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VOLUME FIVE MARCH 2011

Eighteenth-century Science in the Garden

Royal Horticultural Society

Cover illustration:

Hill, *Vegetable System*, vol. 23 (1773) plate 20: Flower-de-luces, or Irises.
Left, *Iris tuberosa*; right, *Iris xiphium*.

Occasional Papers from the RHS Lindley Library

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Philip Miller as a natural philosopher

Brent Elliott
The Lindley Library, The Royal Horticultural Society, London

There have been several textbooks on gardening from the scientific point of view, ranging from Frederick Keeble's *Science lends a Hand in the Garden* (1939) to Ken Thompson's *An Ear to the Ground* (2003), and not forgetting the RHS *Science and the Garden* (2002). The genre did not wait for the twentieth century; its first example was John Lindley's *Theory of Horticulture* (1840), but that work did not have a rival for nearly a hundred years, and was still being used as a textbook at Wisley after the First World War (Elliott, 2004: 322).

Nobody in the eighteenth century compiled a textbook on garden science, but the raw materials were readily available in the successive editions of Philip Miller's *Gardeners Dictionary*, from 1731 to 1768. Miller's *Dictionary* is well known as a source of information on plants, and there are entries for such garden features as Lawn, Parterre, Greenhouse, as well as entries for each of the months (a prototype and abridgement of Miller's *Gardeners Kalendar*, which had a separate life of its own, going through 16 editions). But in addition there are theoretical or scientific discussions of AETHER, AIR, ATMOSPHERE, CLIMATE, COLD, DEW, EARTH, FIRE, FREEZING, FLUIDITY, HUMIDITY, HYDROSTATICKS, ICE, LEVITY, LIGHT, NATURE, RAIN, RAINBOW, SUN, THUNDER, VAPOUR, VAPOURS, WATER, WEATHER, WINDS, and accounts of the BAROMETER, HYGROMETER, and THERMOMETER.[1] I have never seen anyone comment on these entries, which were obviously intended to provide the scientific background for the operations of gardening, and which transport the modern reader back into an age when assumptions about natural processes were very different from today's.

[1] None of the editions of Miller's *Dictionary* carries any page numbers; after all, the entries were printed in alphabetical order, so why bother? I shall identify references simply by naming the articles in SMALL CAPS. This system will work no matter which edition is being used.

