Draft chapter for Mapping Across Academia

What is where? The role of map representations and mapping practices in advancing scholarship

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The emergence of the mapping impulse

> "More mapping of more domains by more nations will probably occur in the next decade than has occurred at any time since Alexander von Humboldt 'rediscovered' the earth in the eighteenth century, and more terra incognita will be charted than ever before in history"
>
> —Stephen S. Hall, *Mapping the Next Millennium* (1992: 22)

> "How many maps, in the descriptive or geographical sense, might be needed to deal exhaustively with a given space, to code and decode all its meanings and content?"
>
> —Henri Lefebvre, *The Production of Space* (1991: 85)

We can state with a fair degree of certainly that map making in some form is as old as human history. That is, when we look at the world population 10,000 years ago the earliest human clans already had someone making or preparing maps in some way. Hunter gathers at that time probably numbered about ten million people who lived in forests, grasslands, and intermediate environments in multiple locations of small numbers on all continents. A major source of their well-being was concerned about basic survival questions, such as the sources of food, water, building materials for homes, places of safety and the locations of friends and adversaries. Place was a primary concern about livelihood. This "spatial" survival information was in the heads of these earliest tropical and subtropical people (Ingold, 2000). It was not only information that was known, but also had to be conveyed to others in some way. Verbal communication was one way these earliest peoples could and did reveal information about "what was where." However, another way also became important in communication was by devising representations or ways of visually demarcating the location of something. In pre-literate and written language cultures some members of a clan or tribal group began to think of creative and imaginative ways to show "what was where." Here we are not talking about maps as we know them today, but other schematic ways to represent and portray vital geographical information for the community.

The earliest mapmakers would, could and did use various ways to depict the location of food sources, good drinking water and place settings that were safe from wild animals or neighboring groups competing for the same territories. They were also concerned about the navigable pathways and the best routes from point A to point B. Boundaries or territorial limits of livelihood spaces were also something always in the minds of the earliest human settlements as well. The earliest proto-"maps" were most likely crude representations of "what was where," made by drawing lines in the sand or mud or using branches of a tree with different sizes and spacings of twigs to show place features. Leafs and flowers and plant stems, all with geometric features, could be used as "maps" as well as they could and did convey information about "what was where" that could supplement orally conveyed knowledge. The arrangement of stones, with stratified by different

sizes, colors and shapes, could also be used to display earth features in the surrounding landscape. (For more details on mapping through songs and stories, ritual dances and ceremonies, body art and tattoos, and rock pictographs in traditional and pre-industrial societies, see Woodward and Lewis, 1998.) The earliest proto-cartographers may have been village elders (women and men) who had the best cognitive maps of their territory and the most lengthy and widespread geographical experiences. Or they may have been someone groomed for the task by village leaders because of a good memory. Alternatively, perhaps they may have been someone with a physical disability who exhibited some artistic talents in making crude maps as a child or even drawing animals, rivers and food sources on a cave wall or carving place knowledge on a piece of bark or hard bone surface. These early cartographers were basically preparing representations of information on earth surface for others, not only hunters and gatherers, but also clan leaders, that is, those responsible for security and instructing others about "what was where?" We might also consider these early cartographers as having some mix of "science and art" talents, that is, not only representing something from an earth scale to some "map" scale, but also including some simple graphical sketches about the directions of a river, the types of trees, which prey animals were to be found in the grasslands, charting changing seasonal food sources and some symbols defining territorial limits. Even though examples of these earth-material maps made 5,000-10,000 years ago do not exist today, we know from other artifacts (pottery, jewelry and clothing), rock art and cave wall sketches that creative artistry was a distinctive feature of many human groups in pre-history, whether they were hunters and gatherers or early coastal communities and sedentary agriculturalists (cf. Delano Smith, 1987). We are also probably safe in assuming that the making of the earliest maps was not confined to one geographical or environmental location and then diffused out of a single hearth. Much more likely was that maps were independently constructed in the ways described above and were prepared by those living in multiple locations throughout the tropical and subtropical worlds of interior east and west Africa, riverine southwest Asia, mountainous southeast and northeast Asia and highland Central and South America. Indeed, research by geographer James Blaut and colleagues has been conducted to see how far mapping can be regarded as a cultural universal; they note that "many other recorded examples, from sites widely separated in space and time, suggest that it is at least plausible that mapping was and is employed by nearly all cultures, everywhere" (Blaut et al., 2003: 181).

Over time the making of maps became more important, not only as the number of clan members increased, but also knowledge about more distant geographical information was gathered which became important for ongoing struggle to survival. The same information about food, security and protection that was important for the earliest communities continued to be of paramount importance as did boundaries demarcated on the land in some way or in the minds of community leaders. The accumulation of more spatial and environmental knowledge meant that new maps and more related spatial representation had to be constructed using a variety of available surfaces: animal bones, tree bark, rocks on which one could carve distinctive spatial features (for broad regional reviews and exemplars, see Delano Smith, 1987; Lopez, 1986; Maggs, 1998; Sutton, 1998). Constructing maps was giving way to previous "maps on the ground" that displayed the location of something by the shape of a branch (which might refer to a river) or placement of stones (the size showing promising sites for edible plants and animal habitats). Early burial sites and graves themselves provide some evidence of Paleolithic humans being familiar with some geometric thinking; specific objects of the deceased were placed in a proper place and alignment, often with respect to some solar or lunar phenomena (full or half-moons or solstices) or some specific landform features that were important in the sites of early settlements. The maps of land star charts of the night skies that were now being constructed and prepared in greater detail would and could also be duplicated more easily and carried about. These characteristics are a vital aspect of Bruno Latour's (1990) conceptualization of maps as immutable mobiles. In this sense, even at this

early time in human settlement and political history, the making of maps came to be associated not only with representing new knowledge about the human and environmental worlds, but as a source of power. Controlling what could be captured in a map and who possessed the map was important.

The earliest cartographers probably had a rather constrained level of power among other hunters, gatherers and herders in their clans and possibly even among the earliest agriculturalists because what they were depicting in some graphical form what was consider essential for human survival. However, as populations grew and more food sources became a priority and as the innate human instincts for knowing "what was beyond the immediate ecumene" increased, being able to illustrate that information and convey it in some form became essential. This included mapping the changing position of stars in the night sky, navigating seas and rivers and measuring important celestial phenomena, all which aided in the construction of calendars. It was not simply what was up or downstream from the encampment or beyond the forest or over the horizon that one observed daily, but where were the *terrae incognitae* to these earliest human families? It is indeed possible that gradually the clan artist or incipient map-maker achieved some sense of prestige within the community. They were an indispensable source of not only listening to what others reported or observed In their nearby daily activities and more distant journeys, but also was able to depict that information on materials that would help the hunter, gatherer and early agriculturalist have more successes and stability. That information was also of increasingly use and value to the clan or tribal leaders. In this sense the mapmaker emerged as someone with respect, power and prestige within the group, not only being able to "know" what was where, but being able to place that information on recordable stable media, fixing territorial limits and aiding governing and even military expansion.

Expanding the early ecumenes

We can and would expect as populations increased, people migrated to nearby and distant locations and sedentary settlements with agricultural and economies based on primary resources evolved and also that the need for map representations and mapping skills would increase. Cartography became an essential part of daily life for settlements, not in the sense that maps became associated with a prehistoric or early historic popular culture, but that someone who was officially being designated as both the "recorder and keeper" of vital geographical information and was also presenting that information to someone (usually someone in power) within the community or group. Many of the early surviving maps held in archives and museums depict the crafts of these early community cartographers. Long before paper appeared as a major source, maps were drawn on materials that would be enduring as noted above, including carvings on large animal bones, slabs of rocks and drawings in caves. Some of these early graphics were intricate in detail with specific geographical details about rivers and tributaries, mountains, sacred sites and depictions of places of power and prestige within the community. Some of these were also rich in designs (plants, animals and stars and sun) and also in color, which suggests that even in early historical periods of human settlement, maps were valued as pieces of scientific information and art just like the earliest celestial calendars, which also required some collective knowledge of "what happened when" (full and partial moons, eclipses, equinoxes and solstices) and also representing that time information in some useful and meaningful way not only for the resident population, but also for those in positions of political and religious power. Map artifacts and mapping practices again became associated with territorial control and ownership, military exploits and also seeking knowledge for scientific or commercial advantage. The "keeper of knowledge" was not only the person or persons in authority, but also the individuals who knew how to make the maps.

The production of maps and the distribution of cartographic knowledge increased with the use of velum, parchment and paper to represent "what was where" (see Woodward, 1975). The

innovation of a paper, which came from China, greatly increased the use of maps for several reasons. Firstly, it reduced one of key costs, and, secondly, it was easier to draw information on these surfaces rather than having to etch them into hard material. Thirdly was that one could make corrections and additions easier as all that was need was some pen and ink to add that information. Fourth, one could reproduce a map easier, even if it required much hand labor, and make it available to more users. Map artefacts could themselves travel. The earliest paper maps, of course, were hand-drawn maps as were the earliest graphical depictions of royalty palaces, temples, monuments and even plants, animals and humans. These graphical artists, as we would call them today, were important members of the powerful political and commercial communities as what they were engaged in was collecting, distilling, updating and representing information that could be useful to support a ruler's ambitions.

