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Cosmography, Knowledge in Transit
A Conspectus

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Abstract

From a modern perspective, it could be argued that cosmography was a protoscience, or ancestral to geography. To systemize it according to its modern legacy, however, dilutes its early modern diversity. Cosmography has a place in both the history of science and in historical geography, without being confined to either discipline. The article explores how cosmography circulated across disciplines, national borders, and social classes. It materialized not only in books, but in a variety of forms, including maps, instruments, letters, and lectures. Knowledge evolved as new discoveries were made about the earth and the heavens, but ideas gain traction only with difficulty when they breach conceptual boundaries. The first parts of the article will address sites, modes, and materials of knowledge exchange. In the final part, I will focus on caution, resistance, and censorship in the transmission and subsequent transformation of knowledge, with particular reference to the Copernican revolution.

Keywords: *Astronomy, Cosmography, Geography, Knowledge, Maps*

1. *Introduction: Origins and Producers of Cosmographical Knowledge*

For modern scholars, the significations of cosmography present difficulties. It has been long out of fashion, indeed, obsolete, in some places. Penguin's *Dictionary of Science*, first published in 1942 with the subtitle *Definitions and Explanations of Terms used in Chemistry, Physics and Elementary Mathematics*, for example, contains no entry for cosmography. Its closest approximation is the unfamiliar 'cosmogony' with its definition of theories as to the origins of the heavenly bodies. Notably, the French translation of the same dictionary, published by Presses Universitaires de France in 1956, voluntarily introduces cosmography into its subtitle: *Mathématique, Mécanique, Cosmographie, Physique, Chimie*, and has an entry on 'cosmographie':

Le sens initial de cette expression: description de l'univers, n'est pas guère utilisé; la cosmographie désigne aujourd'hui l'ensemble des éléments d'astronomie et de géodésie enseigné dans les classes terminales du Second Degré. (Uvarov and Chapman, 1956, 63)[1]

The deliberate revision of the title in the French translation suggests the *longue durée* of cosmography. In France cosmography was taught in classes of rhetoric and philosophy, as is evidenced by the late nineteenth-century publication of Amédée Guillemin's *Eléments de cosmographie* (1867) and Pichot's *Cosmographie élémentaire* (1881). The several editions of these late French cosmographical works exemplify the fact that universal knowledge is not universal in its application. 'Cosmography' represented a pan-European body of knowledge that was widely transmitted, but it took root in different places at different times, and with variations of depth and influence.

The widespread use of 'cosmography' and 'cosmographical' as terms to denote studies that encompassed the earth and the heavens was probably due to the vagaries of translation. When Jacopo Angeli da Scarperia – completing the work of his teacher of Greek, Manuel Chrysoloras – translated Ptolemy's *Geography* into Latin, he did so under the title *Cosmographia* (1406-1409). The term 'cosmography' was adopted in all Latin manuscripts of Ptolemy's work and in the early editions printed in Vicenza, Bologna, Rome, and Ulm (Burnett and Shalev 2011, 5-6). In his preface, Angeli makes far-reaching claims for cosmography and justifies his use of the term:

In addition, our author calls the whole work, in Greek the *Geography* – that, is the description of the earth … we, however, have altered it to *Cosmographia* … since something more is denoted in the term 'cosmography' than the earth itself, which gives its name to geography. For 'cosmos' in Greek is 'mundus' in Latin, which clearly signifies the earth and the heavens themselves, which throughout this work are adduced as a kind of foundation of the subject matter. (In Burnett and Shalev 2011 228)[2]

Since Ptolemy's treatise describes the world (on a map) by means of astronomical data, preference had to be given to a name referring to both earth and heavens. In subsequent editions, however, the title reverted to *Geography*. Nevertheless, its circulation under the title of *Cosmography* inaugurated a European refashioning of a field of study from classical and medieval roots.

Evidently, there was a buoyant market for books advertising cosmography and directed at both the scholar and interested general reader. In the early- to mid-fifteenth century it became a recognizable genre as digests of Ptolemy were published in both Latin and the vernacular. Peter Apian, for example, who combined the work of a mathematician and astronomer with the art of the printer, also lecturing at Ingolstadt, published *Cosmographicus liber* in 1524. It was followed in 1529 by an abridgement *Cosmographiae introductio* with the running title *Rudimenta cosmographiae*'. A second edition of *Cosmographicus liber* was published in Antwerp in 1529, edited by Gemma Frisius, mathematician, physician, instrument maker, and cartographer, who was later to translate the work into French.[3] The 1529 edition formed the basis of an almost continuous publishing history up to 1609. In a bibliography of Apian's works forty-one editions are listed, published in France, Germany, the Netherlands, and Belgium (van Ortroy 1963, 117-156).

[1] (The original meaning of this expression: 'description of the universe', is not widely used now; these days, cosmography refers to all the elements of astronomy and geodesy taught in the final classes of secondary education) (my translation).

[2] Angeli's introduction is included as an appendix to *Ptolemy's Geography in the Renaissance*, where it is translated into English by Charles Burnett (in Burnett and Shalev 2011, 225-229).

[3] *La Cosmographie de Pierre Apian nouvellement tr. de lat. en fr. et par Gemma Frison corrige* (1544).

An overview of the publication, reception, and circulation of Sebastian Münster's *Cosmographia universalis* tells a similar story. Klaus Vogel has commented that over the course of the fifteenth and sixteenth centuries, cosmography began to focus increasingly on what Ptolemy had referred to as 'geography', a systematic description of the *oikumene*: the known, inhabited world (2006, 470). Although the first of the six books of Münster's *Cosmographia* is devoted to astronomical calculations derived from Ptolemy that determine latitude and longitude, and in this sense retains the dual focus of earth and heavens, the remaining books exemplify a shift away from the mathematical and astronomical towards the geocentric and humanistic. As a literary genre, Münster's cosmography encompasses what we would recognize as world and regional geography and also history, biblical history, astronomy and astrology, anthropology, horticulture, and mythology, compiled from classical and modern knowledge. The work's geographical and topographical range, as well as its inclusion of local information, is announced on the title page. Here, it is advertised, the reader will learn about all the lands, peoples, towns, notable places, government, manners, customs, orders, faiths, sects, and trades throughout the whole world.