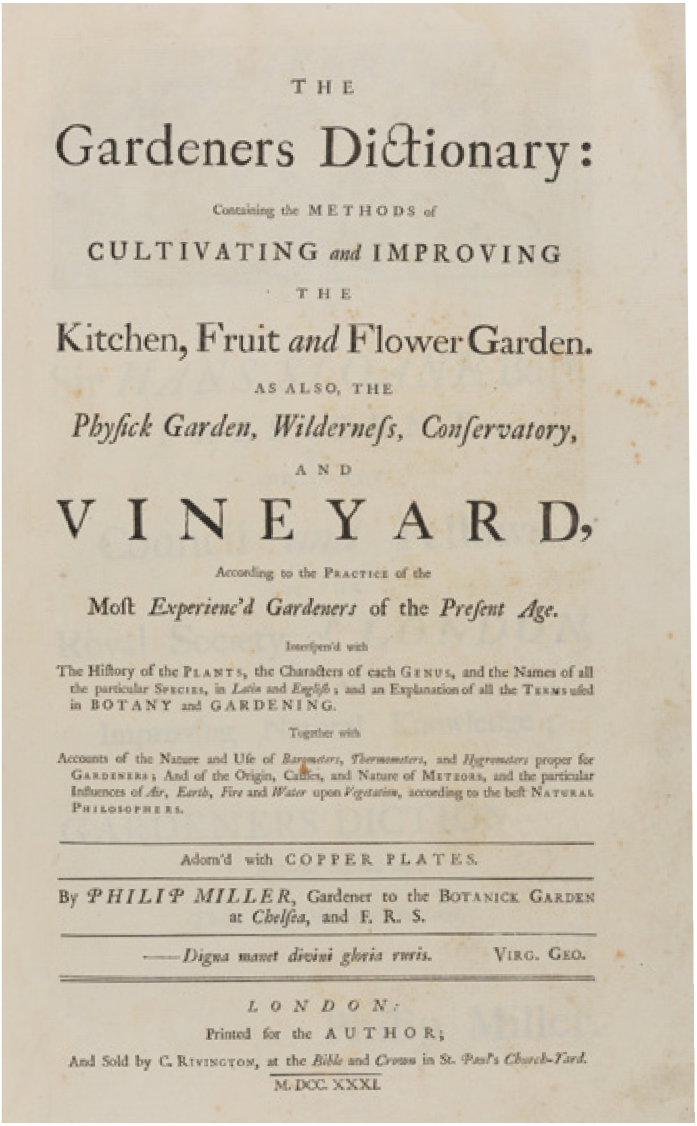
Miller's sources

Miller was 40 when the first edition of his *Dictionary* appeared, but it could still be called a young man's book. It reveals a Miller eager to display his learning, citing over sixty authorities in the entries on the scientific background alone.[1] It was not Miller's first venture into the field. In 1724 he had published a smaller work, *The Gardeners and Florists Dictionary*, two volumes in octavo, and in this he published the first versions of a number of the entries. Most of them were considerably shorter than their successors; many of these were completely rewritten; only the entry on HUMIDITY was retained in its entirety. The entries on HYGROSCOPE (transferred, in the *Dictionary*, to HYGROMETER), ICE, LEVITY, NATURE, SUN, THERMOMETER, THUNDER, VAPOURS, WATER, WEATHER, WINDS yielded substantial sections of the later entries in the *Dictionary*.

Hardly any of the entries on physical science were revised in any of their details in later editions; there were no updates, despite the various scientific discoveries and technological advances made during Miller's lifetime. For example, Daniel Fahrenheit had published his temperature scale in the *Philosophical Transactions* for 1724, and it came into use in England fairly quickly – though not quickly enough for Miller to mention it

---

[1] Guillaume Amontons, Archimedes, Aristotle, Auton de Denicinis [*sic*; = Marco Antonio de Dominis], Sir Francis Bacon, Erasmus Bartholinus (Rasmus Bartholin), John Beale, Henry Beighton, Hermann Boerhaave, Giovanni Alfonso Borelli, Père Bourzes, Robert Boyle, Cabeus (Niccolo Cabeo), Giovanni Domenico Cassini, Centivoglio, Ephraim Chambers, George Cheyne, Samuel Clark, Cruquius (Nicolaas Kruik), James Cunningham, William Derham, John Theophilus Desaguliers, René Descartes, John Gerard, Willem Jacob 's-Gravesande, Nehemiah Grew, Stephen Hales, Edmund Halley, Francis Hauksbee, Johann Baptista van Helmont, J. Hillier, Thomas Hobbes, Wilhelm Homberg, Robert Hooke, Christiaan Huygens, James Keith, Philippe de la Hire, Jean Le Clerc, Nicolas Lemery, Martin Lister, John Locke, Nicolas Malebranche, Edmé Mariotte, Morinus (Jean-Baptiste Morin), Sir Isaac Newton, Père Niccron, Bernard Niewentyt, Jacques Ozanam, Paracelsus, John Patrick, Robert Plot, John Pointer, John Ray, Tancred Robinson, Jacques Rohault, Ole Rømer, Johann Jacob Scheuchzer, Timothy Sheldrake, Michele Angele Tilli, Richard Townley, Basil Valentine, Burchard de Volder, John Wallis, Wolfius (Christian Wolff), and John Woodward; in varying spellings, and sometimes citing specific titles.



THE

Gardeners Dictionary:

Containing the METHODS of

CULTIVATING *and* IMPROVING

THE

Kitchen, Fruit *and* Flower Garden.

AS ALSO, THE

Physick Garden, Wilderness, Conservatory,

AND

VINEYARD,

According to the PRACTICE of the

Most *Experienc'd Gardeners* of the *Present Age.*

Interspers'd with

The History of the PLANTS, the Characters of each GENUS, and the Names of all the particular SPECIES, in *Latin* and *English*; and an Explanation of all the TERMS used in BOTANY and GARDENING.

Together with

Accounts of the Nature and Use of *Barometers, Thermometers,* and *Hygrometers* proper for GARDENERS; And of the Origin, Causes, and Nature of METEORS, and the particular Influences of *Air, Earth, Fire* and *Water* upon *Vegetation,* according to the best NATURAL PHILOSOPHERS.

Adorn'd with COPPER PLATES.

By *PHILIP MILLER,* Gardener to the BOTANICK GARDEN at *Chelsea,* and F. R. S.

——*Digna manet divini gloria ruris.* VIRG. GEO.

