CONTRIBUTIONS

Commentary

A History of the Ecological Sciences, Part 13: Broadening Science in Italy and England, 1600–1650

The number of European scientists and their publications increased steadily during the 1500s to the point that science needed social organization beyond what universities provided. Scientists corresponded with each other (Hatch 2000), and botanical gardens and museums were founded, often connected to a university or a city (Impey and MacGregor 1985, Findlen 1994, 2000, Cooper 2000). Italy led the way. In the later 1500s, a Neapolitan nobleman and natural philosopher, Giambattista della Porta (1535–1615) established the first scientific society, Academia dei Segreti (Academia Secretorum Naturae), while still a teenager (Rienstra 1975, Eamon 2000). He was inspired by the literary academies of Naples. He and his group investigated a wide variety of science topics, such as magnetism, optics, distillation, mechanics of water and steam, making plants bloom or fruit out of season, physiognomy, and topics now called pseudo-sciences, such as physiognomy and strange cures—all of which they called natural magic. Porta was a prolific author, whose most famous work, *Magia Naturalis*, included results from the Academia's investigations; it first appeared in four "books" in 1558, but grew through many later editions to 20 "books" by 1589. Besides the 12 Latin editions, there were four in Italian, seven in French, two in German, and two in English. The English translation was not published until 1658 and the second edition appeared in 1669.

Fig. 1. Giambattista della Porta. Frontispiece of Porta 1608.

Although Porta reported discovering small black "seeds" in fungi in his *Phytognomonica* (1588:240; quoted in English by Ainsworth 1976:14), this did not lead him to conclude that fungi only reproduce by the "seeds" we call spores (Porta 1658:60). One historian of science claimed that in *Phytognomonica* Porta "set out the first ecological grouping of plants according to their geographical locale and distributions"

(Price 1957), but this claim could only be made by someone unfamiliar with the botanical works by Theophrastos (Egerton 2001). Porta's discussions of physical sciences in *Natural Magic* is based to some extent on actual experiments, but his accounts of the generation of animals and production of plants is merely a repetition of traditional beliefs (Porta 1658:27):

> *Plants and living Creatures agree both in this, that some of them are generated of seed, and some of them Nature brings forth of her own accord, without any seed of the same kind: some out of putrified earth and plants, as those Creatures that are divided between head and the belly; some out of the dew that lies upon leaves, as Canker-worms; some out of the mud, as shel-creatures; and some out of living Creatures themselves, and the excrements of their parts, as lice.*

There is no explicit evidence that he performed any of the experiments that he explained for making plants bloom or fruit out of season, all of which seem culled out of authorities he cited, and some of which seem unlikely to work, such as grafting grapevines onto cherry trees (Porta 1658: 74–78).

Although the Inquisition shut down Porta's academy for several years, its activities and his publications later caught the attention of another teenaged nobleman, Federico Cesi (1585–1630). Despite strong opposition from his father, but with his mother's support, Cesi formulated an ambitions program for the development of science (Drake 1971, Freedberg 2002:1–8). His means for implementing his program was to establish in Rome the second scientific society, Accademia dei Lincei, in 1603 (De Renzi 2000, Miniati 2000). Porta had used the lynx as an emblem on the title page of *Magia Naturalis* (1589) because of its alleged ability to see through walls, and Cesi adopted it as a symbol of his academy's desire to penetrate the mysteries of nature (Lüthy 1996:7–9). Initially, it consisted of Cesi and three friends in Rome, but Porta joined in 1610 and Galileo in 1611, and after that it grew to about 30 members. The addition of Galileo broadened the Accademia's agenda beyond natural history to include astronomy and physics; Galileo also introduced his fellow Linceans to the microscope and microscopic studies of animals (Singer 1953, Freedberg 2002:151–154). Galileo's own "microscope" was merely his inverted telescope, and his account of an insect eye was reported by a Scot, John Wodderborn, who was in Padua in 1610 (Lüthy 1996). The Accademia, however, was so busy publishing Galileo's telescopic studies and defending his views, that its members did not begin their microscopic studies until 1624, by which time improvements by Kepler or by Drebbel were in use. Also in 1624 a Lincean, Johannes Faber, coined the word "microscope" (Freedberg 2002:183).