Categorizing 'the order and collection of historians' in his *Methodus*, the late-sixteenth-century philosopher and jurist Jean Bodin placed Münster, along with Strabo and Pomponius Mela, in the category of 'geographistorians' (1945, 367-368). The term captures much of the global ambition of a work that in the first book rehearses Ptolemy's astronomy, describes the Creation (of the cosmos), the Flood, and the dispersal of Noah's sons across the earth. In the second book Münster moves to Europe, breaking down each country into regions, cities, other settlements, hamlets, rivers, islands, mountains, thermal baths, bridges, and fortified towers. In the last two books he describes less chorographically Africa, Asia, and – including as reference an abridgment of Vespucci's account of his voyages – the newly-discovered islands (1550, 1108-1111). The *Cosmographia* continued to expand after Münster's death. In later editions there are cityscapes of the New World, including, for example, a two-page drawing of the Inca city of Cuzco.

Modelled more on Strabo than Ptolemy,[4] Münster's *Cosmographia* was a huge commercial success throughout the sixteenth century and well into the seventeenth. Indeed, in Germany it became the most popular book after the Bible. First published in Basel in 1544, it went into thirty-five editions in total, translated from German into Latin, French, Italian, and Czech. It was posthumously revised, with the last edition appearing in 1650. The first edition had six books; the last edition with much material added was divided into nine. Fifty thousand copies were printed in German and ten thousand in Latin. A comparison with the print run of Shakespeare's first Folio – estimated to be about seven hundred and fifty – shows the extraordinary success and widespread appeal of this first comprehensive description of the whole world.

In broad terms, the texts of Apian and of Münster represent two strands of knowledge appertaining to cosmography: one incorporating mathematics and astronomy, and the other focusing on the histories and geographical features of earthly places. But neither the men nor their works can be readily compartmentalized. They were humanist scholars, map and instrument makers. Münster was a Hebraist. In both, scholarly knowledge was complemented by artisanal expertise. A large number of woodcuts in Münster's lavishly illustrated text were made by Münster himself, either under pressure of time because the artists had not delivered soon enough or because he was himself an experienced draughtsman and woodcutter and often helped in his stepson's workshop (Rücker 2007, 3). In its use of visual media in the form of

[4] Margaret Small discusses the different classical influences on Münster in Burnett and Shalev 2011, 167-186.

volvelles, Apian's *Cosmographia* has been described as a 'Book-Instrument Hybrid' (Gaida 2016). The work contains paper cutouts of common astronomical instruments, designed to enable the reader to determine such questions as the equality of the elevation of the pole and of the latitude of any chosen city. It is a work designed for the autodidact. When Gemma Frisius came to translate Apian's work, a work which he had done so much to promote, he supplemented it with maps and drawings of his own. His additions also included an 'Attendum' describing the new-found land, exemplifying cosmography's norm of inclusivity.

The circulation of what might be described as synthetic cosmographies, such as Martin Waldseemüller's *Cosmographiae introductio*, one of the first introductions, published in St Dié, Lorraine, in 1507, and William Cuningham's *The Cosmographical Glasse* (1559), the first English cosmography – examined by Isabelle Fernandes in this volume – further illustrate this norm of inclusivity. Waldseemüller's cosmography rehearses, as does Cuningham's, the geometrical properties of the sphere, describes the imaginary celestial spheres, climate, and zones: the fundamentals of cosmography as derived from Ptolemy. In the final part of the volume he moves from the ancients to the moderns to include the four voyages of Amerigo Vespucci, translated from French into Latin by Basinus Sendacurius, who, with Philesius Ringmann, was Waldseemüller's collaborator at St. Dié.[5] Similarly, the fifth and final book of *The Cosmographical Glasse* is entitled 'A Perticuler Description of Suche Partes of the America, as Are by Travaile Founde Out' (Cuningham 1559, 200). Aristotle's philosophical conceptions of the heavens and Ptolemy's mathematical astronomy are supplemented by the startling news of discoveries of lands not known to the ancients.

For the reader, the richness and diversity of cosmography as a field of study was part of its appeal. Thomas Elyot in his *The Boke Named the Governour* (1531) recognizes cosmography's value as an appropriate subject for a child's education. In his view, the tedious learning of countries and towns can be alleviated by beholding the tables of Ptolemy 'wherein all the worlde is paynted' (37r) and then reading treatises on the sphere. There is 'none so good lernynge', he affirms, 'as the demonstration of cosmographie, by materiall figures and instrumentes, hauynge a good instructour. And surely this lesson is bothe pleasant and necessary' (37r-37v). From its educative functions, he moves on to expound the delights offered by cosmography to the non-traveller:

> For what pleasure is it, in one houre, to beholde those realmes, cities, sees, ryuers and mountaynes … what incredible delite is taken in beholdynge the diuersities of people, beastis, foules, fisshes, trees, frutes, and herbes; to knowe the sondry maners and conditions of people and the varietie of thryr natures, and that in a warme studie or parler, without perill of the see, or daunger of longe and paynfull iournayes: I cannot tell what more pleasure shulde happen to a gentil witte, than to beholde in his owne house euery thynge that within all the worlde is contayned. (37r)

Elyot's version of cosmography brings together the mathematical and the geographical. While he emphasizes the practical application of knowledge, he recognizes the pleasures for the reader in reading about exotic fauna and the customs and manners of other peoples. The exotic quality of cosmography and its anthropological aspect found in the travel narratives appended to protoscientific works of cosmography were, in England, to be transmitted to a wider audience in the form of romance, as described by Jane Grogan in this volume, and in pamphlets and plays.