LONDON:

Printed for the AUTHOR;

And Sold by C. RIVINGTON, at the *Bible* and *Crown* in St. *Paul's Church-Yard.*

M.DCC.XXXI.

Fig. 1. **Miller, *Gardeners Dictionary* (1731), title page.**

in 1731, because there was always a time lag between the publication of a temperature scale and the manufacture of working thermometers using that scale; but he did not amend his THERMOMETER entry in later editions, when the use of Fahrenheit's scale in England had become widespread. So while the writing of these entries involved an immense amount of reading and thought, it was probably undertaken as a deliberate research project for the compilation of the *Dictionary*, rather than representing an interest that Miller sustained throughout his life.

How much research did Miller undertake for the work? In most cases, the authors he cites are referred to, and their work or their particular experiments summarised, without an individual title being named. It is therefore possible that Miller's acquaintance with their work was indirect, based on report, summaries or references in other literature. In fact, his most frequently used source was Chambers' *Cyclopaedia*, which had recently been published (1728); several passages in Miller were quoted from Chambers virtually word for word, sometimes with altered order, changes in paragraphing, minor abridgment or occasionally additions. (Sometimes Miller made copying errors which were never corrected in future editions, and duplicated passages in more than one entry – compare WEATHER and WIND; at the end of the entry on FIRE there is a cross-reference, copied from Chambers, to an article on Heat which Miller failed to include in his own *Dictionary*.) Many of Miller's citations of authorities appear in these copied passages.

A comparison of Miller's text with Chambers' for the scientific entries is shown in Table 2 (p. 49). Miller was hardly alone in helping himself to Chambers' entries; Diderot and D'Alembert did the same in the 1750s in their celebrated *Encyclopédie* (despite Diderot's insistence that his authors take Chambers only as a starting point and not simply copy his text). Ann-Marie Thornton has traced 85 articles in the *Encyclopédie* that cite Miller directly (Thornton, 2005), but in addition to these it is possible to find passages which correspond exactly to Miller because both were copied from Chambers – compare for example Miller's FREEZING with the *Encyclopédie's* Congelation. Diderot and D'Alembert at least acknowledged Chambers as their source more often than Miller, who referred to Chambers explicitly only once, in the entry on BAROMETER.

Table 1. **Comparison of entries in Miller's *Gardeners and Florists Dictionary* (1724) and *Gardeners Dictionary* (1731)**

Entry	1724*	1731
Air	26	Replaced by different text
Anatomy of Plants	9	Replaced by different text
Climate	1	Replaced by different text
Cold	1	Replaced by different text
Dew	3	First paragraph retained; otherwise replaced by different text
Earth	61	Much of the practical discussion of earths is retained, but the theoretical text is all new
Flower	1	Replaced by different text
Freezing	4	Replaced by different text
Humidity	4	Retained in its entirety
Hydrostaticks	14	All retained apart from the introductory paragraph
Hygrometer	1	Retained as first paragraph of HYGROMETER
Hygroscope	2	Most retained as concluding portion of HYGROMETER
Ice	6	Retained as first half of entry
Levity	3	Retained with revised wording
Light	1	Retained as paragraph 7 of entry
Nature	39	Paragraphs 16–39 retained as 25–49 of enlarged entry
Rain	17	Paragraphs 1–3 retained as 1–6, 4 as 35, 7 as 9, 8 as 7, 10 as 13, 11 as 16, 14–19 as 29–34
Rainbow	11	Paragraphs 2–11 retained as 5–14 of enlarged entry
Sun	18	Retained as paragraphs 128–148 of greatly expanded entry
Thermometer, or Thermoscope	22 & table	Partly retained as paragraphs 21–41 of THERMOSCOPE
Thunder	41	Mostly retaied as paragraphs 21–65
Vapours	24	Almost all retained as paragraphs 1–23
Variegation of Plants	42 & table	Paragraphs 31–42 retained as 109–119 of VARIEGATED
Vegetation	45	Most retained as the bulk of paragraphs 1–42 of greatly expanded entry
Water	86	Paragraphs 1–35 retained as opening of greatly expanded entry
Weather	59	Almost all retained as part of a longer entry
Winds	104	Paragraphs 1–2 retained as 1–2, 3–21 as 96–111, 22 as 119, 36–43 as 120–126, 62–93 as 127–152 of WIND

* Figures denote number of paragraphs

But even in those passages where he quoted Chambers more or less verbatim, it is not safe to conclude that he did not look up the works cited there. