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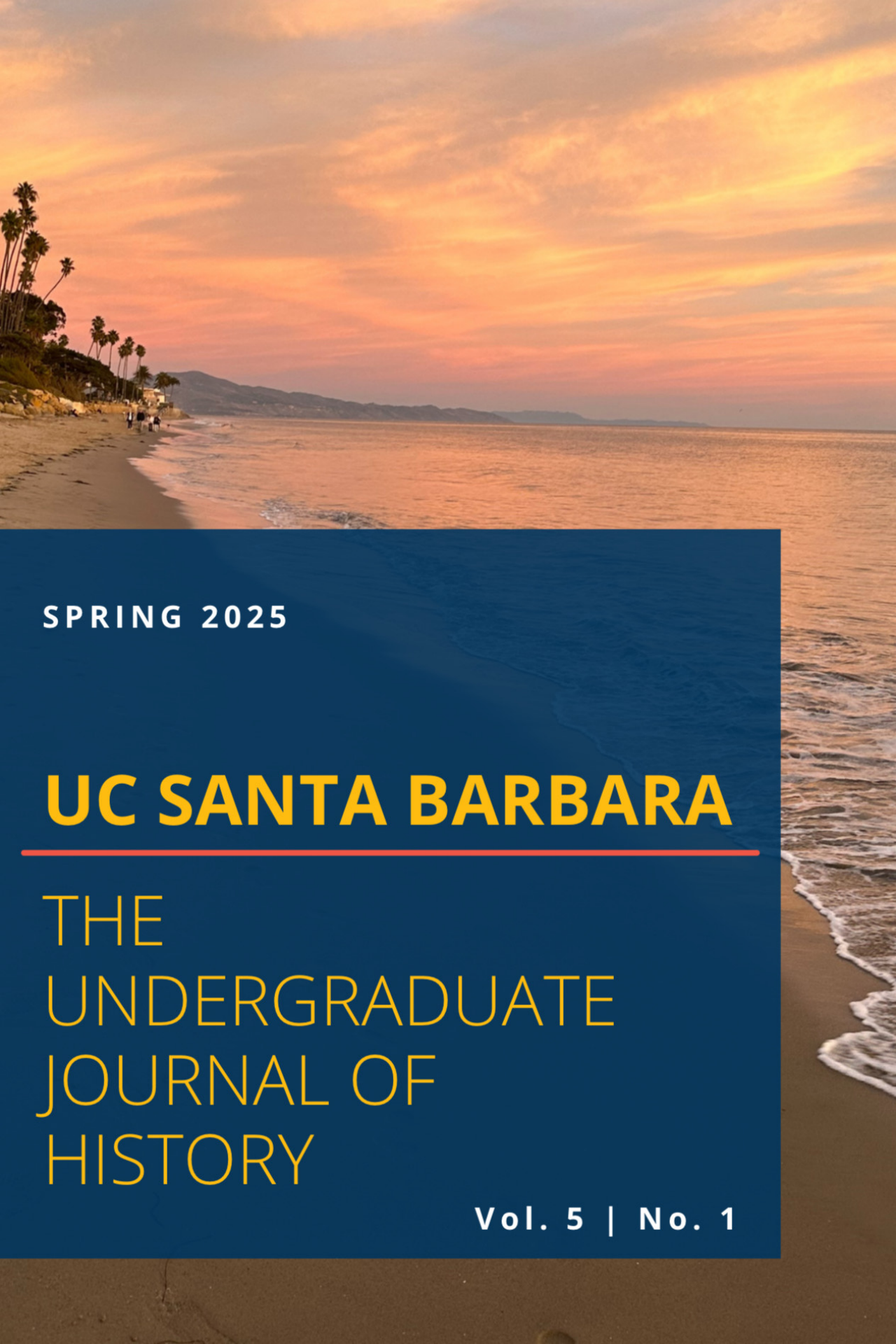
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The Collections Built by Globalization

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In 1572, Ulisse Aldrovani was given a dragon. At the time, dragons were seen by contemporaries as bad omens, and known for his collections and explorative nature, Aldrovani was given the creature to study in order to investigate its origins. His interpretations of this creature from afar display his attempts to categorize, catalog, and depict the creature, a critical example of how many Europeans interacted with the unreachable world, but also an example of how they began to interpret and classify the information they received. From 1350 to 1750, the European understanding of the natural world shifted dramatically, as the period contained the beginnings of global exploration and the ensuing expansion of European control across the world. As the Europeans ventured out of Europe, the map of the world began to expand, not only the places themselves, but the discovery of “previously unknown things” caused them to question their current understanding of the world. As trade and exploration expanded, so did the new artifacts, plants, and animals discovered, challenging the previously understood knowledge taught by the ancient philosophers. In attempting to understand these changes, early natural philosophers in Europe attempted to decipher and organize this new knowledge, doing so via collections of new specimens. The early European collections of worldly artifacts that expanded during the period of globalization between 1350 and 1750 are illustrative of an overall societal shift in how knowledge was understood and interpreted by European natural philosophers, a shift from Aristotle’s casual understanding to early observational analysis and classification.