Religious representations of the known world, in the form of T&O maps (*orbis terrarum*, a seventh century way of depicting the world with Jerusalem at the center), dominated, with the pictorial approach based on geographic descriptions in ancient teachings and the centrality of places such as Jerusalem and Mecca. Western cartography would develop with the adoption of locational grids that provided universal ways to locate the position of points on the surface of the earth and then record this location and represent it accurately on a nautical chart or territorial map. One of the origins for this ability to map space can be traced back to the work of Claudius Ptolemy, an influential 2nd century CE Greco-Roman astronomer, and the rediscovery of his text *Geographia* at the start of Renaissance period. The adoption of his grid of latitude and longitude enabled new maps of the world to be constructed with greater scientific fidelity compared to most of existing mediaeval *mappamundae*. (**Figure 1.1**) The story of the development of techniques and different forms of geographic map representation from the Renaissance period onwards is well considered in volume one of the *History of Cartography* (Harley and Woodward, 1987; available free online at www.press.uchicago.edu/books/HOC/index.html).

Figure 1.1. An early attempt at a world map based on Ptolemaic projection and locational data from *Geographia* as published by J. Angelius in Bologna, 1462. Source: Bayerische StaatsBibliothek.

Methods of surveying subsequently developed that were able to measure accurately large swaths of territory using triangulation techniques which were advanced in the sixteenth century. These came to the fore as techniques underpinning the ambitious national topographic surveys that started in many Western counties (and some of their colonies) in the 18th century. This lineage leads directly to the detailed topographic cartography that forms the geographic framework for modern countries and the modes of government and commerce. (**Figure 1.2**)

Figure 1.2. An example of detail packed on a modern topographic map. This example by USGS from 1953 shows the city of Manchester NH and surrounding countryside. Source: USGS Historic Quad download, http://historicalmaps.arcgis.com/usgs/

While the sovereign, the church and even the early civil governments were the primary promoters of collecting of geospatial information (through royalties' sponsoring nearby surveys, and more distant discoveries (such as the Spanish / Portuguese 'age of exploration' in the fifteenth centuries), there were private ventures and sponsors wanting the same information. Maps were indeed prized and coveted documents that were deemed 'secret' and valued for supposed exclusive commercial, military and strategic purposes. Harley (1989) shows how the Casa de la Contración maintained the *Padrón Real* in the early 16th century as a secret master map to protect the key discoveries of Spanish explorers. In this environment the rivalry for funding knowledge-expeditions and finding "what was where" became a high priority for extra-continental exploits before and during the

periods of exploration and discovery, notably with European sailors in the 14 and 15th centuries in and around Africa and Asia. The development of long distance sailing technologies went hand in hand with cartography advances. These emerging and expanding worlds of geographical knowledge fueled the demand for maps for those in political and military positions of power, traders and commercial colonists, scientific communities and religious elites.

The state became the major source for developing cartography and fueling the demand for professionally trained cartographers and early geographical scientists. This was also the time the states were developing military institutes, which often included surveying and cartographic units, which in tandem served the state's interests of knowledge production and representation and territorial control. New and multiple single maps appeared in atlases of Africa, Asia, the Pacific, and the Western hemisphere, a far different set of *terrae incognitae* than those representing the earliest human settlement geographies and cartographies.

More recent cartographic histories

Most of the earliest maps produced by the state or by individuals showed the "known world" or parts of the space that had been well explored and recorded, for example, the ports and coastlines shown on Portolan charts from the 13th century (Pflederer, 2012). These earliest maps contained locational information about important cities and settlements as well as major physical features, including mountain ranges, rivers and road routes. Well known surviving examples, in the European context, include the Peutinger Table (circa. 13th century copy of a 4th century original) and the mid 1300s Gough map of Great Britain. However, many of these early maps also depicted areas where little was known of what was there; filling in the "empty" places with animals and strange looking peoples (to Europeans as the map producers and readers). Some places on maps delimited territories as these represented where one had or was thought to have ownership and political control.

Geographers and other spatial scientists also valued this evolving knowledge in teaching students and informing the curious public about "what was there," whether about the physical terrain, navigable rivers and port cities, new and different cultures or potential mineral possessions or valuable agricultural regions producing desired products for home countries. New world maps and atlas in the 15th century were produced by the celebrated European cartographers/publishers such as Martin Waldseemüller, Abraham Ortelius and Gerhard Mercator. Some of these new spaces also became areas for new settlements associated with colonization outside the European continent.

Figure 1.3. *The Geographer*, by Johannes Vermeer, c. 1668–1669. The scene illustrates the practices of geographical science in the 'age of discovery', producing knowledge though topographic maps, navigation charts and terrestrial globes. A framed world nautical map hangs on the wall. (Oil on canvas, 52 x 45.5 cm.) Source: http://en.wikipedia.org/wiki/The_Geographer

For most of what might be considered scholarly "cartographic history," a period that would include most of the past five hundred years, the words "map," "globe" or "atlas" were associated with producing the kinds of physical, environmental or exploratory maps of territories described above. Government-produced maps and commercially produced ones for the ever growing knowledge-hungry public, especially with the rapidly expanding urban-industrial populations in the 19th century and widespread primary education and promulgation of middle class sensibilities (including leisure travel and later mass tourism). These new demographic groups were curious about distant lands and changing nature of nearby places and filling in "the gaps" with information about physical environmental settings and peoples and their cultures. This cartographic and pictorial information (globes, wall hung world maps, bound atlases) became standard information

for classes on geography and history. It was only later with more detailed information gathered on organized scientific expeditions that additional topics appeared about climates, vegetation and physical features of "newly discovered" inhabitants. (For example, consider the maps derived from the survey work of Alexander von Humboldt in central and South America at the start of the 19th century; Malcolm, 1987; **Figure 1.4**) Here we are referring to maps that would also show trade routes, heathen populations, colonial lands and economically-valuable resources. Territories and boundary claims ('mine-versus-yours') and changes as a result of conflicts also entered the picture. This is well encapsulated in geopolitical cartography, for example Halford Mackinder's famous 1904 "Geographical Pivot" of history with his 'heartlands' map (cf. Dodds and Sidaway, 2004). **Figure 1.5** These topics not only became the standard fare for thematic maps in multiple printed public and school atlases, but also as content of elementary, high school and university geography textbooks (Cosgrove, 2012). Geography to many of the teachers of the subject and students was a field of study associated with descriptive materials (graphs, globes and thematic maps) about landforms, climates and vegetation as well as about agricultural, mineral and manufacturing economies and generic cultural features (including stereotypical and racist anatomical characteristics such as skins color, facial structures, hair styles, etc.; (cf. Crampton, 2006), religious architecture, demographic counts, densities and trends. The development of lithographic printing techniques enabled more detailed maps to be produced more cheaply. The making of maps, or cartography, was closely associated with geography and geographers. Geographers made maps and used maps because they were considered essential elements in understanding about the planet's known and little known physical environments and cultures, and about the intersections between the natural processes and human sphere at global, regional or local scales. During the middle of the 19th century many significant national geographical societies were formed. (The French Société de Géographie was founded in 1821, the Royal Geographical Society was formed in London 1830, the American Geographical Society in New York City in 1851.) Although these institutions promoted scholarship, data collection and cartography, their exploration mission was often fused to the interests of colonialism and corporate exploitation (cf. Driver, 2001).

Figure 1.4. The influential sketch map, entitled "The Natural Seats of Power," visually formulated the notions of zones of geopolitics. Source: Mackinder, 1904, 435.

Figure 1.5. Map of plant species on Mount Chimborazo 1803, in which Alexander von Humboldt's sought to demonstrate of the influence of altitude and climate on vegetation patterns. Source: R. Paselk, http://www2.humboldt.edu/scimus/AvH_HSU_Centenial Exhibit

The national geographic and cartographic histories discussed above were consistent with major changes occurring in most European and North American countries throughout the first half of the 20th century. States and their scientific societies were both the major producers, consumers and disseminators of much geographical information that was collected by explorers and scientists and also reported in scholarly journals. That information not only included descriptions, as geography was still primarily a data-collecting and descriptive pursuit as were most other natural sciences at the same time, but also the production of maps with information about physical terrain, inhabited places, climates and vegetation, and probably most importantly, territorial control. That information was also the source of much of the information included in school texts at both elementary, secondary school and also university levels. Geography was considered a key discipline where the subject matter about places, economies, cultures, and environments were of central importance to the state. It also played a key role in territorial and extraterritorial conflicts and also competition for such spaces. Boundaries and borders, whether on land, in rivers or across the oceans, were important issues in resolving local, regional or global disputes. All wars in the 20th century were played out with geographical "factors" being important in possession and control,

whether in Europe, Asia or places of territorial competition in South, Southeast and East Asia, the Middle East or colonies throughout the African continent. The associations of geography with national government policies and military control, including during the Cold War from the 1950s through the 1980s, are stories about map production and propaganda that only came to be topics of serious scholarly inquiry in the 1960s and 1970s, after the end of the Cold War, the emergence of the Third and Fourth Worlds, the end of colonialism, the rise of petro economies and the later emergence of Asian 'Tiger' economies and the rise of China as a regional and world economic and political power (cf. Pickles, 2000).

