and cartography become integrated. The first scientific institutions in Europe, the hydrographic offices in the Casa da Mina and the Casa de la Contratación went a long way towards achieving such a degree of integration. Though ultimately a failure, they were examples of the kinds of organisation that were later developed in the integration of science, cartography and the interests of the state in the triangulation of France and the subsequent linking of the French and English national surveys.

This linking created a transnational knowledge space whose ramified bureaucratic structure, in providing the conditions for the possibility of modern science and cartography, has the appearance of determining all our knowledge. However, such a knowledge space is not and cannot be entirely hegemonic as is shown by the example of Captain Cook, who some have claimed as 'the first scientific explorer'.[95] Cook was sent to Tahiti to observe the transit of Venus which would provide a measure of solar parallax and hence determine the dimensions of the solar system, an astronomical problem directly related to the 'great problem of the day'—the determination of longitude. Cook found Tahiti 'scientifically' by using a map and calculating longitude by the method of 'lunar distances', Tahiti's longitudinal position having been fixed previously by its 'discoverer', Captain Wallis. This canonical tale of scientific discovery and mapping now stands in need of deflation by appropriate application of the jester's bladder.

As we have already seen, the problem of determining longitude was crucially dependent on the resolution of the uncertainties involved in fixing the relative positions of the Greenwich and Paris observatories. So that Cook, despite having calculated his way to the Pacific, was 4 degrees adrift by the time he reached New Zealand, demonstrating that maps and scientific discovery can only be maximally effective when set in a social network. His predecessors, without such advantages, should perhaps be denied the title of explorers or 'deliberate discovers'. But when Cook was in Tahiti he took on board the Polynesian navigator Tupaia who was able draw him a map covering an area of the Pacific as large as the United States and giving the position of 74 islands. (see Fig. 24) Tupaia and his predecessors had systematically explored and colonised the entire Pacific, making two-way deliberate voyages without the use of paper maps. Clearly, though there are significant differences between Polynesian and European modes of knowledge assembly, there is no great cartographical divide. The salient point is that the Polynesian methods were basically performative, not representational. To the extent that we too, do not know the world simply through maps and representations, but through practice and performance, we can resist the dominance of maps and of science. Not only do maps carry within themselves the seeds of their

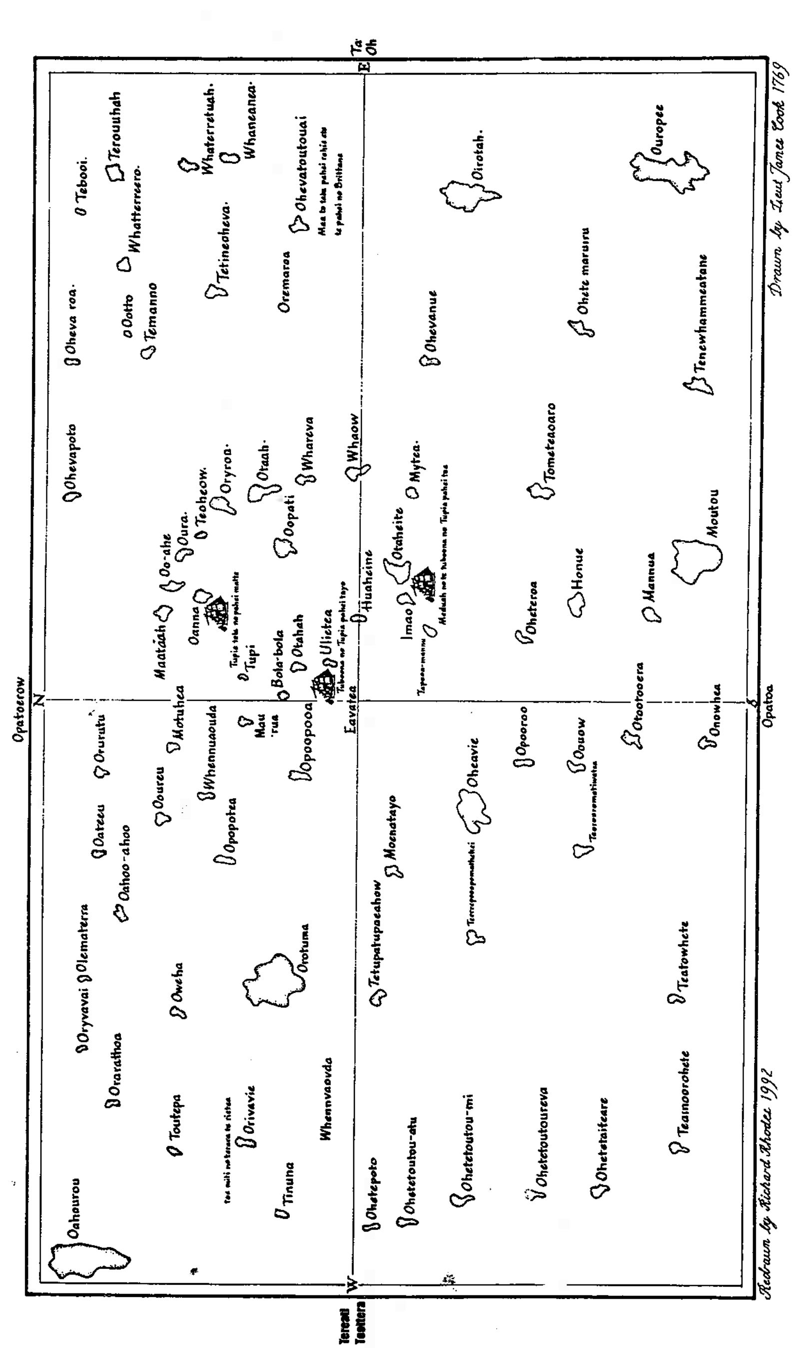

Figure 24 'Tupaia's Chart'. By permission of The British Library (Shelfmark: 1008767.011).

alternatives, but they are not the only way of knowing the world or of assembling knowledge, as is shown by the example of Pacific navigation.

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