I. Understanding of the world pre-1500

Before 1500, classical philosophy governed understanding for hundreds of years and was instrumental in creating the system in which philosophers sought to understand and process knowledge. Most understanding of the natural world came from the work of the ancient philosophers, each with their own theory or system for classification. These philosophers sought to explain the existence of the natural world, and the teachings of these philosophers were deeply ingrained within the curriculum of the time. As such, before the era of globalization, the system itself was static. There were agreed-upon foundations for comprehending the natural world, which were not challenged until the influx of flora and fauna into Europe.

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Greek philosopher Aristotle saw the world through the idea that we see the way that things behave. It was generally understood in most European university settings of the time that “in logic, natural philosophy ... the doctrine of Aristotle is to be followed.”² Aristotle based his philosophies on the idea of “experience-based knowledge,” which is a “matter of what can be inferred from experience.”³ This Aristotelian framework, known as natural philosophy, was integrated into the general scholarly understanding of the world during the twelfth and thirteenth centuries.

The natural and physical world, as interpreted by Aristotle, was comprehended in terms of matter and elements. According to Aristotle, the world had bodies, consisting of “four elements: earth, water, air, and fire.”⁴ Each element had both primary and motive qualities: “Primary qualities were hot, cold, wet, and dry. Earth was cold and dry; water, cold and wet; air, hot and wet; and fire, hot and dry ... the elements had motive qualities, either heavy or light; earth and water, the heavy elements, had a tendency to fall downward toward the center of the world, and air and fire tended to rise and move away from the center of the world.”⁵ Such qualities were based on the idea that the earth was the center of the universe, surrounded first by water, then the elements of air and fire.⁶ It was understood that these elements were infrequently found in pure form, usually a specimen held different primary and motive properties based on the combination of elements within it. Alongside this foundational understanding of the natural world came the Aristotelian concept behind the “causes” of things. His four causes sought to “[analyze] the categories of human explanation ... ‘How do we understand things?’”⁷ Each cause is needed to combine to create the “coming-to-be of a substance” which needs to interact to “[explain] the motions or changes that a substance undergoes.”⁸ These causes interacted with this understanding of the elements and created the framework behind the baseline Aristotelian logic on natural philosophy taught pre-1500.

Additionally, according to Aristotle in his work *The History of Animals*, he wrote about the way to study and understand animals, “what it is about them that needs to be studied, in order that we may first grasp the differences and the attributes belonging to all animals. After we do this, we must

² S. J. Ladislaus Lukas, ed., *Ratio atque institutio studiorum*, (Institutum Historicum Societatis Iesu, 1986), p. 98.

³ Dear, *Revolutionizing the Sciences*, p. 11.

⁴ Daniel Garber, “Physics and Foundations,” in *The Cambridge History of Science, Volume 3: Early Modern Science*, ed. Katharine Park and Lorraine Daston (Cambridge University Press, 2006), p. 28.

⁵ Garber, “Physics and Foundations,” p. 28.

⁶ Garber, “Physics and Foundations,” p. 28.

⁷ Dear, *Revolutionizing the Sciences*, p. 13.

⁸ Lynn S. Joy, “Scientific Explanation: From Formal Causes to Laws of Nature,” in *The Cambridge History of Science, Volume 3: Early Modern Science*, ed. Katharine Park and Lorraine Daston (Cambridge University Press, 2006), p. 74.

attempt to discover the causes.”⁹ In turn, one must approach the study of these specimens by inquiry, with the “aim of grasping the differences between, and attributes of, all the animals,” and then follow by attempting to discern the causes therein.¹⁰ Pre-1500, this Aristotelian causation was the shared Western understanding for the interpretation of animal life. Demonstrative understanding, based in the examination of attributes followed by the causes created this interpretation. This comprehension of the physical world was a theory upon which most universities based their approaches to natural philosophy and the examination and analysis of plant and animal properties and behaviors.

Another key figure in examining the framework of knowledge in pre-1500 Europe was Pliny the Elder, whose theories helped sustain the early European scientific method. The Roman encyclopedist was a widely available source and built off of the work of Aristotle in creating some of the earliest treatises on animals and plants, representing “the earliest surviving efforts to describe and classify the natural work in any detail.”¹¹ He saw natural history as “all entities found in nature, or derived from nature.” Different from Aristotle, Pliny’s work was far less causal and more descriptive as he attempted to create a foundation for “the general rule of nature.”¹² Dioscorides, a contemporary of Pliny, was also highly involved with creating foundational knowledge for those in early modern Europe. In his treatise *De Materia Medica*, Dioscorides attempts to describe a wide variety of plant and animal specimens and to find a proper form of categorization within the Aristotelian system of knowledge available to him. “Additionally, they have erred in the categorisation of medicines: some associate those of quite different powers, others establish an alphabetical system in their discussions and thus separate types and activities of materials that are similar, so that they become harder to remember.”¹³ Dioscorides exemplifies another issue, even before European expansion around the globe; knowledge was difficult to fit within any baseline classification system because of the way it was interpreted differently from philosopher to philosopher. Dioscorides was focused on using nature “in the service of medicine,” whereas Pliny focused on a “descriptive foundation,” compared to Aristotle’s “causal” study of nature.¹⁴ These descriptions and the lack of a widely accepted system made studying the natural sciences different. Although most Europeans did not find fault within this system, it did set

⁹ Aristotle, *History of Animals*, trans. D’Arcy W. Thompson (Harvard University Press, 1910), as cited in Lindsay Judson, “Aristotle’s Biology,” *Stanford Encyclopedia of Philosophy*, last modified October 31, 2018.