Sea changes

While changes were occurring within the geography discipline, there were also changes emerging in other disciplines. In regards to geography the aforementioned standard "mix" of topics studied and mapped began to change from the post-war period, especially into the 1960s and 1970s with new themes and topics being studied by geographers (cf. Johnston, 1996). These included economic development, environmental quality and change, and geopolitics or the intersections of power and politics. Cartography can also be added to this list. Maps and mapping were "stretching across the humanities and sciences" in ways unheard of at mid-century. Some geographers actively pursued "geography as a science" in which they sought with statistical modeling and testing to provide more "rigor" to understanding aspects of human behavior and spatial thinking. The developments in behavioral geographic and interest in the cognitive basis of spatiality broadened the understanding of the "worlds" or "environments" or "locations" studied by physical, human and human/physical geographers. Cognitive mapping or mental maps were terms that emerged and were studied by scholars with cultural, economic, political and social backgrounds (Montello, 2002). A similar "scientific" disciplinary mindset was also emerging in the other social sciences. This "scientific" fabric influenced the growth in aviation along with the impact of aerial photography, both which were highly significant in changing the nature of comprehending space and envisioning place (cf. Dorrian and Pousin, 2013). Sputnik, the imagery of the Earth from the Apollo missions, Skylab and Landsat and SPOT satellite remote sensing were all changing the ways scholars looked at the earth from above (the "Blue Marble" concept) and from below. Ever cheaper and more capable global telecommunications, remote sensing, computer graphics and digital cartography were integral parts of these emerging information revolutions (production, consumption, exchanges, manipulation and representations) sweeping across the sciences first and later the humanities as we discuss below. (See the debate conducted in 2000 by John Pickles and Michael Goodchild in their papers in *Cartographic Perspective* journal.)

The emergence of transdisciplinary global development initiatives and post-colonial worlds led to focusing on a new series of topics associated with economic (the so-called 'Third World' and developing worlds as emerging fields of study), and later, social development, disasters and hazards, improved weather forecasting, income gaps and especially poverty, petro-based economies, globalization and postindustrial societies. The Cold War conflict noted above, between the Western and Eastern blocs, itself was a dominant geographical factor that was fought in part through cartography (cf. Barney, 2015). It was a world with new knowledge subfields associated with transportation, trade, education, health care and diseases, tourism, social well-being, along with topics associated with race and ethnicity, language, religion, children, and gender and political/geopolitical themes related to conflicts (local and regional) including boundary changes, military power and defense agreements, political conflicts and border disputes, and developing environmental concerns related to biodiversity, endangered species, environmental protection, air and water pollution and later climate change. The spate of new topics soon began to appear as "new" maps in regional and world atlases as well as maps in primary, high school and university textbooks. This included unconventional designs, such as the use of cartograms, as maps that

deliberately distort spatial scale as a way to stimulate thinking about social patterns being represented (e.g., Seager, 1990, 1997; Dorling, 1995; Kidron and Segal, 1995). New map projections were produced and maps themselves could be produced almost instantly that are centered anywhere on the planet. Such efforts were not without controversy, a point well-illustrated by the attempt by Arno Peters (and the so-called 'Peter's Projection;) to re-frame the world in the early 1970s in the service of progressive interests with a novel equal-area projection that challenged the cartographic hegemony of the centuries' old familiar Mercator conventions (Monmonier, 2005). Maps were produced not only of new and previously unmapped or little mapped places on Planet Earth, but on surfaces beyond earth: the Moon, Mars, Venus and then the diverse satellites of the outer gas giants.

In short, the field of geography was undergoing dynamic disciplinary changes, but so were the topics of maps in texts and atlases produced for the ever evolving geographically-curious public (cf. accessible review given by Hall in 1992). At the same time some of the spatial thinking and cartographic representations were starting to diffuse to other related and previously unrelated fields with common themes for the geography community, viz., surfaces, networks, landscapes, places, regions and environments.

Contemporary developments

The increased social and environmental awareness that was apparent in the training of geographers in the 1970s and 1980s was increasingly evident in the atlases produced and the maps appearing in standard school and university texts. Two additional changes contributed to this evolving nature of the geography discipline and to the importance and understanding of maps and mapping. One was the introduction of new technologies associated with gathering, processing and producing representation of a "location" or "place" nature and what Michael Goodchild (2000) has characterized as the digital transition in cartography. These included computer, GIS and satellite technologies based on digital data, graphic information exchanges and powerful web-based dissemination, such as Google maps service. These innovations ushered in whole new scales of data gathering and map analysis from individual surveillance to extraterrestrial environments. Mapping went from the earth and earth surface, or from cities, countries and earth regions, to being associated with visualizing the body and the brain to studying the earth's deep interiors and outer space. Rather than distinct surveys, mapping in some domains happens continuously with results delivered in near real-time to users. No longer was cartography simply a field that was mapping earth space, but now associated with whole spectrum of spatial and temporal scales.

Coupled with these technology-related developments was a second change in what was considered geographical analysis and place knowledge in different scholarly fields. This change was evident especially across the humanities and in the natural and social sciences. There were changes in the way these subjects were considered, including some for the first time. Spatial concepts and modes of enquiry were emerging. These introductions of commonly understood concepts familiar to geographers (including map display) about place, location, networks and environment in disciplines were emerging in disciplines that had long ignored them (cf. Scholten et al., 2009). Some have gone as far as to characterize this development as a 'Spatial Turn' (Warf and Arias, 2008; see also Penz et al., 2004).

For example, it is also apparent now that place has become an important concept for those studying literature, as well as for many writers, poets and lyricists. It was a theme important in understanding a society's culture or role within a larger cultural or multicultural complex (for recent reviews see Caquard and Cartwright, 2014; Cooper et al., 2015; Rossetto, 2014). Place itself is also an important to understanding historical and contemporary religion, language diffusion,

gender and identity issues, popular culture and the human imagination. Ethnomusicologists, literary scholars, media theorists, drama, theater and museum studies began to value the importance of place, spatial relations and geographical embeddedness (e.g. in relation to human experience Van Swaaij and Klare, 2000; and film, Conley, 2007; Hallam and Roberts, 2014). What this emergent thinking led to was a recognition that map representations and mapping practices in particular places were well worth analyzing. Particular places, regional contexts and environmental situations form unique locations where "things happened" begun to be considered by those who studied not only tourism and recreation, consumer preferences and population migration, languages and dialects, border cultures and social networks, but also those who studied transboundary economies and conflicts, international laws, regional social and economic development and planning, place promotion and preservation, infrastructure (transportation and communication) impacts and public policies. All these are examples of fields of study where maps and mapping have intersected with existing empirical techniques, modes of analysis and theoretical advancements.

The social sciences and humanities uses of map representations and mapping practices were also occurring with scholars working in various science-technology fields as well. Beyond physical geography and the earth sciences, maps are now considered fundamental to those studying the human brain and anatomy, climate modeling, natural hazard prediction and disaster planning. The "visual" world has taken on a new meaning, we would argue, with the emergence of novel maps and mapping analysis, a development that goes well beyond what has conventionally been considered as "geography." These are currently all fields where map representations and mapping practices are now considered "part and parcel" of learning about places and environments at all scales, but also making sound policies for humankind's present and future.

Mapping practice is embedded in academic processes

We would argue that "mapping matters" in scholarship as a way to simplify and summarize, which is ever more crucial in science and technology, with the need to produce plausible models of reality, cope with the exponential growth in data and theoretical complexity. Mapping can help researchers work efficiently and also explore problems from new perspectives. Mapping then is part of current 'battle' for academia in utilizing the 'information explosion' and 'big data' with the hope that these developments will to lead to a better understanding and an expansion of knowledge. Concepts can be spatially envisioned and geographically mapped and also aid in our understandings and communications with other audiences. They can also be aid in efforts to convince others about the truth of the ideas (be they fellow scholars, policy-makers in government, or business investors).

Obviously, much of the above contemporary about the role for mapping can be read as part of a wider image-based working and about the primacy for the visual in scholarly practice, at least since the Renaissance. John Barrow's 2008 book catalogues this well and reminds us of the long history of powerful scientific imagery that can encapsulate a complex idea and help communicate it in compelling fashion. Barrow (2008: 2) argued that:

> "some images defined our step in understanding the Universe, others have proved so effective in communicating the nature of reality that they are part of the process of thinking itself, like numbers or the letters of the alphabet. Others, equally influential, are so familiar that they appear unnoticed in the scientific process, part of the vocabulary of science that we use without thinking."