[5] Herbermann regards Sendacurius and Ringmann as collaborators, with Waldseemüller as 'the real publisher of the entire work' (1969, 5). For the contributions of Sendacurius and Ringmann, see 13-15.

Cosmography has a place in the history of science and equally in historical geography, without being confined to either discipline. Historians of science might see cosmography as ancestral to science while others, along with historical geographers, see cosmography as ancestral to geography. It is true that mathematicians and physicists are best placed to understand the geometric and astronomical practices that figure in sixteenth-century cosmographies, but early modern cosmography contained no such disciplinary boundaries. On the contrary, its practitioners were theologians, doctors of medicine, astronomers, philosophers, philologists, humanists engaged in the study of classical sources, and armchair travellers. Its readers, as the articles in this volume attest, range across rulers and noblemen, explorers, artisans, and amateurs intent on furthering general knowledge and satisfying their curiosity about the world. Universal knowledge seemed within grasp.

2. *Materials*

In recommending cosmography as a fit subject for study, Thomas Elyot conveys its multiple materials. Books, instruments, figures (in the context, this probably refers to drawings and diagrams) are all involved in its pedagogical practice. Cosmographical treatises are lavishly illustrated with drawings and diagrams of increasing technical sophistication as the chapters progress. The early chapters of Apian and Frisius' cosmography, for example, contain simple illustrations, such as drawings of a nose and face, to convey the essential and hierarchical difference between chorography and cosmography: the former constituting a section of a larger body of knowledge. A move from the simple and homely to technical instruction is indicated in later chapters outlining how to determine the circumference of the earth or compute latitude and longitude. The arrangement of the chapters suggests incremental learning. It is probable that a cosmography like that of Apian and Frisius was designed to appeal to a range of readers interested in different gradations of knowledge. Cuningham's *The Cosmographical Glasse* follows a similar pattern. As with many cosmographical treatises, the work takes the popular form of a dialogue, here between Spoudaeus, who is eager not to succumb to ignorance, and his instructor in cosmography, Philonicus. Spoudaeus responds appreciatively to Philonicus' differentiation of cosmography, geography, and chorography, concluding that cosmography is 'more excellent than the other two' and that 'it cōteineth and comprehendeth the other in it selfe' (1559, 8). However, he apprehends the difference only after Philonicus has met his request to see 'figures of euery of them' (7). An image of an armillary sphere represents cosmography, a map, geography, while a map of the city of Norwich in East Anglia conveys the microscopic concerns of chorography.

As articles in this volume demonstrate, text and image in treatises are interdependent although the function of the images varies from the illustrative to the expository to the autodidactic. Two-dimensional representations of instruments, such as the armillary sphere with its arrangement of circles used for teaching astronomy, feature in treatises as illustrations of practice. In Cuningham's work the diagrams that explain geometrical principles do not have the same autodidactic function as the volvelles in the cosmography of Apian and Frisius. Cosmography bridged *ars* and *scientia*, best understood, as Peter Burke points out, as theoretical and practical knowledge (2000, 12). Its practice included – to use Lesley Cormack's definitions – those who know by doing (practitioners or craftsmen) and those who know by thinking (scholars and philosophers). Only by taking seriously the interaction between the two groups and the resultant mathematization of natural philosophy can we understand the nature of the scientific revolution of the later sixteenth century (Cormack *et al.* 2017, 2). Amongst the first category were makers of microscopes and telescopes who established the craft in England shortly after they had been developed as practical instruments by Dutch spectacle-makers around 1608 (Clifton 1993, 343). With the development of scientific instruments of observation, notably the telescope, cosmography can be seen to tilt away from the universal and theoretical knowledge associated with scholars and philosophers towards investigation and empiricism.

The interdependence of the verbal and the visual also characterizes the more geocentric branch of cosmography. On the title page of Münster's *Cosmographia universalis* the reader is informed that all that is found in every land will be explained with figures and fine land maps presented to the eye. In addition to world, regional, and urban maps, almost every page has a woodcut accompanying and illustrating the text. A feature of the woodprints is their mobility, as various images are shifted and repurposed in another geographical context. A finely-detailed woodcut of Ptolemy holding a quadrant, an instrument used to measure the altitude of celestial objects above the horizon, appears in Book 1 in which the principles of cosmography are elucidated; the same image is used in a section on Chaldean astrology in a chapter on Babylon in Book 5 and then in a later chapter on astronomy in Babylon. Images of cannibals appear in a variety of places – in descriptions of Tartary, Scythia, in the new islands discovered by Columbus and, in later editions, Guyana. The double-paged maps – as many as 24 in some editions – placed in the volume before the text are taken from Münster's edition of Ptolemy's *Geography*, which was first published in 1540.[6] The world map, for instance, which was to influence the cartography of Mercator and Ortelius, appeared in both the geography and the cosmography.

Images range from the quasi-scientific to the realistic to the fantastic; from the mathematical and closely observed to the speculative. Book 1 presents the reader with the scientific aspect of cosmography as Münster reworks the first book of Ptolemy's *Geography* and includes familiar diagrams of the sphere, zones, and directions for the calculation of latitude. The books on the countries of Europe contain many regional and urban maps, portraits of rulers and folk heroes, alongside detailed illustrations of work, trades, and husbandry. A woodcut in Book 3, a book devoted to Germany, shows the sieving, washing and sorting of ore, with men washing and sieving and women doing the more sedentary sorting (Münster 1550, 435). While the woodcut is technically sophisticated its design is based on everyday observation. Other cuts are derived from the descriptions of the text and clearly not founded on first-hand experience. Some woodcuts, like the two-page chart of sea wonders or monsters, evidently became collectors' items since in some extant editions the chart has been cut out of the book. Evidently, images gained a circulation beyond the text.