¹⁰ Judson, “Aristotle’s Biology,” *Stanford Encyclopedia of Philosophy*.

¹¹ Paula Findlen, “Natural History,” in *The Cambridge History of Science, Volume 3: Early Modern Science*, ed. Katharine Park and Lorraine Daston (Cambridge University Press, 2006), p. 438.

¹² Findlen, “Natural History,” p. 438.

¹³ Dioscorides, *De Materia Medica*, trans. and indexed by Tess Anne Osbaldeston and R. P. A. Wood (Ibidis Press, 2000), p. [viii and xi](#).

¹⁴ Findlen, “Natural History,” p. 438.

the framework for early modern natural philosophers to choose from a wide array of backgrounds when they began to categorize masses of new information from within the broader world.

Despite such a wide array of foundational knowledge, the data accessible was relatively stable until the emergence of global exploration. The ancient foundational methodologies created the system in which natural philosophers understood knowledge about the natural world. This created a system for the initial collection of data from around the world, and it would be the system challenged by the sheer amount of information that came back to Europe due to globalization and European conquest.

II. Globalization

Columbus famously discovered the Americas in 1492, but his discovery was part of a far larger trend of globalization from the 1300s to the 1700s. During that time, the European world expanded to include places previously not conceptualized by the philosophers of ancient days. The sheer amount of information on new flora and fauna that swept into Europe post-1500 challenged previous notions of institutional knowledge. It forced contemporaries to find new ways to understand the world around them.

By the sixteenth century, the world “came to contain more accredited places, real places to which travel was not possible; but it also designated previously unknown things.”¹⁵ Both natural philosophers and doctors were interested in such discoveries and sponsored by powerful individuals, monarchs, trade companies, and even religious orders such as the Jesuits.¹⁶ One author, José de Acosta, a Jesuit missionary and early naturalist who lived in the 1500s, gives a great explanation of the reasoning and motivation behind these journeys. In his work, *Natural and Moral History of the Indies*, he writes in his preface that “a knowledge of ... the works of nature ... causes a feeling of pleasure and delight in refined understandings, and as an acquaintance with strange customs and deeds also pleases from its novelty, I hold that this work may serve as an honest and useful entertainment to your Highness.”¹⁷ Acosta exemplifies both the individual urge to expand the horizons of knowledge and new information into the New World and the connection to the networks back home that supported such journeys. The Jesuit order “constituted perhaps the most elaborate and well-organized international intelligence network in the world,” whose missions were often exploited to “acquire knowledge of nature for philosophical purposes.”¹⁸ Not only was Acosta on a mission for the Spanish

¹⁵ Dear, *Revolutionizing the Sciences*, p. 123.

¹⁶ Dear, *Revolutionizing the Sciences*, p. 124.

¹⁷ José de Acosta and Frances M. López-Morillas, *Natural and Moral History of the Indies*, ed. Jane E. Mangan (Duke University Press, 2002), [accessed 29 November 2024](#).

¹⁸ Dear, *Revolutionizing the Sciences*, p. 124.

monarchy, but the Jesuit system of which he was a part supported this exploration for new knowledge, for both himself and others within his circles.

Another such explorer was the Spanish doctor, Francisco Hernández. Dr. Hernández lived from 1515 to 1587 and was the royal doctor and chief medical officer in New Spain. He was sent to the New World by King Philip II of Spain in 1570 and wrote a collection of sources within “The Mexican Treasury” on orders of the King to document and research the natural history and resources of the region.¹⁹ The audience of his work was, of course, the King, but also an array of other physicians, researchers, and doctors back in Spain and in the Americas who were interested in the knowledge he had acquired during his journeys. Dr. Hernandez’s sources are substantial and during his seven-year journey to the New World he produced numerous documents on his findings, including several volumes and indices. One such work was *Cuatro libros de la naturaleza*, which was one of the first of Hernandez’s writings to be published.²⁰ It was published in Mexico City in 1615 and includes an extensive list of natural resources, including trees and herbs, which the Doctor meticulously documented. In his writing, the Doctor is diligent in describing the appearance, texture, and properties of the vegetation and the location and medicinal applications of each plant. For example, one tree that Hernandez describes is the tlámatl, “a tree that has leaves like those of the sage plant, but thicker and softer.”²¹ Beyond its description, he writes on the medicinal qualities of the leaves, explaining that “when crushed in the quantity of a fistful and drink in water, are said to purge all the humors gently, without any irritation, by means of vomiting.”²²

By examining the influences on Hernandez’s work, one can quickly see the impact of ancient theory, as seen by the reference to Galen’s humors. The Greek physician’s (late second century AD) doctrines “concerned the balance of the four ‘humours’ that comprise the human body,” thus the influence of ancient doctrines.²³ Yet, despite these references to ancient medicine, the influence of the changing practice in the sixteenth century shift is present. From the Aristotelian contemplative and Galenic humours to the newer “practical knowledge of nature,” which can be seen in the context of German medical mystic, Paracelsus’s work.²⁴ Paracelsus emphasized that “true knowledge of the natural world ... could only be acquired through an intimate acquaintance with the properties of things.”²⁵ By

¹⁹ Simon Varey, *The Mexican Treasury: The Writings of Dr. Francisco Hernandez*, (Stanford University Press 2000) p. xi.