Understanding the cultural roots of visual representation as a primary means of producing believable 'truth' and convincing wider scientific communities has been the focus of much work in

Science and Technology Studies. They have documented how this kind of change happens, often in mundane daily practices in labs, university classrooms and through pages of journals (e.g., Baigrie, 1996; Latour, 1990; Shapin and Schaffer, 1985). The powerful potential of diagrams and spatial order is that they can impose provide and develop a deeper understanding to what is being studied in a spatial context, a development similar to the development of the Periodic Table and its impact on chemistry and wider material sciences (Scerri, 2007). Some recent related comparative work explores these intersections, especially how different kinds of charts, diagrams, technical images, and visual practices are played out in different disciplines (Elkins, 2007; Lynch and Woolgar, 1990; Rose, 2015).

Also, some scholars have argued that the last decade or so has seen a 'spatial turn' in a number of scholarly disciplines that have previously been a-geographical and lacking in cartographic communication (Warf and Arias, 2008; Scholten et al., 2009; Penz et al., 2004). Indeed, there is much evidence of a new creation and new application of cartographic representations and map-like visual artifacts, the use of the concept of geographic location scale, spatial flows and place embeddedness (for example in explaining scientific discovery and the network of technological diffusion, Livingstone, 2010), and also community mapping projects within the context of PPGIS (Public Participation GIS). Mapping as an approach and the value of GIS tools, for example, has grown in importance in the arts (e.g. scholarship around film and cinema: Conley, 2007; Hallam and Roberts, 2014) with some claiming the emergence of Geohumanities paradigm in recent years (Bodenhamer et al., 2010; Dear et al., 2011; Fraser, 2015). This change has been defined as a "transdisciplinary and multi-methodological inquiry that begins with the human meanings of place and proceeds to reconstruct those meanings in ways that produce new knowledge and the promise of a better-informed scholarly and political practice" (Dear et al., 2011: 312). There is also active engagement in mapping practices and often the actual production of cartographic forms by a growing number of artists (see reviews in Harmon, 2009; O'Rourke, 2013).

Relevant to the discussion here, it is worth noting those efforts to categorize and visually map the patterns of knowledge itself. This has often been done by applying spatial structure and drawing some kind of graphical representations of the size of fields of scholarships and connections between expert practice. For example in the 1780s French philosophers of science Diderot and D'Alembert illustrated their pioneering *Encyclopedie* with hierarchical decomposition of the domains of knowledge (cf. Bender and Marrinan, 2010) (**Figure 1.6**). Subsequently many others have tried to produce genealogical trees to show change and growth in academic disciplines and fields of knowledge. Moving beyond simple hierarchy and linear branching, some have used different diagrammatic approaches and spatial arrangements to show the structure of science. There are map-like displays using spatial proximity and a visual clustering together of activities that are intellectually similar. (We intuitively understand that things close in space are likely to be similar in character). (**Figure 1.7**) Advances in bibliographic science since the 1940s and, in particular, the creation of comprehensive citation indexes of academic literature have facilitated analysis of knowledge space through co-citation patterns and collaborative networks of researchers. The results of such analysis have most often been mapped as simple link-node diagrams, but sophisticated map-like displays have been developed in recent decades that frequently draw on ideas from information visualization (cf. Borner et al., 2003; Skupin and Fabrikant, 2003). Many examples are documented in Katy Borner's recent synthesis, *Atlas of Knowledge* (2015).

Figure 1.6. An attempt to bring structure to burgeoning scale of recorded information in the European Enlightenment. This hierarchical diagram, a 'tree of human knowledge'; its taxonomy is an attempt organizes knowledge under three main branches, "memory"/history,

"reason"/philosophy, and "imagination"/arts. It was deployed as an illustration in Diderot and d'Alembert eighteenth century *Encyclopédie*. Source: https://en.wikipedia.org/wiki/File:ENC_SYSTEME_FIGURE.jpeg

Figure 1.7. A pioneering hand-drawn mapping of the structure of the natural sciences and technology as interpreted by Harold Ellingham (1948), a physical chemist working in mid twentieth century. He uses the spatial metaphor of distance equating to intellectual similarity. The direction and orientation of name labeling is also used to denote commonality between fields of study. The overlaid polygons showed how different scientific abstracting services at that time were covering. Source: Ellingham 1948, Courtesy of the Royal Society.

Developing '*Mapping Across Academia*'

This book represents an attempt, edited by two geographers but consciously drawing on a wide range of subject specialists, to delineate and discuss the importance of map representations and mapping practices across the scholarly landscape. We made a decision to edit a such volume with expert contributors from many other disciplines who both appreciate and understand the role of maps and mapping in non-traditionally geographic domains and sometimes fields of study that have been wholly a-spatial in the past. While geography, geology and other environmental sciences have long traditions of studying and using maps in their teaching, research and theory construction, and public communication and policy contributions, there are other new subjects where the making and use of maps are emerging as important perspectives and also providing valuable ingredients in what is studied. Here we would refer to map representations and mapping practices associated with the study of language, film, literature, religion, music, architecture, security, sustainability, but also with respect to studying human anatomy, and neurology. Maps are not only being employed to organize data and "show" where something is, but for providing new insights into interpreting and analyzing the problem and generating explanations and theory.

We would be the first to argue that more work needs to be done on the fields of study addressed in this volume and, of course, to those academic disciplines not covered in the context. Not included would also be the importance of maps related to what we could identify as "intersecting" fields which are emerging as the important arenas for present and future scholarly inquiry. These intersecting fields would include human consciousness and machine intelligence and faith/belief systems, preservation, climate change, environmental security, and shared futures in the Anthropocene. It is not difficult to envision dozens of maps that one could prepare that would help understand the interfacing subject matter, but also solve or resolve conflicts that might/will emerge.

We sought thoughtful and original essays that reflect upon the role of map representations, mapping practices and spatial understanding in a particular transdisciplinary disciplinary area. We tasked domain experts to consider how maps, broadly conceived, contribute to scholarship in other fields in terms of generating novels ideas, conducting empirical research, presenting and analyzing data, understanding spatial structures and patterns, and in disseminating results and communicating to different audiences. Authors could be personal, anecdotal, and opinionated.

The book is conceptually divided into two major sections - the sciences and humanities - and includes 15 chapters on different intellectual areas and related disciplinary fields (**Table 1**). Our selection and the division of academic endeavor was inevitably somewhat arbitrary but has provided a diverse and widely representative coverage and one that we believe will provoke an insightful range of essays. We hope this review of past and current mapping research challenges

across disciplines will enhance our understanding of spatial processes and geographic visualization at scales ranging from the molecular to the galactic.

Table 1. Organization of *Mapping Across Academia*.

Section One: The Sciences

Intellectual areas	Academic experts
Chap 2: Geomorphology	Mike Smith and James Griffiths
Chap 3: Cities and planning	Amy Hillier
Chap 4: Ecology	David Barnett and colleagues
Chap 5: Astronomy	Richard Gott
Chap 6: Anatomy, human body	Jane Garb
Chap 7: Neuroscience	Jordan Harp and Walter High
Chap 8: Weather	James Carter
Chap 9: Health and disease	Lance Waller

Section Two: The Humanities

Intellectual Areas	Academic experts
Chap 10: Language, linguistic	Roland Kehrien
Chap 11: Landscape	Kenneth Olwig
Chap 12: Power and Geopolitics	Edoardo Boria
Chap 13: Literature	Andrew Frayn
Chap 14: Musicology	John Gold and colleagues
Chap 15: Culture	Ann Kingsolver and colleagues
Chap 16: Religion	Lillian Larsen

Where we go from here

It is our hope that this book serves three purposes. First, that it informs increasingly growing academic communities and cross-disciplinary groups of scholars about the importance of map representations and mapping practices subject matter at multiple scales (from the sub-atomic, genetic social, planetary and to expanded universes). Second, that it will encourage scholars who work in the fields and subfield discussed to continue exploring, and perhaps expands the uses of maps in their instruction and research. Third, that the book will stimulate others to explore those fascinating intersections in intersecting and emerging subject matter across the sciences, humanities and public policies. In this way future scholars and students, whether in classes, seminars or workshops, will observe not only the importance of producing maps, but also recognize their basic importance in providing a sound understanding of visual representations and knowledge in "what happens where, when and why."