The Linceans chose to focus their attention and their microscopes first on the honey bee, which was readily available, but especially because there were three bees on the coat of arms of the Barberini family, one of whom had become Pope Urban VIII in 1623. They wanted his support at a time when various churchmen were already complaining about Galileo's publications. In 1625 Johan Friedrich Greuter produced for the Linceans the first printed illustration made with a microscope, entitled *Melissographia* and magnified about 20 times (Fig. 2). Also in 1625 Cesi published an accompanying *Apiarium*, a synthesis of everything known about honey bees. Although the Linceans published books of conventional size by Galileo, Cesi chose to publish *Apiarium* as four gigantic sheets, 107 × 69.5 cm (Freedberg 2002:160–192). This awkward format, with small Latin print, greatly limited its dissemination and preservation. The Lincei also used magnification to elucidate various aspects of plants. They discovered that the brown grains on the underside of fern leaves are actually "seeds," and next they discovered the "seeds" of mosses (Freedberg 2002:225–232).

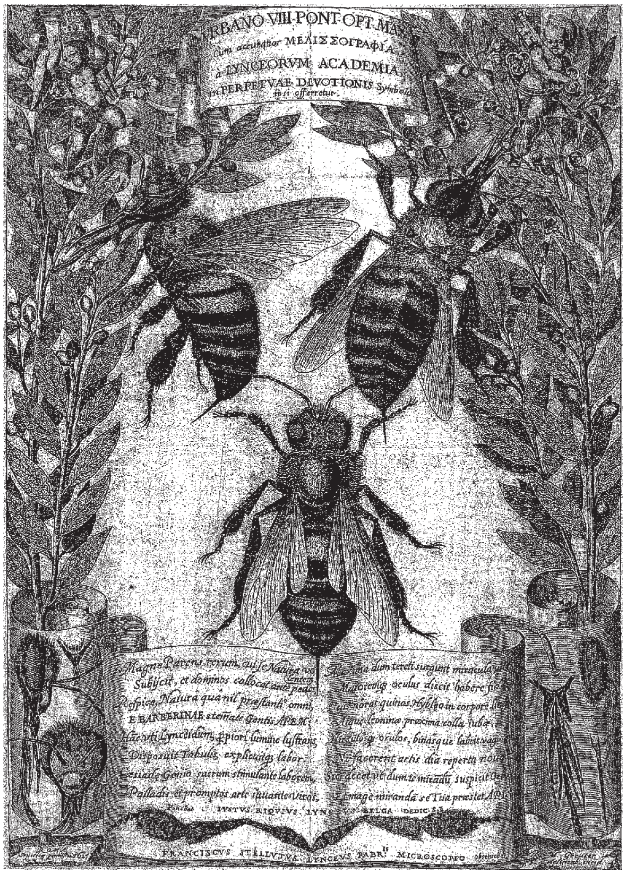

Fig. 2. *Melissographia*, the first published microscopic drawing (Singer 1953).

Despite these discoveries, Cesi, like Porta, still believed that some plants can arise by spontaneous generation (1630; cited from Thorndike 1958: 59). Cesi's ambitious plans to publish on botany were cut short by his death. A Lincean who did publish important botanical works was Fabio Colonna (1567–1650), though he had published a substantial part of them before he joined the Accademia in 1612 (Greene 1983:Chapter 23, Freedberg 2002).

Another important Lincean project was publication of an abridgement of a natural history of Mexico by Francisco Hernández (1517–1587). Freedberg (2002:246) calls this "the central project of Cesi's life, as well as that of his fellow Linceans." Hernández was a Spanish physician who was interested in his country's natural history. He began an annotated Spanish translation of Pliny's *Natural History* in 1566, which he finished while in Mexico in the 1570s, and it was published in Madrid in 1624 (reprinted as Volumes 4, 5, and 5a in Hernández 1959–1976). Felipe II, who had a general interest in science (Pierson 2000), made Hernandez the chief medical officer for Mexico on 11 January 1570, and then sent him there to study its plants, animals, and minerals, with emphasis on medicinal uses (Somolinos d'Ardois 1960, Vernet 1972, Lopez-Piñero 2000*a*, Varey et al. 2000). Hernández' heterodox religious–philosophical views might have been a factor in the king's decision (Benito-Vessels 2000). They assumed that it would take about five years, but in his fourth letter to Felipe, on 30 April 1572, Hernández (2000*a*:50) reported it might take nine or ten years.