²⁰ Francisco Hernandez, “Quatro Libros De La Naturaleza” in *The Mexican Treasury: the Writings of Dr. Francisco Hernández*, ed., Simon Varey (Stanford University Press, 2000), p. 117.

²¹ Hernández, “Quatro Libros,” in *The Mexican Treasury*, p. 123.

²² Hernández, “Quatro Libros,” in *The Mexican Treasury*, p. 123.

²³ Dear, *Revolutionizing the Sciences*, p.17, 48.

²⁴ Dear, *Revolutionizing the Sciences*, p. 47.

²⁵ Dear, *Revolutionizing the Sciences*, p. 47.

simply examining the detail with which Hernandez documents the characteristics of the *tlalámatl*, one can see the influence of gaining knowledge via “intimate acquaintance.” By mere virtue of the Doctor’s task, traveling across the Atlantic to New Spain to document new types of plant and animal life, one can see the immediate effects that the increasing knowledge of the natural world during the sixteenth century had on his work. Hernandez’s methods of collection and documentation demonstrate a shift in operational knowledge by looking at the incorporation of the Aristotelian framework to the inclusion of observational data in specimen collection during this time.

Another plant mentioned in Hernandez’s *Quatro Libros* is *mexóchitl*, a shrub “the height of a man ... [that] emits a strong acrid smell.”²⁶ Similar to the *Tlalámatl* that Hernandez describes, the description of the plant is detailed. He mentions “fibrous roots, leaves ... small flowers in dense clusters,” as well as the medicinal value of the shrub, “the leaves, crushed, are taken for poisonous animal bites.”²⁷ Such descriptions are further evidence for the sixteenth-century adaption of knowledge to deep interaction with the properties of ‘things.’ Additionally, the *mexóchitl* is one of Hernandez’s plants that is mentioned by other authors of the time. Henry Stubbe published *The Indian Nectar* in London in 1662 and incorporated some of the passages Hernandez wrote in *Quatro Libros* into his own work.²⁸ He approaches the description of the shrub in a different manner, however, explaining that “it is Cordial, good against Wind, and Poyson; it brings away the dead child, it provokes Urine.”²⁹ Despite the different description, Stubbe’s work is quite reliant on the theories of Paracelsus, who focused on sympathies, which were “astronomical/alchemical correlations between particular planets and particular minerals ... extended, crucially, to the human body itself.”³⁰ Paracelsus “emphasized the direct interrogation of nature,” and his works were directed “towards practical medicine to cure specific diseases and ailments.”³¹ Stubbe’s interpretation of *Mexóchitl* is an example of Paracelsus’s ideas in action, “it repairs the decay of natural heat,” may refer to the alchemical correlations between the world and the human body, the plant being a potential solution to the natural heat in question. Additionally, it connects directly to Aristotelian ideas of those base elements and properties. Stubbe’s focus on the *Mexóchitl*’s properties as “[strengthening] the body” or “[strengthening] the Liver,” depict the new ideas surrounding the treatment and cure of ailments instead of accepting such illnesses as a way of life.³²

²⁶ Hernández, “Quatro Libros,” in *The Mexican Treasury*, p. 130.

²⁷ Hernández, “Quatro Libros,” in *The Mexican Treasury*, p. 130.

²⁸ Hernández, “Quatro Libros,” in *The Mexican Treasury*, p. 239, 240.

²⁹ Hernández, “Quatro Libros,” in *The Mexican Treasury*, p. 242.

³⁰ Dear, *Revolutionizing the Sciences*, p. 49.

³¹ Dear, *Revolutionizing the Sciences*, p. 50.

³² Hernández, “Quatro Libros,” in *The Mexican Treasury*, p. 243.

Stubbe's interpretation of Hernandez's texts is fundamental in understanding the implications that globalization had on the interpretation of knowledge during the sixteenth century. Another interesting observation from these primary sources is that both authors still refer to the plants by the names that the Indigenous people used. The *tlalámatl* and the *mexóchitl* are both designations used by the people of the New World, not Spanish names. Such an observation is proof that the vast array of new flora and fauna that Hernandez found was indeed new, and its sheer volumes were such that they could not be translated directly into European dialect. Hernandez's writings are evidence of both the presence and framework of Aristotelian theories in his writings as well as a more observational and property-based depiction of ideas that contemporaries needed to incorporate into their methods in order to properly understand the new discoveries.

This new influx of flora and fauna into Europe was compiled by those who were taught the basic framework of scientific collecting in the Aristotelian sense, but as the globalization of the new world expanded, so did their methods. How knowledge was collected at the time were indicative of both past and present. Explorers needed the past to provide a framework in which they sought out knowledge, but the new knowledge was more than they could have imagined and strained the ancient methodology. The discoveries were so expansive that even in collecting and documenting them, new methods needed to be invented to effectively categorize and bring back specimens. This article only explores a few specimens, but the extent to which each specimen is examined here extends to the thousands of plant and animal specimens Hernandez found, and expands even more to a myriad of other explorers at the time. They sought to bring back globalized and integrated knowledge back home. Still, just as it had been difficult to comprehensively collect and document in the New World, it was similarly difficult to process and categorize the excessive amounts of new knowledge back in Europe.