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Figure 1.1


CAVRVS
CIRCIVS
SEPTENTRIO
AQVILO
SVNVRVTVL
LIBIA INTERIOR
ETHIOPIA INTERIOR
LONGITVDO ELVS STADIORVM 60000
LONGITVDO ELVS STADIORVM 16000
TERRA INCOGNITA
REGIO BARBARICA
SINVS BARBARICVS
MARE
INDICVM
CIRCVLVS
CAPRICORNVS
EQVATOR
PERSICVS
SCITHIA
SACHA
REGIO
INDIA INTRA GANGEM
GANGES
ARABIA
ETHIOPIA
LIBIA TOTV EGIPTVS
FORTVNATE INSVLA
CIRCVLVS CANCRI
CIRCVLVS EQVINOCIALIS
CIRCVLVS ZODIACI
NOTVS
VRONOTVS
EVRVS
VRICVS
VESTER

Figure 1.2

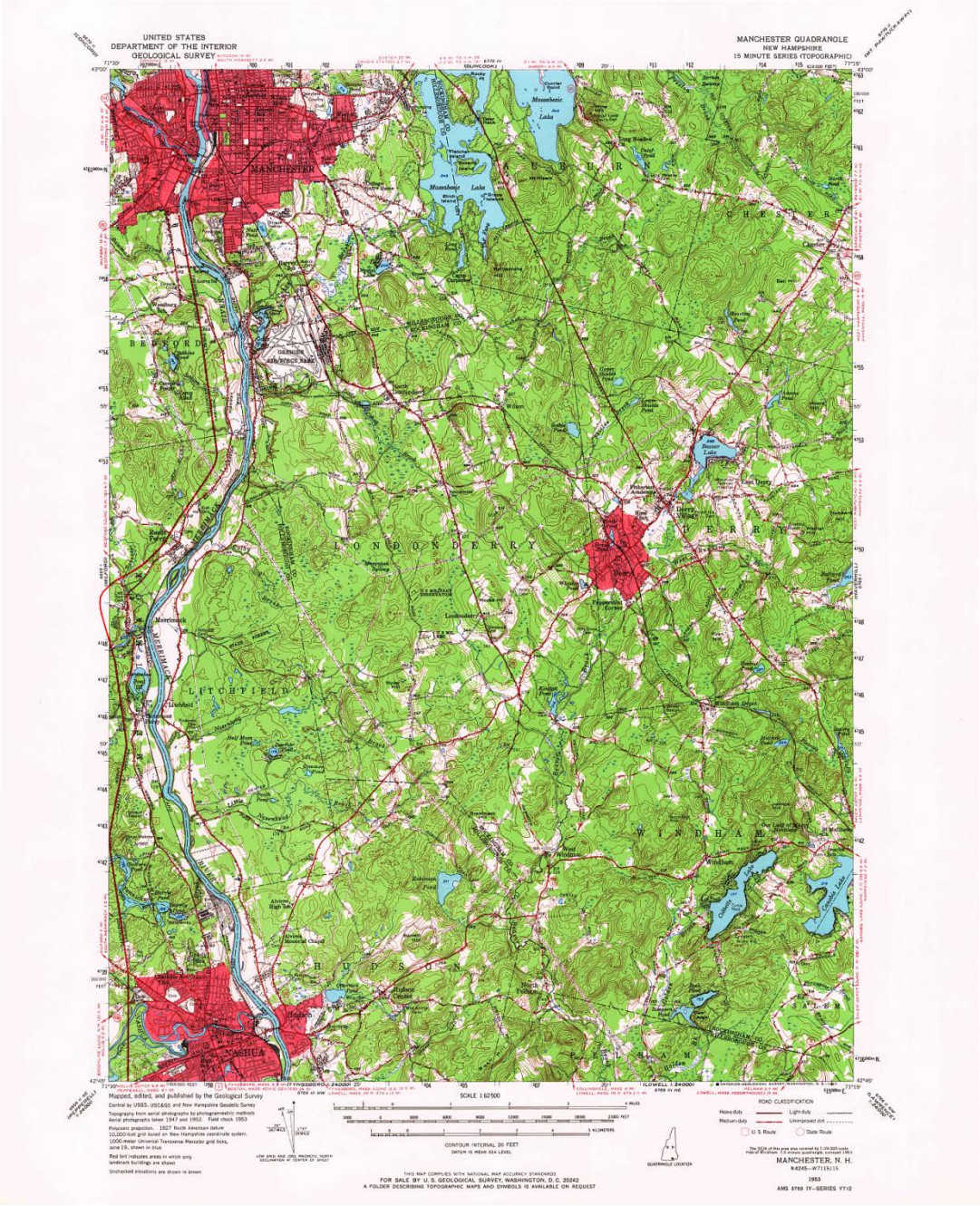

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
MANCHESTER QUADRANGLE
NEW HAMPSHIRE
15 MINUTE SERIES (TOPOGRAPHIC)
MANCHESTER
BEDFORD
LONDONDERRY
DERRY
LITCHFIELD
WINDHAM
HUDSON
NASHUA
Mapped, edited, and published by the Geological Survey
SCALE 1:62 500
CONTOUR INTERVAL 20 FEET
ROAD CLASSIFICATION
MANCHESTER, N. H.
1953