Maps constitute a notable omission in Elyot's list of tools for teaching cosmography, given that they offer a concrete example of learning and, as they become larger to accommodate new discoveries, provide a clear indication of the current extent of geographical knowledge. Cartographers formed part of a wide-ranging community sharing knowledge and expertise. In his *Theatrum orbis terrarium*, regarded as the first modern atlas, Abraham Ortelius – cosmographer to Philip II – includes a 'Catalogus Auctorum' representing the first printed catalogue of cartographers and the maps that Ortelius knew to have been made by them (Karrow and Bagrow 1993, xi). Amongst the eighty-six cartographers who according to Ortelius had contributed to sixteenth-century geographic knowledge were figures such as Münster, Apian, Frisius, and Thevet who were also known as cosmographers.

To keep pace with fresh discoveries, maps were redrawn, offering a visual analogy to the way in which universal cosmographies expanded to accommodate new knowledge. Martin

[6] Münster edited six editions of the *Geographia* from 1540 to 1552 (the year of his death) (see Ruland 1962, 88-89).

Waldseemüller's celebrated wall map (1507) is made up of twelve map sheets that partition the modern world and draw attention to the limits of the ancient. In the caption above 'Cathay', Waldseemüller describes his methodology, indicating the two temporal levels of the cosmographers, ancient and modern:

> In describing the general appearance of the whole world, it has seemed best to put down the discoveries of the ancients, and to add what has since been discovered by the moderns, for instance, the land of Cathay, so that those who are interested in such matters and wish to find out various things may gain their wishes and be grateful for our labour, when they see nearly everything that has been discovered here and there, or recently explored, carefully and clearly brought together, so as to be seen at a glance. (in Hessler and van Duzer 2012, 30)

The coming together of the ancient and the modern world on the surface of the map was illustrated in the drawing of Africa. The representation of Europe and North Africa is based on Ptolemy, while the removal of the border to map the lower regions of Africa which were unknown to Ptolemy draws attention to cosmographical extension. Vespucci and Columbus are celebrated for extending the known world. A caption accompanies their island discoveries:

> A general discovery of the various lands and islands, including some of which the ancients make no mention, discovered lately between 1497 and 1504 in four voyages over the seas, two commanded by Fernando of Castile, and two by Manuel of Portugal, most serene monarchs, with Amerigo Vespucci as one of the navigators and officers of the fleet; and especially a delineation of many places hitherto unknown. All this we have carefully drawn on the map, to furnish true and precise geographical knowledge. (17)

In its concern for accuracy, this 1507 world map by a German humanist carefully records the recent discoveries – knowledge of which was circulating across Europe in the form of letters – of the Italian navigators Columbus and Vespucci.

Printed in large runs, maps were widely owned and had both a decorative and utilitarian function.[7] In his dedication of *Principall Navigations* to Francis Walsingham, Richard Hakluyt recalls his early encounter with cosmography, his curiosity awakened by the sight of a 'universall Mappe':

> I do remember that being a youth, and one of her Maiesties scholars at Westminster that fruitfull nurserie, it was my happe to visit the chamber of M. *Richard Hakluyt* my cosin, a Gentleman of the Middle Temple … at a time when I found lying open vpon his boord certeine bookes of Cosmographie, with an vniversall Mappe: he seeing me somewhat curious in the view therof, began to instruct my ignorance, by shewing me the diuision of the earth into three parts after the olde account, and then according to the latter, & better distribution, into more: he pointed with his wand to all the knowen Seas, Gulfs, Bayes, Straights, Capes, Riuers, Empires, Kingdomes, Dukedomes, and Territories of ech part. (Hakluyt 1589, *2r)

Since – following his instruction on the contemporary expansion of the world – the elder Hakluyt points with his wand to various features, the map must have been imposing. It is more likely that it was a separate map on a table rather than one of the many included in translations of Ptolemy or in Münster's *Cosmographia universalis*. On the basis that Hakluyt knew Ortelius, corresponding with him about the construction of a large world map in c. 1567-1568, it has been suggested that the map in question was Ortelius' cordiform world map (on eight sheets) published in 1564 (Taylor 1935, 77-83). Among the 'bookes of Cosmographie', it seems

[7] Comparatively few copies have survived, suggesting that their beauty and utility led to over-use.

probable that one of them – since it is the geographical dimension of cosmography which sparks Hakluyt's interest – was Münster's *Cosmographia* or his edition of Ptolemy. In the address to the reader, Hakluyt pays tribute to Ptolemy's notion of geography as *perigrinationis historia* which he contrasts implicitly and favourably with volumes 'bearing the titles of vniversall Cosmographie' which in his view were 'ramassed and hurled together' (Hakluyt 1589, *3v).

3. *Media: Networks, Communities, Letters and Books*

In disseminating cosmographical knowledge it is evident that international networks and communities as well as exchanges between individuals – like those of Hakluyt and Ortelius – played an important part. Knowledge was produced amongst academic elites as well as artisans, although it is less easy to trace the pathways of the latter. Scholars – less so artisans in this period – belonged to communities that transcended national boundaries. Focusing on the astronomer Tycho Brahe, Adam Mosley (2007) has explored how astronomical knowledge circulated through exchanges of letters, books and instruments. Brahe was part of a community of scholars, instrument makers, and noblemen that facilitated not only intellectual collaboration but the exchange of gifts, the purchasing or copying of books, even the acquisition of libraries of deceased scholars. He owned a printing press – in fact, as Mosley points out, two presses – enabling the publication of his letters, *Epistolae astronomicae* (1596), in Uraniborg on the island of Hevn where he had his observatory. Brahe planned for a large print run of *Epistolae astronomicae* and, through his contact with printers and booksellers, a wide distribution linking his observatory with a public realm of knowledge. The collection of letters was the first of Brahe's published works to indicate the full scope of his astronomical project (Mosley 2007, 125-126), relaying his response to the question of world systems in the correspondence with Christoph Rothmann, court astrologer to Landgrave Wilhelm IV in Kassel. Brahe disputed the Copernican theory advocated by Rothmann, putting forward his own geo-heliocentric model. Thus, through publication, what began as a private disputation became an issue in wider astronomical circles.