III. European Collections

As all of these discoveries were brought back to Europe, they were implemented and analyzed by a variety of people, including naturalists, natural philosophers, and physicians. Collections were a way in which contemporaries attempted to sort information, and are emblematic of the way that the framework set up by the ancients was forced to evolve through new knowledge.

Collections were the gathering of specimens and artifacts used to pursue "cumulative knowledge of the natural world," in turn, integrating all of the discoveries "into a system."³³ There were a wide variety of such collections, but the shared goal of "organizing ideas around objects," forced a societal shift into the inquiries of knowledge, "naturalists increasingly saw philosophical inquiry as the

³³ Dear, *Revolutionizing the Sciences*, p. 127.

product of a continuous engagement with material culture.”³⁴ Collections were critical in the way that knowledge changed during this period, as ancients like Aristotle were not able to collect, nor did they collect, specimens on the same scale as those fifteenth-century naturalists. This philosophizing was seen as the naturalist’s commitment to understanding nature in the way the ancients did. However, even through that lens, the sheer number of discoveries found would require a different way to process new information. By the sixteenth century, collecting itself had changed; the New World had innumerable new flora and fauna, and instead of merely analyzing the descriptions, as had been done in the past, “botanists began to collect actual specimens of plants, rather than simply describing them.”³⁵ Additionally, these collections shaped how discoveries were attained. The networks expanded and adapted to support the increasing desire for new information and were tied into many other expansions, such as missionary work, trade, and, of course, early colonialism.

Paula Findlen’s book, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy*, discusses the way in which the context of Italian history during this period made it possible for scientific activity to thrive in Italy. She argues that the process of exchange and the integration of patronage into the idea of natural science, “engendered the collector and the museum.”³⁶ In providing evidence, Findlen discusses Ulisse Aldrovani as an example. Aldrovani was an Italian collector in the latter half of the sixteenth century, and his collection was representative of the general contradiction of the time, that while natural history was rooted in ancient work, the limits of such work were being pushed by exploration and exchange.³⁷ Aldrovani was deeply interested in the voyages of exploration during his lifetime and attempted to interest patrons such as Pope Gregory XIII and the Spanish King Philip II in sponsoring his own expeditions.³⁸ He was unsuccessful, but nevertheless, his collection flourished, as he “[mastered] the various forms of knowledge pertinent to knowing nature.”³⁹

As mentioned above, the work of patrons was critical in providing support for exploration, not to mention the actual administration of museums and collections. For example, one of the most well-known collectors’ items of this period was Aldrovani’s 1572 dragon, found in Bologna. Not only did he include the dragon in his expansive collection, but he also argued that the dragon “presaged a fruitful relationship with his chosen patron, Gregory XIII.”⁴⁰ In examining an illustration of his

³⁴ Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (University of California Press, 1994), p. 5.

³⁵ Dear, *Revolutionizing the Sciences*, p. 126.

³⁶ Findlen, *Possessing Nature*, p. 291.

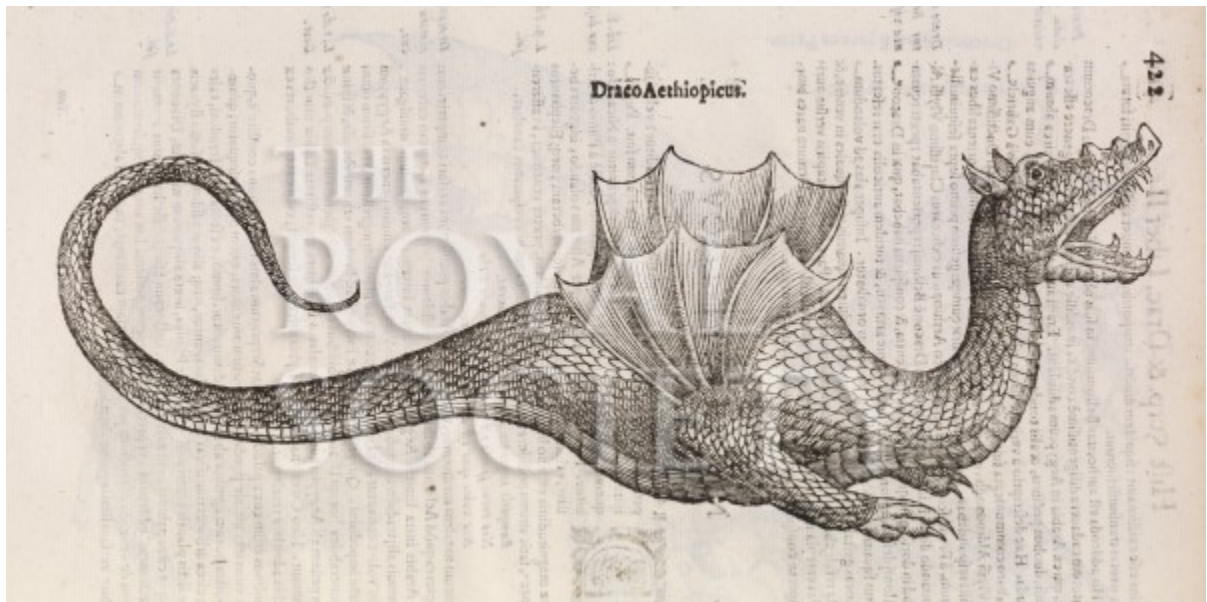
³⁷ Dear, *Revolutionizing the Sciences*, p.125.