Fig. 3. Fabio Colonna. Frontispiece, *Ecphrasis* (1616). From Greene 1983:834.

Finally, he accumulated a vast collection of 10 folio volumes of colored paintings and six of verbal descriptions of 3000 plants, 40 quadrupeds, 229 birds, 58 reptiles, 30 insects, 54 aquatic animals, and 35 minerals, and also dried Aztec plants (Chabrán and Varey 2000:4, Freedberg 2002: 246–247). Seeds and plants he brought back were planted in Spanish botanic gardens, particularly at Aranjuez (Weiner 2000:8). Although he took notes on geography and climate (Weiner 2000:5) he focused primarily on collecting and describing specimens, presumably intending to organize the collection for publication after he returned. He lived another decade after returning to Spain but never did organize it. That he returned in poor health was perhaps relevant, though there is also the possibility that his heterodox outlook was a factor (Benito-Vessels 2000, Weiner 2000:8). In 1580 he retired, and Felipe II gave his successor, Nardo Antonio Recchi (d.1595), the responsibility of preparing the immense amount of written and illustrated manuscripts for publication. In 1582 Recci completed his task and returned to his native Naples, carrying his reorganized manuscript with him, under the assumption that he would publish it. But he never did that either. Hernandez had left a copy of his materials in Mexico City, and some of it was published there in 1579 and more in 1615. The latter, entitled *Quatro libros de la naturaleza*, is now in English (Hernández 2000*b*: 117–156); it may be the earliest natural history book published in the New World. Porta wrote to Ulisse Aldrovandi in 1589 that Hernandez had died of a broken heart when Felipe II's Council of the Indies told him that his illustrations and descriptions of 4000 plants and animals were of little use "since they were of Indian plants that could not be used in Spain; and besides, the book had no order to it" (Freedberg 2002:248). If Porta's information was correct, Felipe did not take the advice seriously, since he continued to want to have it published, but the Council might have delayed its publication (Weiner 2000:8–9).

Fig. 4. *Centaurea crupina* L. Colonna, *Ecphrasis* (1616: 34). From Greene 1983:840.

In 1610 Cesi went to Naples to view Recchi's redaction, which Recci had left to a nephew. He was able to obtain a copy of the text and gained access to the illustrations in 1611. Publishing it occupied Cesi and other Linceans for the rest of their lives (Freedberg 2002:254). The great magnitude of the undertaking caused delays beyond anyone's imagining. They printed almost 900 pages and 800 illustrations in 1628, and a few copies were published in 1630, but Cesi's death in that year was a big setback. Colonna published his own botanical works with etchings that show fine details, but there were only 37 of them in his *Phytobasanos* (1592) and 210 in *Ecphrasis* (1616). The Linceans could not afford 800 etchings and made do with simpler woodcuts having less detail. Despite Recchi's work, their editorial tasks were demanding. There were corrections to be made and commentaries to write (many of which were longer than necessary), and when three churchmen returned from Mexico with additional information on plants and animals, the Linceans were glad to add their contribution (Freedberg 2002:261). The long struggle for publication ended successfully in 1651, but the whole process was so complex that no two copies of *Rerum Medicarum Novae Hispaniae Thesaurus seu Plantarum Animalium Mexicanorum Historia ex Francisci Hernandez* are the same (Varey 2000:xvii–xix, Freedberg 2002:272,). It is reprinted in Hernández's *Obras Completas* under the title *Historia Natural de Nueva España* (Volumes 2–3).

Fig. 5. Tlatlauhquiítztic. Hernandez 1959–1976, II:424.

Another project that occupied the Accademia dei Lincei was a collection of a vast "paper museum" (Freedberg's term)—well-executed color drawings of plants, animals, and fossils. Unfortunately, due to Cesi's early death, this impressive contribution to natural history lay buried in European libraries until its recent publication by Freedberg (2002: 15–64). Linceans also became quite interested in fossils. Cesi wanted to find a way to classify them. The Linceans commissioned an impressive series of drawings of fossils, and since they published few of them, they were also part of its "paper museum." Cesi had hoped to publish their findings, and Francesco Stelluti did finally publish a regional study, *Trattato del Legno Fossile Minerale* (1637), in which he implied that he spoke from a consensus of Linceans. He believed that fossil wood "is not generated from the seed or root of any plant whatsoever, but only from a piece of earth, containing much clay" (1637:6, translated by Freedberg 2002:332–333). Freedberg wonders if the struggles Galileo was having with the Catholic Church in the 1620s may have caused Cesi to postpone publication of his own thoughts on the origin of fossils, and then the writer died before he could publish.