As both a community and a magnet for peripatetic teachers and students, the university was a nexus for knowledge exchange. Scholars moved between universities and were bound together by multiple-stranded networks of epistolary contacts fostering diffusion and discussion of ideas across Europe (Rüegg 1992, 27). In such a wide and complex field, the role of the universities can only be briefly and selectively discussed. Obviously, there were regional differences. Padua and Leiden, for example, were amongst the most advanced universities in the development of the new science (Porter 1992, 535). In his article in this volume, Willy Maley alludes to the innovative interdisciplinary research at Leiden in the early seventeenth century. In general, however, there is little evidence to show the universities played anything but a limited part in the transmission of new knowledge. The curriculum was established on the basis of classical authors and the various commentaries on their texts rather than on research, discovery, and novelty. It was slow to change. The disciplines that could be studied officially were confined to the seven liberal arts and then theology, law, and medicine as subjects for those pursuing a career as a Master of the Faculty. Olaf Pedersen has pointed out that the technical problems of a rapidly changing society presented challenges with which the quadrivium was unable to cope. New disciplines of cartography, navigation and hydrography that developed alongside new world discoveries were taught outside the universities in special schools such as the Casa de la Contratación in Seville and, much later, at Gresham College, established in London in 1592 (1992, 466).

In astronomy the teaching was orthodox, specifically in its deference to the Aristotelean cosmology *De cælo* (On the Heavens). Roy Porter has observed that the geostatic and the geocentric system still predominated in university teaching in 1600 (1992, 537). The manuscript lecture notes of Henry Savile, who lectured on Mathematics at Oxford in the 1570s, are extant and show that beyond the classical authors new ideas were circulating. In conjunction with the work of Ptolemy, Savile was teaching Copernican theory.[8] Nevertheless, in their cautious presentation of the latter the lecture notes convey something of the entrenchment of traditional doctrine. In Savile's estimation, Copernicus has 'indeed earned immortal fame: but he has not added anything new to astronomy that was not already thoroughly discussed by Ptolemy. Indeed, he has clarified the same problems by means of a new method, with different hypotheses' (Ms. Oxford, Savile 29, 23r in Goulding 2010, 95). Savile's stress on the theory as a hypothesis and his comment that Copernicus' ideas with their classical sources are not new is characteristic of the conservative qualification that accompanied the transmission of Copernican theory in the late-sixteenth and early-seventeenth centuries.

As Savile's lectures illustrate, teaching was broader than the formal statutes and curriculum of the university suggest. This is evident in the field of geography. Pietro Martire d'Anghiera, author of *De orbe novo* and chronicler for the Council of the Indies, taught briefly at the University of Salamanca. Sebastian Münster lectured on geography at Heidelberg. In her examination of book ownership amongst students and fellows of Oxford and Cambridge, Lesley Cormack has demonstrated that there was a marked interest in geography old and new. Details of book ownership in the 1580s reveal that amongst the most commonly owned books were Ptolemy's *Geographia*, Pomponius Mela's *De situ orbis*, Strabo's *De situ orbis*, and the cosmographies of Münster and Apian. By the turn of the century, while the classical authors were still owned, it is evident that students and fellows were beginning to experiment with new and continental ideas found in works by Apian, Ortelius, and Copernicus, among others (1997, 40-41). Geography was taught at Oxford in the 1570s. In his dedication of *Principall Navigations* to Walsingham, Hakluyt refers to his public lectures on geography although he does not refer to it by that name. He recalls that he, Hakluyt, was the first to teach by way of demonstration:

> and in my publike lectures was the first, that produced and shewed both the olde imperfectly composed, and the new lately reformed Mappes, Globes, Spheares, and other instruments of this Art for demonstration in the common schooles, to the singular pleasure, and generall contentment of my auditory. (Hakluyt 1589, *2r)

Two aspects of Hakluyt's teaching are here disclosed: the practical use of instruments and his use of old and new maps to illustrate the changing understanding of the *oikumene*. Hakluyt's lectures are generally thought to be 'ordinary' lectures (that is, read at regular times), given to all members of the university on the obligatory set texts. However, as Anthony Payne comments, this would not necessarily have precluded innovative considerations of recent developments in learning (2021, 7). Quite clearly, in terms of knowledge, 'the olde imperfectly composed' and 'the new lately reformed' – in Hakluyt's words – could co-exist, seemingly without tension.

Following such groundbreaking studies as those of Lucien Febvre and Henri-Jean Martin's *The Coming of the Book* (1976)[9] and Elizabeth Eisenstein's *The Printing Press as an Agent of Change* (1980), it has become a commonplace that print is an historically important intermediary in the circulation of knowledge. Books helped to bring about vital changes in thought and attitude.

[8] The copy of Copernicus' *De revolutionibus* in Eton College library belonged to Thomas Savile, Henry Savile's brother.

[9] The title of the English translation of *L'Apparition du livre* (1958). Scholars outside France have been slow to recognize 'The History of the Book' as the field is now known.