³⁸ Findlen, *Possessing Nature*, p. 314.

³⁹ Findlen, *Possessing Nature*, p. 315.

⁴⁰ Findlen, *Possessing Nature*, p. 377.

dragon, one can see the incredible detail in which Aldrovani illustrates the aspects of the dragon, from the wings to the tail, and even the lack of legs.⁴¹ To try to understand this dragon, one can reference the detailed drawings and notes that Aldrovani makes on the specimen. His notes in Latin infer that his findings were meant for the educated and that he likely sought to communicate this information to those in the same field to decipher the specimen. Aldrovanni's methods are emblematic of a new theme - people were gathering pieces of collections and bringing them back to Europe, alongside other museums across the globe, where they were attempted to be understood through analysis by naturalists and collectors. Today, historians know that whatever was found was not a dragon, but the attempts by Aldrovani to categorize and classify an unknown discovery using known, but inaccurate, references. As Europeans went out and began to conquer the world, they found a wide variety of new information that they tried to interpret to keep control over their newly conquered realms. This is emblematic of the idea that the ancient framework hampered natural philosophers in attempting to understand new information at the time. However, foreign objects from new places, such as this dragon, were critical in building new relationships between knowledge, collection, and analysis.



An “Ethiopian dragon,” (1640).

Aldrovani also exemplifies another aspect of the mid-sixteenth-century European collections. Brian Olgilvie's book, *The Science of Describing: Natural History in Renaissance Europe*, is another secondary

⁴¹ Ulisse Aldrovandi, *Serpentum et Draconum Historiae* [Natural History of Snakes and Dragons] (Bologna, 1640), plate showing the “Draco Aethiopicus” (Ethiopian dragon), Royal Society, ([accessed 29 November 2024](#)).

source examining the collection of natural history during the period referred to as the Scientific Revolution. Ogilvie writes about Aldrovani, a naturalist who was unable to go see each new creature or specimen and who often relied on accounts from others, but that such accounts could be contradictory. Thus, in creating his own knowledge and classification of animals, Aldrovani was forced to “[confront] contradictory sources and [use] a similar method to resolve them.”⁴² The inability of naturalists to see all the new material they gathered was a detriment as “specimens were often unique,” and the depictions were often inaccurate, but as knowledge developed, naturalists like Aldrovani used previous work to compare and make assertions; “his measurements of another elk antler convinced him.”⁴³ Prior work and knowledge of others is representative of the importance of trade and communication during this time of exploration. At this time, the work of European countries in conquering the New World was paramount, and often the aggregation of new specimen and information was a way for those countries to gain control, as depicted by the motivation behind Hernandez’s work. Many naturalists could not travel far and the accuracy was dependent on a larger network of organized naturalists to be effective in the way that knowledge was gathered and disseminated. All of the specimens brought back to Europe were important in gaining understanding, but because many collectors, such as Aldrovani, could not go see them in person, they had to rely on second-hand accounts. Because there was no overarching method of categorization, research, or data collection, the accounts coming back to Europe were not consistent, and often in fact contradictory, exemplifying the growing need for some system to accurately organize this knowledge.

Ogilvie builds on this, writing about Andrea Cesalpino, a Florentine physician in the 1500s. He discusses the way that naturalists in this period began to change the way nature was classified on a larger scale because they were overwhelmed by the sheer amount of new material and the old system could not keep up. Cesalpino wrote *De plantis* in 1583 about the consequences of not having a logical way to classify new material, proposing that “natural classification would thus be based on the organs of nutrition and reproduction: the root and the shoot on the one hand, and the flowers and fruit on the other.”⁴⁴ Ogilvie writes that “methods of finding and studying *naturalia* ... played an important role in producing knowledge that others could trust.”⁴⁵ Without a method, the lack of a shared technique was the issue. New material gathered from globalization forced naturalists to organize information differently, adapting their methods based on the influx of new data coming in at the time.

A last example of the inconsistent application of new information is evident in the processing of Dr. Hernandez’s work by another English author, James Newton. In his work, *The Complete*

⁴² Ogilvie, *The Science of Describing*, p. 241.

⁴³ Ogilvie, *The Science of Describing*, p. 242.

⁴⁴ Ogilvie, *The Science of Describing*, p. 224.

⁴⁵ Ogilvie, *The Science of Describing*, p. 23.

Herbal, published in London in 1752, Newton discusses varieties of apples. Pulling from the discoveries and writings of Hernandez, Newton writes on several types of fauna, such as *huitztomatzin* and the Amacóztic *huitzomatzin* and *amacóztic*. In writing on each, he includes a section titled “Nature & Virtue” where he discusses the application of each plant. The former, “half an ounce of its bark, bruised, and drunk in water, purgeth all Humors; is good in Dropsies, fevers, and Difficulty Breathing,” the latter, “good to ... ease pains of the breast, & purgeth cholor and phlegm both ways.”⁴⁶ His categorization and descriptions of each are precise, but his observations stem directly from Hernandez, who mentions the *huitzomatzin* in his drafts. He writes about the spiny tomato, which “is a bush with thick ramified roots, from which spiny stems grow four palms long. Its leaves are similar, up to a point, to spinach leaves.”⁴⁷ The key here is that the descriptions and application share similarities, but the organization of the observations is not standardized. Additionally, as Newton’s work comes over a century after Hernandez’s, it is interesting to note his goals. His work was explicitly created to apply new information; as a motivator, it is fascinating, as it shows a movement toward the goal of collection and aggregation post-discovery, a newer application of certain developing scientific standards. Newton’s appendix collection of fauna describes what Hernandez discusses, but it is by no means equivalent to the details that Hernandez includes.