Figure 1.3

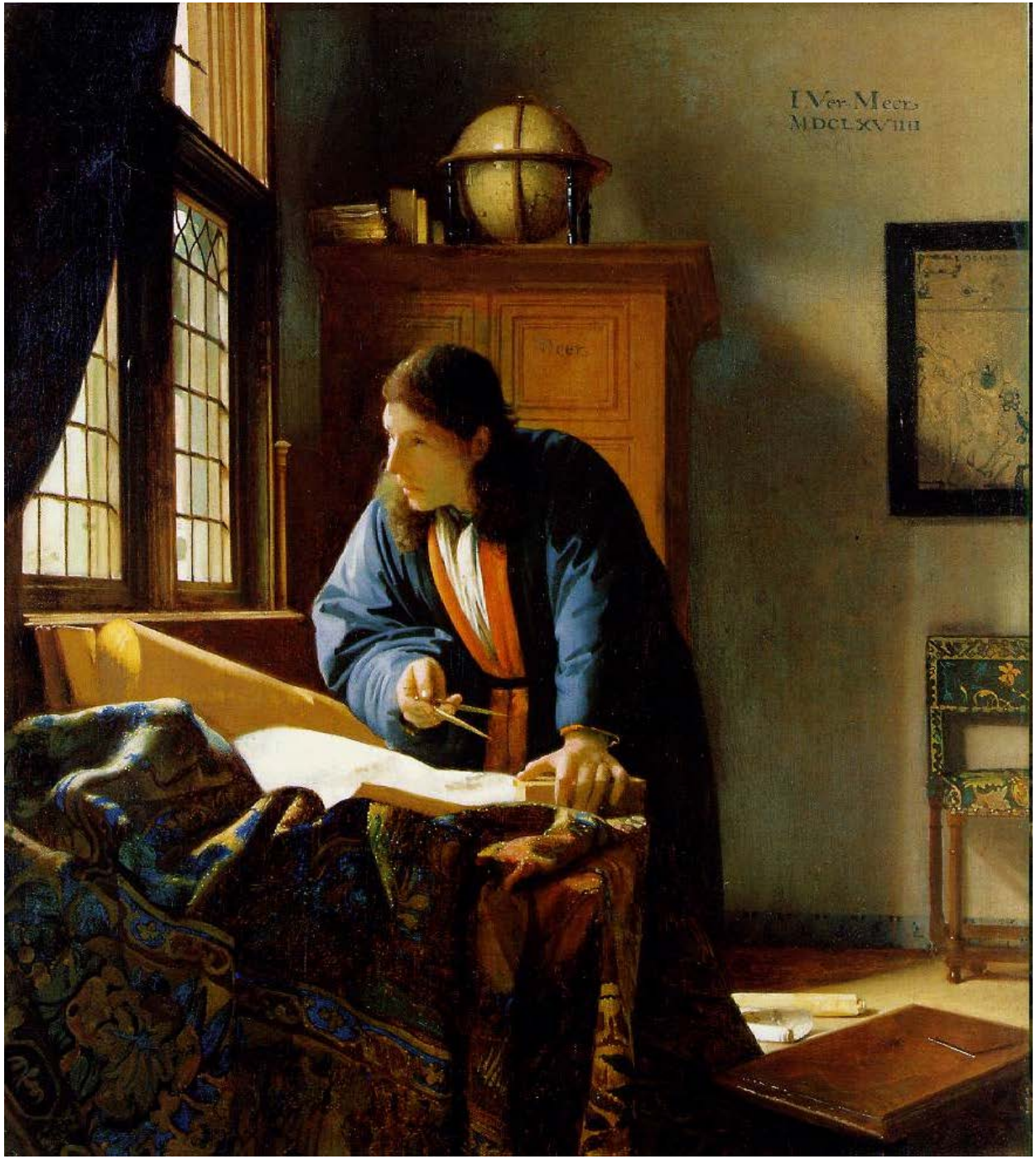


Figure 1.4

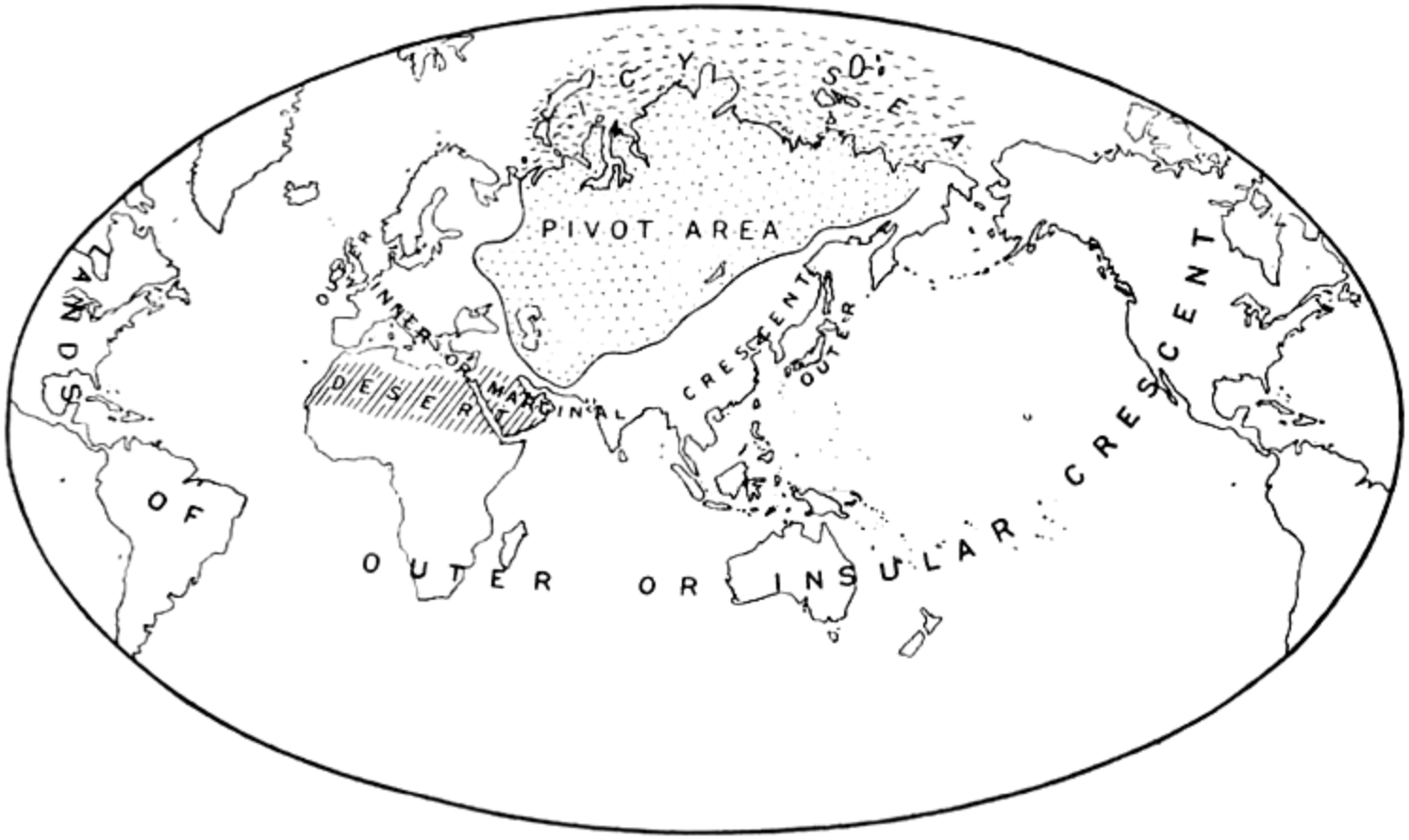

ICY SEA
PIVOT AREA
OUTER
INNER OR MARGINAL CRESCENT
DESERT
OUTER
LANDS OF
OUTER OR INSULAR CRESCENT

Figure 1.5

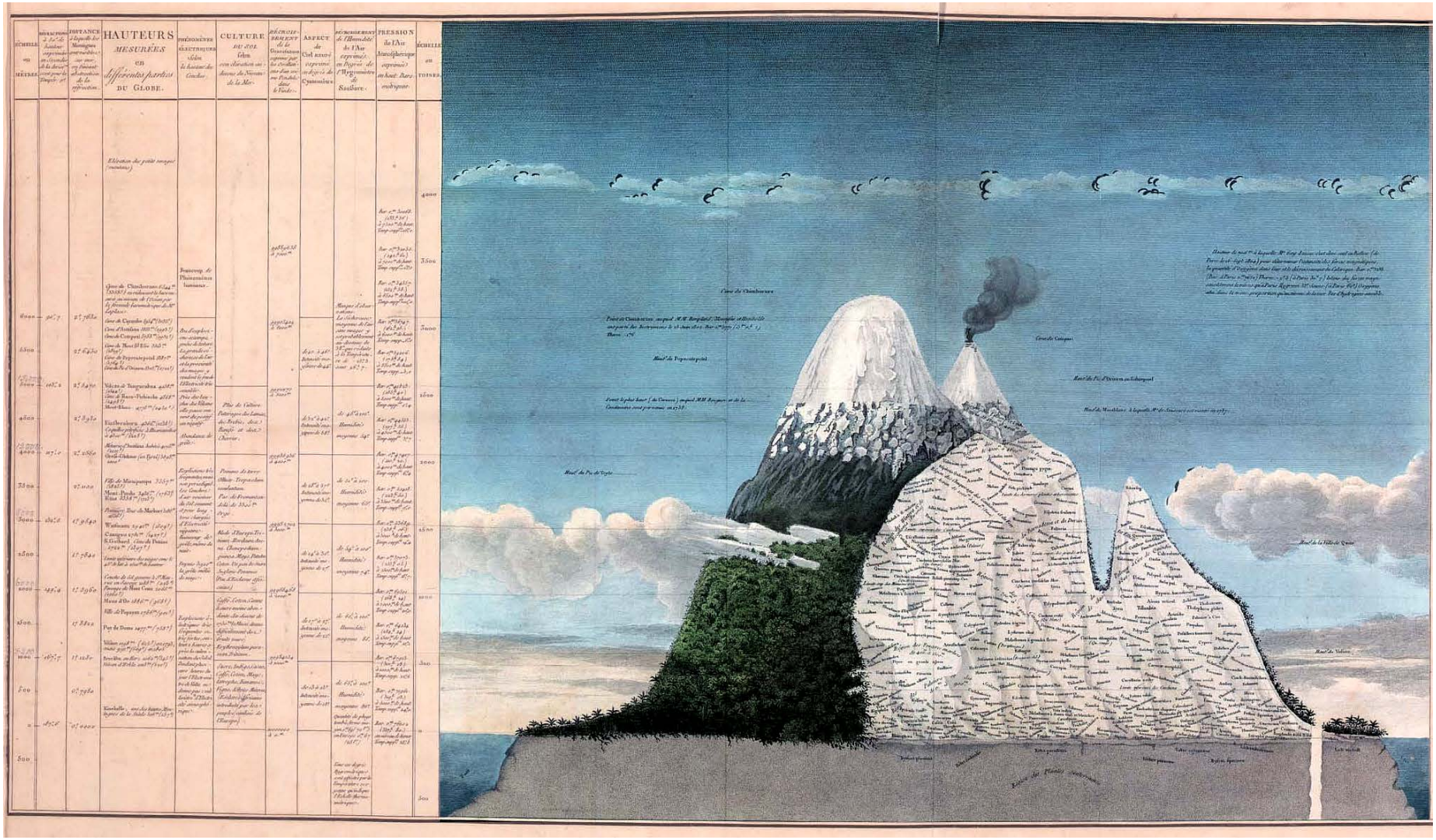

HAUTEURS
MESURÉES
EN
différentes parties
DU GLOBE.
Cone de Chimborazo
Cone de Cotopaxi
Mont du Pic de Teyde
Mont de la Ville de Quito
Mont du Volcan