The momentousness of the invention of printing was well recognized by contemporaries and is eloquently encapsulated by Galileo in his *Dialogo sopra i due massimi sistemi del mondo* (*Dialogue Concerning the Two Chief World Systems*) (1632). Adopting the dialogical form enables the author to employ a rhetorical style and – as the three interlocutors, Salviati, Sagredo, and Simplicio, meet over several days to discuss ancient and modern cosmographical theories – to convey a plurality of views. Following a discussion of the acuteness of the human mind in relation to the Divine, Sagredo alludes to man's inventions, the most far-reaching being that of the printing press:

> But surpassing all stupendous inventions, what sublimity of mind was his who dreamed of finding means to communicate his deepest thoughts to any other person, though distant by mighty intervals of place and time! Of talking with those who are in India; or speaking to those who are not yet born and will not be born for a thousand or ten thousand years; and with what facility, by the different arrangements of twenty characters upon a page! (Galilei 1953, 105)

Here, in a scientific work, is a rhapsodic recognition of the far-reaching role played by print in the dissemination of thought and knowledge beyond time and place. Yet, some of the larger claims for the press by contemporaries and posterity should be qualified. Febvre and Martin argue that print did not necessarily hasten the acceptance of new ideas or knowledge. Publication revitalized works of classical authority that otherwise may not have survived and reliance continued to be placed on these texts even as new discoveries were made (2010, 278). Long-cherished and traditional beliefs were – through publication – strengthened and popularized. As Peter Burke observes, in every culture there are 'knowledges' (2000, 13). While print enabled the circulation of knowledge it was inevitably left to the reader to discriminate between the cosmographic systems of Aristotle, Ptolemy, Copernicus, Brahe, and Galileo.

To ensure circulation, established routes between the places in which knowledge is discovered or elaborated and the places from where – via printing – it is distributed are crucial. In his work on the European book world in the sixteenth century, Andrew Pettegree has demonstrated that an extraordinary proportion of the entire output of European printing was concentrated in fewer than a dozen large centres of production. What Pettegree describes as 'a steel spine' (2008, 104) ran along Europe's major trade routes from Antwerp and Paris in the north, through Cologne, Basel, Strasbourg, and Lyon, to Venice in the south. The St Gotthard Pass through the Alps provided a direct connection between Venice and the major southern German publishing and trading cities of Nuremberg and Augsburg. Expansive and lavishly-illustrated scholarly texts, such as the translations of Ptolemy's *Geography* with its multitude of tables, and the cosmographies of Sebastian Münster, André Thévet, and François Belleforest, demanded considerable financial outlay. The publication history of sixteenth-century cosmographical works largely bears out the point that the printing houses of the aforementioned cities were the natural focus of projects that required substantial investment. Different editions of Münster's *Cosmographia* and the second edition of Copernicus' *De revolutionibus* were printed by Henricus Petrus in Basel. Johannes Petrius in Nuremberg published the first edition of the latter. As leading scientific printers, Petrus and Petrius had the technical means and skills to publish such lavishly-illustrated texts, as well as wide distribution networks. In contrast, trade in learned texts in England was essentially an import trade.

The ready availability of news as well as knowledge was closely dependent on the explosion of print. Letters of discoveries addressed to patrons and sponsors and then printed the same year carried news of marvelous 'discoveries'. On his return to Spain in 1493, on what he thought was a discovery of the Indies, Christopher Columbus announced his findings in a letter addressed to Gabriel Sanchez, the royal treasurer of Spain, and to Luis de Santangel, the secretary of the exchequer. The letter – the original is lost – was published in Spanish at Barcelona (Goff 1946, 3). In the same year, it was translated into Latin by the Italian priest Aliander de Cosco and published in Rome. It appeared in various editions printed in Rome, Florence, Basel, Paris, and Strasbourg, and in Italian and German translations (Eames 1892, v-xiii). One was an Italian version in *ottava rima* by Guiliano Dati. An edition, published in Basel in 1494 and containing illustrations, was appended to a drama in praise of King Ferdinand written by Carolus Verardus (Goff 1946, 3). The woodcuts representing Columbus' caravel, his arrival in Haiti, and his meeting with the indigenous people enhance the appeal to a potential purchaser. Mary L. Dudy Bjork has compared the letter in Spanish with its Latin translation, exposing significant semantic changes as a letter initially addressed to patrons was redirected to a wider European audience. In Cosco's translation there is a dilution of the marvellous that informed Columbus' 'understanding of the entire quest' (Bjork 2005, 44). In his reworking, Cosco normalizes and stabilizes language, subduing the text possibly, as Bjork suggests, to draw in investors (52). Amazement at the geography of the island (Española) – that had resonances of a more fantastical traveller's tale – is replaced with a more practical description conveying its suitability for investment.

As with Columbus' letter, the letters of Amerigo Vespucci, *Lettera di Amerigo Vespucci: delle isole nuovamente trovate in quattro suoi viaggi*, recounting his alleged discoveries off the coast of America, circulated in various bibliographical contexts and reached the wider public through their inclusion in the cosmographies of Waldseemüller and Münster. Appearing in different editions, their genealogy is complex. The available evidence points to the original recipients of the letters as Lorenzo di Piero Francesco de' Medici and Piero Soderini, friend of Vespucci's and chief magistrate (*gonfaloniere*) in Florence. Both letters were translated into French and Latin and published in France, Italy, and Germany (Markham 1894, xiv-xix). Indicative of their interlingual circulation, a French translation was used for the Latin version included in *Cosmographiae introductio* (Herbermann, 1969, 10-13). 'Philesius', the Hellenized name of Mattias Ringmann, the translator, addresses the reader in a preface to the translation, alluding to the new land 'encircled by a vast ocean' and 'inhabited by a race of naked men', unknown to Ptolemy, discovered through the fleets of the King of Portugal (Portugal is given its archaic name of Lusitania). Playfully, he advises the reader not to be like the rhinoceros: impervious to the momentousness of Vespucci's discoveries. The authenticity of Vespucci's account of his voyages is now much in doubt, but the wide circulation of the letters ensured that it was Vespucci who was connected throughout Europe with the discovery of the *Mundus Novus*.