Even as these collections began to bring together key specimens from the New World, the overwhelming number of specimens caused collectors to pick and choose what they wanted to describe and which benefits they wanted to highlight. Finland writes that “the addition of a new artifact predictably occasioned speculation on its ability to maintain or dismantle long-standing interpretations of its scientific and medicinal properties.”⁴⁸ These catalogs of categorization were specific to the author and collector, and despite the great leaps in knowledge, still brought doubt and uncertainty. Looking back as a historian today, it is also evident that the way that Hernandez’s texts were processed and used by future naturalists was not standard, thus adding to the general confusion and overwhelm that early researchers must have felt when attempting to sort through more and more knowledge during the period of globalization.

The work of contemporaries in seeking to understand the world around them interacted with the influx of flora and fauna at the time. Of course, most naturalists would have been unable to travel, thus using collections to compare and examine the specimens they were able to gather. In turn, the

⁴⁶ James Newton, “The Complete Herbal,” in *The Mexican Treasury: the Writings of Dr. Francisco Hernández*, ed., Simon Varey (Stanford University Press, 2000), p. 245.

⁴⁷ Fransisco Hernandez, “Five Special Texts: Cacao, Chili, Corn, Tobacco, and Tomato,” in *The Mexican Treasury: the Writings of Dr. Francisco Hernández*, ed., Simon Varey (Stanford University Press, 2000), p. 245.

⁴⁸ Findlen, *Possessing Nature*, p. 37.

collection of new data needed to be discussed, exemplifying the need for a standardized system to convey new knowledge and discoveries about the natural world.

IV. Classification of the Natural World

The influx of discoveries completely overwhelmed the previously used Aristotelian framework of knowledge, and in turn, upended previous systems of classification used by contemporaries. Late 1500s English philosopher Francis Bacon was a proponent of local collections, one of his most famous being his proposition to Queen Elizabeth in the 1590s for a botanical garden as “part of a national research enterprise.”⁴⁹ Having specimens available would eliminate the errors made due to the interpretation of conflicting secondary sources. Bacon’s own rhetoric supported this idea of research: new discoveries must be integrated into an existing system of knowledge “that would enable its effective exploitation.”⁵⁰ Thus, as these discoveries poured into Europe, not only were the ancient frameworks proven to be ineffective and inaccurate in comparison, but the sheer amount of new information no longer fit into the predefined system, and there needed to be a new way to make sense of all the information that had been acquired.

These voyages to the New World expanded and challenged the standing Aristotelian framework. Not only were new plant and animal specimens entering the discourse, but how the ancients described the world was forced to adapt. Ann Blair writes in her chapter on Natural Philosophy that “[included] natural historical and geographical topics that ranged far beyond the prescribed Aristotilian texts.”⁵¹ The voyages expanded Aristotle’s knowledge of the world, which would be taught to students in universities across Europe. Additionally, new places of study, such as the aforementioned botanical gardens, became commonplace in universities, evidence of this stretch in ancient knowledge to begin understanding New World findings. Findlen supports this notion, discussing how botanical gardens were not only a place of education, but also of importance. She writes that the monarchical sponsorship of such gardens “challenged other rulers to match his innovations to maintain the reputation of their medical faculties,” expanding this array of knowledge and creating competition between early researchers.⁵² Additionally, as more and more European countries expanded and began to conquer the New World, their leaders needed to know how to leverage the new information they had, giving further motivation for the need to organize and comprehend so much new knowledge.

⁴⁹ Dear, *Revolutionizing the Sciences*, p. 127.

⁵⁰ Dear, *Revolutionizing the Sciences*, p. 127.

⁵¹ Ann Blair, “Natural Philosophy,” in *The Cambridge History of Science, Volume 3: Early Modern Science*, ed. Katharine Park and Lorraine Daston (Cambridge University Press, 2006), p. 388.

⁵² Findlen, *Possessing Nature*, p. 256.

Aldrovani provided another example of these collections that sought to push forward the contemporary understanding of classification and organization. Within the first decade of his own botanical garden, the philosopher collected over 1500 samples from across the world.⁵³ He wrote that “these public and private gardens, with the lectures, are the reason that natural things are elucidated ... joined to the New World that we are still discovering.”⁵⁴ The gardens are a perfect example of this societal shift. They often fell within the preexisting Aristotelian university system, yet they sought to not only begin early observational research and experimentation on flora and fauna, they sought to collect it. One of Aldrovani’s custodians was praised for “housing foreign gardeners who bring new plants into his home a few times every year.”⁵⁵ There was an active goal in the minds of contemporaries to expand these gardens to house new knowledge, expanding upon the Aristotelian framework of information previously known.

As more specimens from the New World were discovered and as European natural philosophers began to move beyond the limitations of Aristotelian thought, there was also a growing need for better systems to organize the increasing amount of new information. One such example mentioned above is the aggregation of flora and fauna into botanical gardens, which exemplifies the further specification of knowledge. However, this shift is also evident in examining the individual categorizations of knowledge. In a 1686 chart of taxonomic distinctions by John Ray in his work *Historia plantarum*, plants are distinguished based on observational qualifications, instead of place of origin.⁵⁶ This image represents the shift in categorizing knowledge and the shift that stemmed from new discoveries. The knowledge itself within this taxonomic chart is based entirely on observational data; the chart includes notes on characteristics such as “petalis” (petals) and descriptors such as “concavo” (concave).⁵⁷ Observational data, instead of Aristotelian causal data, is evidence of the shift in the way that knowledge was collected and analyzed, details only present if the author had been able to interact with the material. Additionally, Ray’s classification, including plants “regardless of their places of origin,” implies that the places where plants were being found were widespread enough to require a

⁵³ Findlen, *Possessing Nature*, p. 257.

⁵⁴ Ulysses Aldrovandi, ms. 70, c. 62r, *Biblioteca Universitaria di Bologna* (BUB), as cited in Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (University of California Press, 1994), p. 257-58.

⁵⁵ Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (University of California Press, 1994), pg. 259, citing ASB, *Assunteria di studio, Requisiti dei lettori*, 1:27.

⁵⁶ John Ray, *Historia Plantarum* (London: 1686), quoted in Peter Dear, *Revolutionizing the Sciences: European Knowledge and Its Ambitions, 1500–1700* (Princeton University Press, 2019), p. 129.

⁵⁷ Ray, *Historia Plantarum*, as discussed in Dear, *Revolutionizing the Sciences*, p. 129.

larger taxonomic system.⁵⁸ Ray's work is evidence that he was trying to find a way to classify the information coming back to Europe via some sort of system, given the expansive new knowledge available to those in Europe. The need to create a system large enough to encompass discoveries based on the new characteristics found in the foreign specimens is indicative of the fact that so many new flora and fauna had flooded into Europe that those previous systems, not based on observational data, could not accurately describe the new information.

Further evidence of this evolution in collections can be seen in the analysis of New World records. One such example can be seen in *Tesoro messicano* or *Mexican Treasure*, a seventeenth-century aggregation of records on discoveries from the New World. While the book contains an exceptional amount of information from authors such as Francisco Hernandez and Johann Faber, there are also comments included from authors such as Fabio Colonna. Italian printer Vitale Mascardi compiled it in the 1650s.⁵⁹ Mascardi sections his work into a table of contents, which suggests an early categorization attempt. His table of contents is divided into sections such as “acres herbas habet” (to have sharp herbs) and “amaras herbes continet” (to contain bitter herbs).⁶⁰ Mascardi is attempting to organize the flora and fauna by specific characteristics and the impact of those characteristics. By arranging it based on types of characteristics, Mascardi, similarly to Ray, was attempting to differentiate how specimens were sorted. In attempting to find shared characteristics, as opposed to Aristotelian “causes,” it can be inferred that contemporaries were trying to understand the extensive wealth of new information through new classifications. By the 1600s, the need to organize the New World information was critical, and this amassed volume is evidence that the works of previous explorers and writers needed to be compiled to be effectively organized and understood. The compilation of this work is evidence of the need to sort information, whether via tangible collections or collections of discoveries, and in turn, the increased contemporary interaction with the new material. It is also evidence that prior collection and aggregation methods were not up to par, and there needed to be adjustments to organizational methods to study in a new, more observational way.

Conclusion

The legacy of globalization is widespread, both within the field of early science as well as outside of its boundaries. Exploration and discoveries set the stage for a complete revision and reframing of the world of natural history and natural philosophy into a far more complex scientific framework that is

⁵⁸ Dear, *Revolutionizing the Sciences*, p. 129.

⁵⁹ Library of Congress, *Mexican Treasure* (Rerum medicarum Novae Hispaniae thesaurus), [1651](#).

⁶⁰ Cesi, Federico, Annotator, Fabio Colonna, Johann Faber, Johann Friedrich Greuter, Vitale Mascardi, King Of Spain Philip Iv, Francesco Stelluti, and Joannes Terentius. *Mexican Treasure*. Rome: Vitale Mascardi, [1651](#).

much closer to contemporary methodologies. The methods and categorization that developed as a result of the influx of the flora and fauna discoveries of the new world were a key aspect in shaping the way that certain aspects of scientific knowledge were categorized, from causal to observational, and from an Aristotelian philosophy using the humors for explanation to the search to find out why things were the way they were, thereby generating the beginnings of modern research. Globalization impacted the European understanding of the world from the 1300s to the 1700s in various ways, and observing the way knowledge of the natural world became organized through the collections of contemporaries shines a unique light on how this complicated challenge began to be resolved. Despite the great scientific discoveries and intellectual leaps during this time, it is crucial to recognize that globalization was not a means of exploration and discovery but also colonization. This article examines the benefits of globalization on information collected on the natural world. Still, those benefits cannot be fully recognized without understanding the complexities behind the horrific tragedies and abuses intertwined with the European exploration of the globe. Globalization was a key catalyst in the development of new scientific theories and understanding, but it was often at the expense of Indigenous populations and the countless lives of innocent people. While the intellectual gains of the era were significant, they were deeply intertwined with exploitation and violence. To fully grasp the legacy of this period, we must hold both realities in view, acknowledging the scientific progress while confronting the system of power and abuse that made it possible. Only by deeply exploring both sides of the story can we come to a more honest and complete understanding of this transformative era.