An impulse to organize science also arose in England around the same time, but took a different form. Francis Bacon (1561–1626) became both a philosopher and advocate of science, and his influence was as great or greater than Porta and Cesi's combined, although it came almost entirely after his death (Hesse 1970, Rees 2000*a*, *b*, Van Helvoort 2000). Bacon's education included three years in France to learn Roman law and French, but while there he read the writings of radical education reformer Pierre de La Ramée (1515–1572), famous for his attacks on the sterile teachings of the Aristotelians (Mahoney 1975). Bacon's prominent career in government undoubtedly lent weight to his pronouncements on science. He attacked the education of the time in *The Advancement of Learning* (1604), but his own attempt to steer science toward meaningful research was unsuccessful. His posthumous *Sylva Sylvarum* (1627) is largely a compendium of traditional knowledge, as for example: “The moss of trees is a kind of hair; for it is the juice of the tree that is excerned [exuded], and doth not assimulate” (Bacon 1857–1874, Volume 2:511). Such notions led William Harvey to famously comment that Bacon wrote natural philosophy “like a Lord Chancellor” (Crowther 1960:11). Nevertheless, Bacon was influenced by Porta’s *Natural Magic* to conduct a series of experiments to increase plant growth rate; he grew several plants in water and found they sprouted more quickly than in soil (Bacon 1857–1874, Volume 2:477–478). Bacon’s “Catalogue of Particular Histories by Titles” served later as a list of desirable projects for English scientists; among the titles were (1857–1874, Volume 4:266–267):

> *19. Natural History of Geography; of Mountains, Vallies, Woods, Plains, Sands, Marshes, Lakes, Rivers, Torrents, Springs…*
>
> *20. History of Ebbs and Flows of the Sea; Currents, Undulations, and other Motions of the Sea.*
>
> *21. History of the other Accidents of the Sea; its Saltness, its various Colours, its Depth; also of Rocks, Mountains and Vallies under the Sea, and the like*
>
> *34. History of Plantes, Trees, Shrubs, Herbs; and of their parts, Roots, Stalks, Wood, Leaves, Flowers, Fruits, Seeds, Gums, &c.*
>
> *35. Chemical History of Vegetables.*
>
> *36. History of Fishes, and the Parts and Generation of them.*
>
> *37. History of Birds, and the Parts and Generation of them.*
>
> *38. History of Quadrupeds, and the Parts and Generation of them.*
>
> *39. History of Serpents, Worms, Flies, and other insects; and of the Parts and Generation of them.*

One of the few experiments Bacon actually performed killed him—he took a gutted chicken outside and stuffed snow in it to test its preservative properties, and later died from the effects of his exposure to the cold (Aubrey 1949:16).

Fig. 6. A much later illustration of Bacon’s Solomon’s House, which he described in *The New Atlantis* (1627).

Animal physiology may not be an ecological science, but the contributions by William Harvey (1578–1657) are nevertheless of interest here. To establish his discovery of the circulation of the blood, he needed to refute the teachings of Galen, and the only way to do that was to experiment. Ancient and medieval science were overwhelmingly observational sciences. Occasional experimentation, including several experiments by Galen, did not revolutionize scientific methodology. However, when Galileo and Harvey set out to refute Aristotelian physics and Galenic physiology, respectively, the only way to convince skeptics was to perform repeatable experiments (Bylebyl 2000). In doing so, they not only revolutionized their own sciences, but also influenced the methodology of some other sciences. Sciences relevant to ecology were slower than others to adopt experimentation, although Francesco Redi set an example that some of these sciences could have followed. In *De motu cordis* (1628, 1957), Harvey described experiments he had conducted on dogs, rabbits, snakes (vivisectional), and humans (nonvivisectional). Harvey seemed ambivalent about spontaneous generation of some species. His book on reproduction and embryology (1651) carried a phrase on the frontispiece, "ex ovo omnia" (all are from eggs), that caught the interest of Redi and others, but he nevertheless seemed to accept spontaneous generation for some species (Keynes 1966:352, Lopez-Piñero 2000*b*). When Harvey investigated the mating habits of the red deer, *Cervus elaphus*, he could draw upon first-hand experience. As the King's physician, he often accompanied Charles I on his almost weekly hunts of bucks during the summer and hinds in the fall, and he had opportunities to observe mating and to study and describe deer genitals and embryos. He also gleaned information from the King's game wardens (Harvey 1847:474–476, Egerton 1961).