An important dimension of cosmography addressed by Antonio Sánchez Martínez in this volume is practical cosmography – the domain of navigators, sailors, and their instructors. It was conveyed orally as much as by print. *The Libro de cosmografiía* by Pedro de Medina – a teacher, astronomer, chronicler, and an examiner of ships' pilots in Seville – exists only in manuscript (see Medina 1972). It takes a simple question and answer form (here, questions from a pupil to a pilot), reflecting the experience of instruction and covering all the knowledge needed for pilots, navigators, and explorers. Navigation manuals did circulate internationally. De Medina's *Arte de navegar* (1545) was translated into French and went into some twenty editions. Martín Cortés' *Breve compendio de la sphera y de la arte de nauegar* was translated into English by Richard Eden and published in 1561. In his dedication of *The Arte of Navigation* to two aldermen of the City of London, the haberdasher William Garrard and Thomas Lodge (father of the prose writer), Eden refers to his dedicatees as governors of a fellowship of the nobility and merchant adventurers whose purpose is 'the discovery of Landes, Territories, Ilandes, and Seignories unknowen' (Cortés 1561). Eden's desired readers for his translation of Cortés' work belong to a circle of city merchants, artisans, and overseas venturers keen to acquire knowledge of new skills based on firmer astronomical navigation emanating from the Iberian Peninsula.

4. *Caution and Censorship*

In her study of the contribution of the Spanish and Portuguese empires to the practice of science, María Portuondo has revealed how the Spanish safeguarded cosmographical knowledge (2013, 103-136). Concealment, censorship, counter-narratives, and disbelief are factors that counter the circulation of knowledge. They can be seen to operate as new ideas about the world disturbed traditional and popular thought and only slowly gained traction. Jim Bennett makes the point that in the context of early-sixteenth-century cosmography the geographical description of the different parts of the earth were occupying ever more space, while the astronomical content was relatively static (2017, 37). Eventually, the revolutionary theories of Copernicus, Brahe, Kepler, and Galileo were to unsettle the static nature of celestial cosmography. Yet, the dissemination of this novel cosmology was to encounter cautious reception, censorship, and rejection. In part, this lay in the way the theories were presented and marketed as hypotheses open to acceptance or rejection. Equally, to posit the movement of the earth posed an alarming challenge to Ptolemaic and Aristotelian conceptions of the universe and, moreover, to the words of the Bible. The model of the geocentric world remained remarkably resistant.

The publication of *De revolutionibus orbium coelestium libri VI* (1543) has a complex history evidently shaped by anxieties about its radical astronomical and theological content. From the address to the Pope, Paul III, which serves as the book's Preface, it appears that Copernicus was reluctant to release his manuscript, concealing it for more than nine years.[10] Facilitated by the support of international scholars, its route to print is a further illustration of the significance of European networks linking scholars and printers. Its publication was initiated by Georg Joachim Rheticus, Professor of Wittenberg, who, while he was in Nuremberg, learnt about Copernicus' work from Johann Schöner, astronomer, instrument maker and mathematician, and from the printer Johannes Petreius. Rheticus visited Copernicus in Frauenberg, where Copernicus was canon, and was given permission to publish an introduction to the new cosmology: *Narratio prima*, printed in Gdansk in 1540, appeared in the form of a letter from Rheticus to Schöner. Having introduced the heliocentric thesis to the astronomical community, Copernicus entrusted his manuscript to Rheticus who took it to Petreius' shop in Nuremberg.

The title page includes an address advertising not only the book's scope but the subversive nature of its thesis:

> Diligent reader, in this work, which has just been created and published, you have the motions of the fixed stars and planets, as these motions have been reconstituted on the basis of ancient as well as recent observations, and have moreover been embellished by new and marvelous hypotheses. You also have most convenient tables, from which you will be able to compute those motions with the utmost ease for any time whatever. Therefore buy, read and enjoy. (Copernicus 1978, xv)

[10] In the Preface, Copernicus refers to the friends who persuaded him to publish, 'Foremost among them was the cardinal of Capua, Nicholas Schönberg … Next to him was a man who loves me dearly, Tiedemann Giese, bishop of Chelmno' (1978, 3).

Prospective readers are left to wonder at the nature of the 'marvelous hypotheses' advanced. The most startling is expressed in chapter ten of the first book containing a diagram of the celestial spheres with the sun at the centre of the universe. After referring to the annual revolution of the planets around the sun, Copernicus asserts unequivocally: 'near the sun is the center of the universe. Moreover, since the sun remains stationary, whatever appears as a motion of the sun is really due rather to the motion of the earth' (20).

The revolutionary statement is followed by caution as Copernicus acknowledges that his statements are difficult, almost inconceivable, and opposed to the beliefs of many people. Copernicus' circumspect note is followed by the promise that with God's help his statements will appear 'clearer than sunlight' or at least to 'those who are not unacquainted with the science of astronomy' (21). The notion that the treatise is directed towards the astronomical community reiterates Copernicus' unequivocal statement in the dedication of *De revolutionibus* to the Pope that 'astronomy is written for astronomers' (5).

The book's paratextual material reveals different impulses at work. In an anonymous foreword addressed to the reader, 'Concerning the Hypotheses of this Work', its author alludes to widespread reports about these novel hypotheses which are likely to cause offence and confusion. The reader is offered the assurance that neither the astronomer nor the philosopher can state anything certain about the celestial motions unless it be divinely revealed. Thus, the reader must regard *De revolutionibus* as a series of hypotheses only. The latter 'need not be true nor even probable' and they should be read in conjunction with 'ancient hypotheses, which are no more probable' (xvi). The author of the unauthorized foreword was a Lutheran theologian and priest at St Lorenz, Nuremberg, Andreas Osiander, whom Rheticus had left to oversee the final stage of publication (*ibid.*). Whatever motives lay behind Osiander's intervention it was evidently designed to predetermine the reader's response and preempt hostile rejection or enthusiastic endorsement. Its cautionary tone is at variance with Copernicus' confident address to the Pope, composed, of course, without any knowledge of the foreword. Here, after explaining why he had delayed publication, Copernicus presents his theory, supported he says by classical authorities. However, he anticipates unfounded objections to it, making an analogy between resistance – now discredited – to the idea that the earth has the form of a globe and anticipated resistance to the idea of a movable earth. While Copernicus' ideal reader is the astronomer, he recognizes that his thesis will spread amongst the educated and uneducated alike: 'Perhaps there will be babblers who claim to be judges of astronomy although completely ignorant of the subject and, badly distorting some passage of Scripture to their purpose, will dare to find fault with my undertaking and censure it' (5). His prediction was entirely accurate. There is ample evidence that *De revolutionibus* did encounter resistance of various kinds.