Figure 1.6

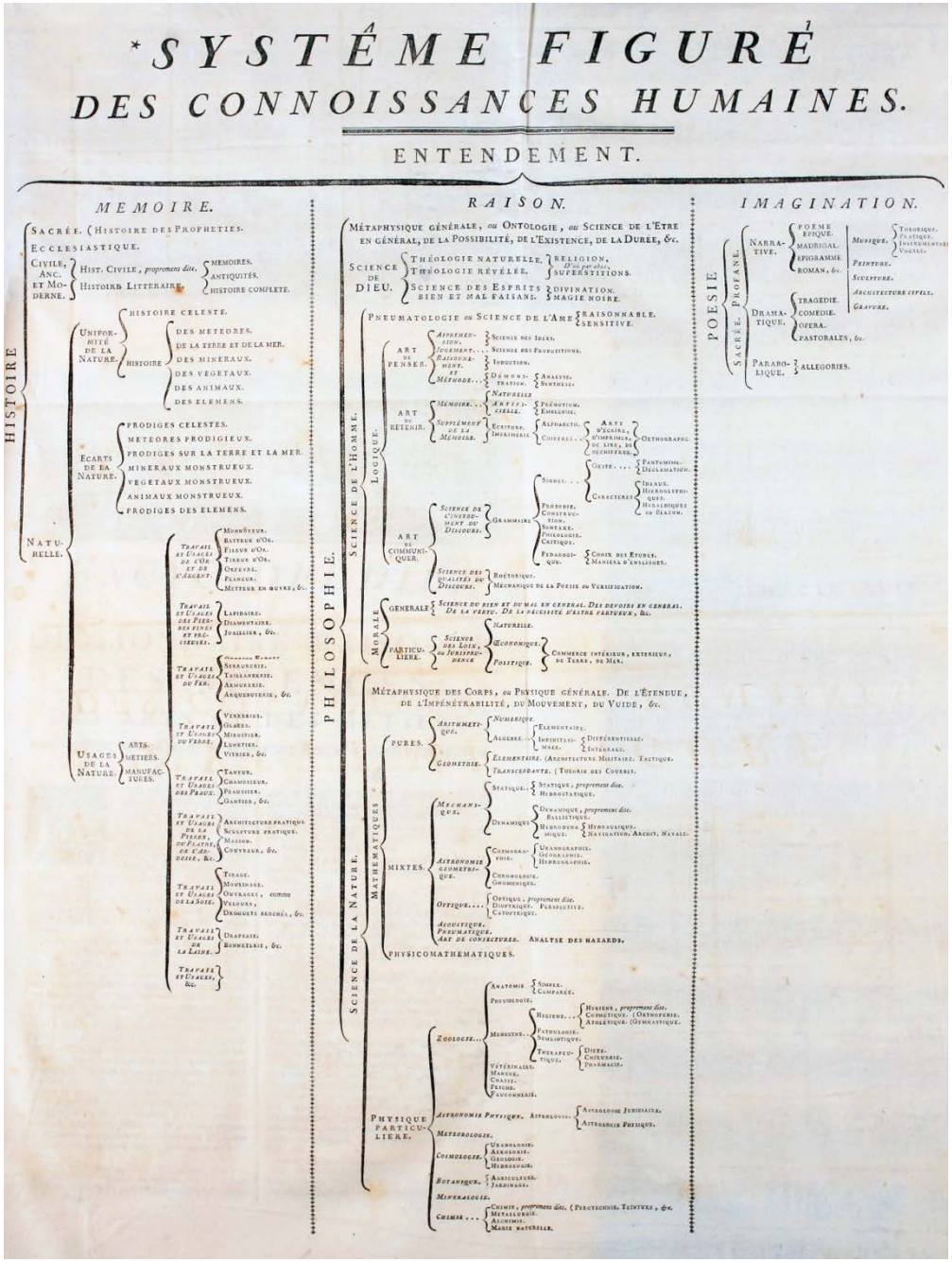
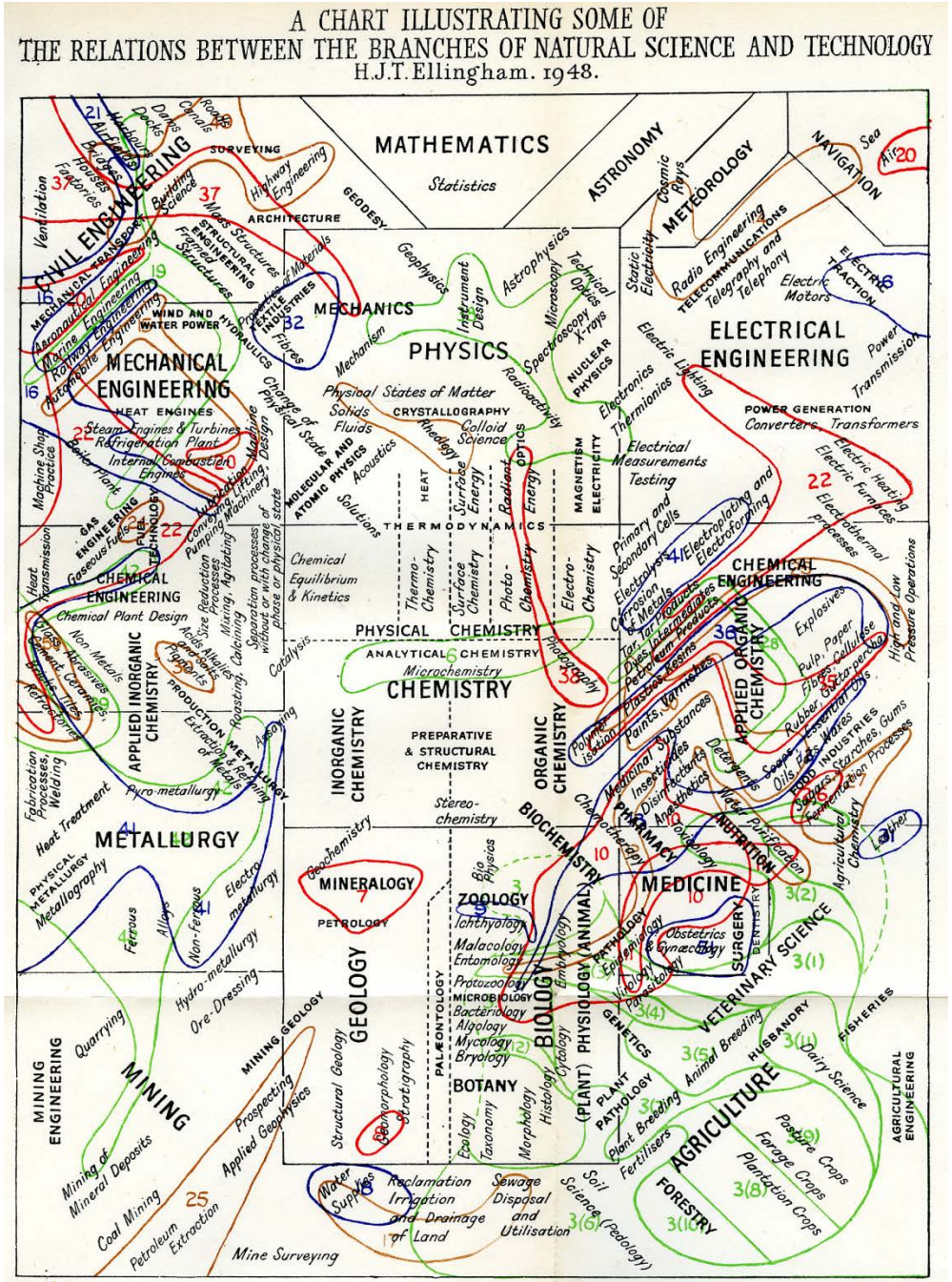