A younger fellow physician, Thomas Browne (1605–1682), had an English and Continental medical education comparable to Harvey's, but he did not aspire to practice among the élite of his hometown, London. He settled instead in Norwich—becoming a big fish in a small pond rather than a little fish in a big pond. Browne's interests were much broader than Harvey's, but because of that, his scientific investigations were also more superficial. Browne addressed his broad interests in a very popular book, *Pseudodoxia epidemica: or Enquiries Into Very Many Received Tenents and Commonly Presumed Truths* (published 1646; Browne 1964). Many contemporaries approved of his desire to separate fact from folklore, but it was a difficult project when one cast one's net as broadly as he did. Worthy predecessors who had met with only limited success included Pliny, Albertus Magnus, and Gessner. One of the "errors" Browne investigated was the claim by Pliny, Virgil, and others that "Viscus Arboreus *or Misseltoe is bred upon Trees, from seeds which Birds, especially Thrushes and Ring-doves let fall thereon*…" (Browne 1964, Volume 2:146). If that were true, he wondered, why does it only grow on some of the species in which they perch?

> *…it groweth upon Almond-trees, Chestnut, Apples, Oaks, and Pine-trees… Crab[apple]s, and White-thorn; sometimes upon Sallow, Hazel, and…rarely upon Ash, Lime-tree, and Maple; never, that I could observe, upon Holly, Elm, and many more.*

Browne was inclined to agree with Bacon that mistletoe is "*an arboreous excrescence, or rather super-plant, bred of a viscous and superfluous sap which the tree it self cannot assimilate*." Browne collected galls from oaks and other plants in November and found that little maggots in them became flies in June. From these observations he concluded that "…*if the putrifying juices of bodies bring forth plenty of Flies and Maggots, they give testimony of common corruption, and declare that the Elements are full of the seeds of putrifaction, as the great number of Caterpillars, Gnats, and ordinary Insects do also declare* (Browne 1964, Volume 2:151–152). He easily dismissed such claims as elephants having no joints in their legs, horses having no gall, and badgers having legs on one side longer than on the other side. When he tackled the claims of great longevity for animals he employed several kinds of evidence.

Aristotle had noted some correlation between gestation period, maturation period, and longevity. An elephant, which might live to be a hundred, has a gestation period of a year and takes 20 years to mature. Sheep and goats, which live only 8 or 10 years, have a gestation period of five months and reach maturity in two years. Therefore, "*Deer that endureth the womb but eight moneths, and is compleat at six years, from the course of Nature, we cannot expect to live an hundred; nor in any proportional allowance much more then thirty*" (Browne 1964, Volume 2:181). Furthermore, animals like deer that have "excess of venery" do not live as long as those that do not. Some species (as Aristotle noted) can also be aged by their horns and teeth. In the case of deer, "*From the horns* [antlers] *there is a particular and annual account unto six years: they arising first plain, and so successively branching: after which the judgment of their years by particular marks becomes uncertain. But when they grow old, they grow less branched, and first do lose their* propugnacula*; that is, their brow-antlers…. In old age they have few or none* [teeth] *in either jaw*" (Browne 1964, Volume 2: 183). Later editions of *Pseudodoxia Epidemica* appeared in 1650, 1658, 1669, and 1672—all containing revisions and additions. That book was not the end of his writings, however. He also wrote "*Miscellany Tracts*," which were not refutations of "errors"; these essays were only published posthumously in 1683. Among them was "*Of Hawks and Falconry, Ancient and Modern*," which is an intelligent summary of lore from many sources, except that he was obviously unaware of Frederick II's *De arte venandi cum avibus*, which had been printed in 1596 (Browne 1964, Volume 3:60–64, Egerton 2003:43). International communication among scholars was improving, but was still quite modest by modern standards. Browne's *Garden of Cyrus* (1658) will be discussed in Part 14 of the *History of the Ecological Sciences*.

Italy and England provided good environments for the expansion of science, 1600–1650, but so did France and The Netherlands. Germany was suffering through the Thirty Years War, 1618–1648.

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