Censorship was far from immediate. Not until 1616 was the book placed on the *Index of Prohibited Books* 'until Corrected' and not until 1620 were the required corrections listed (Gingerich 2002, 367). Owen Gingerich makes the point that this was an extraordinary move since in very few cases did the Roman Index specify precise changes to text. The stipulated changes include the deletion of a passage from the preface that contains Copernicus' assertion that 'astronomy is written for astronomers' thereby removing the implication that the natural sciences are not the domain of theologians. The most draconian of the stipulated corrections is the removal of chapter 8 of Book I 'because it teaches the truth of the earth's motion while it discredits the time-honored reasons for proving its immobility' (*ibid.*). However, here there is a concession that since the matter is treated problematically the chapter can remain so 'the sequence and arrangement of the books would remain intact' if various suggested amendments are made. In his census of the 1543 (Nuremberg) and 1556 (Basel) editions of the work, Owen

Gingerich examined over six hundred extant copies, many recording provenance and ownership, annotation, and marginalia. Two-thirds of the copies held in Italian libraries are censored texts conforming with Roman censorship while virtually none of the Spanish and French copies contain corrections (146). Annotations in other copies illustrate a favourable response to Copernicus' theory. Michael Maestlin, Professor of Mathematics at Tübingen, in the copy he owned (now in the Stadtbibliothek in Schaffhausen) commented, according to Gingerich, soon after he acquired the book in 1570, on Osiander's address to the reader:

> This preface was added by someone whoever its author may be (for indeed its weakness of style and choice of words reveal that it is not by Copernicus), lest someone at the mention of these hypotheses would hiss them off the stage as false and unworthy of reading, or would approve them at first glance injudicially out of love of novelty: first he ought to read and reread them, and only then judge them. (220)

Hissing off the stage is perhaps too colourful a metaphor to describe the more general non-reception of Copernican theory. Certainly, as surveys of reception illustrate, it was slow to take hold (Stimson 1917; Dobrzycki 1972; Cynarski 1973). A century after the publication of *De revolutionibus*, in two public lectures on cosmography delivered in 1649 at Sir Balthazar Gerbier's Academy in Bethnel Green, London, the heliocentric system was categorically rejected on theological and rational grounds. The lectures were published in pamphlet form the same year, with the second containing an address to the President of the Council of State (the governing body of the new English Republic) in which Gerbier outlines the moral and educative purpose of his Academy erected 'for the glory of God, the honour of this State and Nation, the encouragement and *improvement* of all *Lovers of Vertue*' (Gerbier 1649b, A2r).

'Read gratis', the lectures, in their simple expository style and structure, are designed for an audience relatively unfamiliar with cosmography. Beginning with the stock definition of cosmography as the 'description of the Celestiall and Elementary Region', the first lecture expounds the Aristotelian position that the 'Earth the heavier of the foure [elements] holds in the Center' (Gerbier 1649a, B2r). In the second lecture the geocentric position is reiterated: 'all the Heavens or Orbes doe surround the Earth as a circle doth its center, and the further they are from it, the longer they are accomplishing their circuits' (Gerbier 1649b, A4v). The final section, 'That the Earth is unmovable' sets out to prove that 'excellent astronomer' Copernicus wrong. The earth's immobility at the centre of the universe is proved by reason and scripture. The stars remain of 'the selfe same bignesse' which would not be the case if the earth were 'in one place then the other' (B4v). That the sun has its course and motion needs no further proof than the citation of the Old Testament narrative of Joshua commanding the sun to stand still: 'Sunne, stande thou still upon Gibeon … And the Sunne stood still, and the Moone stopped, untill the people of Israel had avenged themselves on their enemies' (Josh. 10:12-13). Auditors are reminded of the limitations of human enquiry. The 'coelum impereum' (empyrean) must remain a mystery for the living and is beyond the reach of astrologers: 'it behooves the Divines and not the Astrologers to discourse of it' (Gerbier 1649b, 3). Even as science was breaking conceptual boundaries it was recognized that certain knowledge – *arcana Dei* – was beyond the acquisition and comprehension of humanity.

5. *Conclusion*

In the late fifteenth century cosmography appeared as a type of knowledge that was to expand considerably, crossing what we would regard as disciplinary boundaries. Within the cosmographical frame knowledge about the new world, the heavens, nature, and man existed alongside each other, constituting a comprehensive and in that sense coherent body of knowledge, at variance with modern specialization. This article has explored how, true to its diverse make-up, the media through which cosmography was transmitted included the printed word, maps and instruments. Knowledge was purveyed by humanist scholars, philologists, university teachers, printers, cartographers, pilots, and seamen. From the originators and producers of knowledge the discussion moved to transmission and reception, with an emphasis on the circulation of cosmographical knowledge amongst the relative elite who could travel, read, and afford to buy books. Inevitably, the book was the means by which knowledge was given shape, organized, and circulated. In addition to authorial production, books on cosmography went into multiple editions with additional – or less – matter, were translated, and had changing paratexts as they circulated across Europe over the course of a century, forming and formed by the world view of generations. Old and new concepts of the earth and heavens circulated concurrently, determining gradual shifts in knowledge that remained circumscribed by theological certainty.

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