SYSTÊME FIGURÉ
DES CONNOISSANCES HUMAINES.
ENTENDEMENT.
MEMOIRE.
HISTOIRE
SACRÉE. (HISTOIRE DES PROPHETIES.
ECCLESIASTIQUE.
CIVILE, ANC. ET MODERNE.
HIST. CIVILE, proprement dite.
HISTOIRE LITTERAIRE.
MEMOIRES.
ANTIQUITÉS.
HISTOIRE COMPLETE.
UNIFORMITÉ DE LA NATURE.
HISTOIRE
HISTOIRE CELESTE.
DES METEORES.
DE LA TERRE ET DE LA MER.
DES MINERAUX.
DES VEGETAUX.
DES ANIMAUX.
DES ELEMENS.
ECARTS DE LA NATURE.
PRODIGES CELESTES.
METEORES PRODIGIEUX.
PRODIGES SUR LA TERRE ET LA MER.
MINERAUX MONSTRUEUX.
VEGETAUX MONSTRUEUX.
ANIMAUX MONSTRUEUX.
PRODIGES DES ELEMENS.
NATURELLE.
USAGES DE LA NATURE.
ARTS.
METIERS.
MANUFACTURES.
TRAVAIL ET USAGES DE L'OR ET DE L'ARGENT.
MONNOYEUR.
BATTEUR D'OR.
FILEUR D'OR.
TIREUR D'OR.
ORFEVRE.
PLANEUR.
METTEUR EN ŒUVRE, &c.
TRAVAIL ET USAGES DES PIERRES FINES ET PRECIEUSES.
LAPIDAIRE.
DIAMENTAIRE.
JOAILLIER, &c.
TRAVAIL ET USAGES DU FER.
SERRURIER.
TAILLANDIERIE.
ARMURERIE.
ARQUEBUSERIE, &c.
TRAVAIL ET USAGES DU VERRE.
VERRERIE.
GLACES.
MIROITIER.
LUNETTES.
VITRIER, &c.
TRAVAIL ET USAGES DES PEAUX.
TANEUR.
CHAMOISEUR.
PEAUSSIER.
GANTIER, &c.
TRAVAIL ET USAGES DE LA PIERRE, DU PLATRE, DE L'ARDOISE, &c.
ARCHITECTURE PRATIQUE.
SCULPTURE PRATIQUE.
MASSON.
COUVREUR, &c.
TRAVAIL ET USAGES DE LA SOIE.
TIRAGE.
MOULINAGE.
OUVRAGES, comme VELOURS, DRAGUETS BROCHÉS, &c.
TRAVAIL ET USAGES DE LA LAINE.
DRAPERIE.
BONNETERIE, &c.
TRAVAIL ET USAGES, &c.
RAISON.
PHILOSOPHIE.
SCIENCE DE L'HOMME.
MÉTAPHYSIQUE GÉNÉRALE, ou ONTOLOGIE, ou SCIENCE DE L'ETRE EN GÉNÉRAL, DE LA POSSIBILITÉ, DE L'EXISTENCE, DE LA DURÉE, &c.
SCIENCE DE DIEU.
THÉOLOGIE NATURELLE.
THÉOLOGIE RÉVÉLÉE.
RELIGION.
SUPERSTITIONS.
SCIENCE DES ESPRITS BIEN ET MAL FAISANS.
DIVINATION.
MAGIE NOIRE.
PNEUMATOLOGIE ou SCIENCE DE L'AME
RAISONNABLE.
SENSITIVE.
LOGIQUE.
ART DE PENSER.
APPREHENSION, JUGEMENT, RAISONNEMENT, ET MÉTHODE.
SCIENCE DES IDEES.
SCIENCE DES PROPOSITIONS.
INDUCTION.
DÉMONSTRATION.
ANALYSE.
SYNTHESE.
ART DE RETENIR.
MÉMOIRE.
NATURELLE.
ARTIFICIELLE.
PRÉMOTION.
EMBLEME.
SUPPLÉMENT DE LA MÉMOIRE.
ECRITURE.
IMPRIMERIE.
ALPHABETS.
CHIFFRES.
ARTS D'ÉCRIRE, D'IMPRIMER, DE LIRE, DE CHIFFRER.
ORTHOGRAPHE.
ART DE COMMUNIQUER.
SCIENCE DE L'ENTREMENT DU DISCOURS.
GRAMMAIRE.
SIGNES.
PROPRIÉTÉ.
CONSTRUCTION.
SYNTAXE.
DIALOGISTE.
CRITIQUE.
PEDAGOGIQUE.
CHOIX DES ETUDES.
MANIERE D'ENSEIGNER.
GESTE.
PANTOMIME.
DECLAMATION.
CARACTERES.
IDEAUX.
HIEROGLYPHIQUES.
HERALDIQUES ou BLASON.
SCIENCE DES QUALITÉS DU DISCOURS.
RHETORIQUE.
MECHANIQUE DE LA POESIE OU VERSIFICATION.
MORALE
GENERALE
SCIENCE DU BIEN ET DU MAL EN GENERAL. DES DEVOIRS EN GENERAL. DE LA VERTU. DE LA NÉCESSITÉ D'ETRE VERTUEUX, &c.
PARTICULIERE.
SCIENCE DES LOIX, OU JURISPRUDENCE
NATURELLE.
ŒCONOMIQUE.
POLITIQUE.
COMMERCE INTÉRIEUR, EXTERIEUR, DE TERRE, DE MER.
SCIENCE DE LA NATURE.
MÉTAPHYSIQUE DES CORPS, ou PHYSIQUE GÉNERALE. DE L'ÉTENDUE, DE L'IMPÉNÉTRABILITÉ, DU MOUVEMENT, DU VUIDE, &c.
MATHEMATIQUES.
PURES.
ARITHMETIQUE.
NUMERIQUE.
ALGEBRE.
ELEMENTAIRE.
INFINITESIMALES.
DIFFÉRENTIELLE.
INTÉGRALE.
GEOMETRIE.
ELEMENTAIRE. (ARCHITECTURE MILITAIRE. TACTIQUE.
TRANSCENDANTE. (THEORIE DES COURBES.
MIXTES.
MECHANIQUES.
STATIQUE.
STATIQUE, proprement dite.
HYDROSTATIQUE.
DYNAMIQUE.
DYNAMIQUE, proprement dite.
BALLISTIQUE.
HYDRODYNAMIQUE.
HYDRAULIQUE.
NAVIGATION. ARCHIT. NAVALE.
ASTRONOMIE GEOMETRIQUE.
COSMOGRAPHIE.
URANOGRAPHIE.
GEOGRAPHIE.
HYDROGRAPHIE.
CHRONOLOGIE.
GNOMONIQUE.
OPTIQUE.
OPTIQUE, proprement dite.
DIOPTRIQUE.
PERSPECTIVE.
CATOPTRIQUE.
ACOUSTIQUE.
PNEUMATIQUE.
ART DE CONJECTURER. ANALYSE DES HAZARDS.
PHYSICOMATHEMATIQUES.
PHYSIQUE PARTICULIERE.
ZOOLOGIE.
ANATOMIE.
SIMPLE.
COMPARÉE.
PHYSIOLOGIE.
MEDECINE.
HYGIENE.
HYGIENE, proprement dite.
COSMETIQUE. (ORTHOPERIE.
ATHLETIQUE. (GYMNASTIQUE.
PATHOLOGIE.
SEMIOTIQUE.
THERAPEUTIQUE.
DIETE.
CHIRURGIE.
PHARMACIE.
VÉTÉRINAIRE.
MANGE.
CHASSE.
PECHE.
FAUCONNERIE.
ASTRONOMIE PHYSIQUE. ASTROLOGIE.
ASTROLOGIE JUDICIAIRE.
ASTROLOGIE PHYSIQUE.
METEOROLOGIE.
COSMOLOGIE.
URANOLOGIE.
AEROLOGIE.
GEOLOGIE.
HYDROLOGIE.
BOTANIQUE.
AGRICULTURE.
JARDINAGE.
MINERALOGIE.
CHIMIE.
CHIMIE, proprement dite. (PYROTECHNIE. TEINTURE, &c.
METALLURGIE.
ALCHIMIE.
MAGIE NATURELLE.
IMAGINATION.
POESIE
SACRÉE.
PROFANE.
NARRATIVE.
POEME EPIQUE.
MADRIGAL.
EPIGRAMME.
ROMAN, &c.
MUSIQUE.
THEORIQUE.
PRATIQUE.
INSTRUMENTALE.
VOCALE.
PEINTURE.
SCULPTURE.
ARCHITECTURE CIVILE.
GRAVURE.
DRAMATIQUE.
TRAGEDIE.
COMEDIE.
OPERA.
PASTORALES, &c.
PARABOLIQUE.
ALLEGORIES.

Figure 1.7


A CHART ILLUSTRATING SOME OF
THE RELATIONS BETWEEN THE BRANCHES OF NATURAL SCIENCE AND TECHNOLOGY
H.J.T. Ellingham. 1948.
MATHEMATICS
Statistics
ASTRONOMY
METEOROLOGY
NAVIGATION
CIVIL ENGINEERING
SURVEYING
ARCHITECTURE
GEODESY
MECHANICAL ENGINEERING
WIND AND WATER POWER
HEAT ENGINES
Steam Engines & Turbines
Refrigeration Plant
Internal Combustion Engines
MECHANICS
PHYSICS
Physical States of Matter
Solids
Fluids
CRYSTALLOGRAPHY
Colloid Science
MOLECULAR AND ATOMIC PHYSICS
HEAT
THERMODYNAMICS
NUCLEAR PHYSICS
OPTICS
MAGNETISM
ELECTRICITY
ELECTRICAL ENGINEERING
POWER GENERATION
Converters, Transformers
TELECOMMUNICATIONS
Radio Engineering
Telegraphy and Telephony
Electric Motors
Electrical Measurements
Testing
CHEMICAL ENGINEERING
Chemical Plant Design
GAS ENGINEERING
FUEL TECHNOLOGY
Chemical Equilibrium & Kinetics
PHYSICAL CHEMISTRY
ANALYTICAL CHEMISTRY
Microchemistry
CHEMISTRY
PREPARATIVE & STRUCTURAL CHEMISTRY
Stereo-chemistry
INORGANIC CHEMISTRY
ORGANIC CHEMISTRY
APPLIED INORGANIC CHEMISTRY
APPLIED ORGANIC CHEMISTRY
PRODUCTION METALLURGY
METALLURGY
PHYSICAL METALLURGY
Metallography
Pyro-metallurgy
Electro-metallurgy
Hydro-metallurgy
Ore-Dressing
MINERALOGY
PETROLOGY
GEOLOGY
Structural Geology
Geomorphology
Stratigraphy
PALÆONTOLOGY
BIOLOGY
ZOOLOGY
Ichthyology
Malacology
Entomology
Protozoology
MICROBIOLOGY
Bacteriology
Algology
Mycology
Bryology
BOTANY
Ecology
Taxonomy
Morphology
Histology
Cytology
Embryology
ANIMAL PHYSIOLOGY
(PLANT) PHYSIOLOGY
BIOCHEMISTRY
PHARMACY
MEDICINE
SURGERY
DENTISTRY
PATHOLOGY
Epidemiology
Histology
Parasitology
Obstetrics & Gynæcology
NUTRITION
FOOD INDUSTRIES
VETERINARY SCIENCE
GENETICS
PLANT PATHOLOGY
Plant Breeding
Fertilisers
HUSBANDRY
Animal Breeding
Dairy Science
FISHERIES
AGRICULTURE
Pasture Crops
Forage Crops
Plantation Crops
FORESTRY
AGRICULTURAL ENGINEERING
Soil Science (Pedology)
Sewage Disposal and Utilisation
Reclamation Irrigation and Drainage of Land
Water Supplies
MINING ENGINEERING
MINING
Quarrying
Mining of Mineral Deposits
Coal Mining
Petroleum Extraction
Prospecting
Applied Geophysics
MINING GEOLOGY
Mine Surveying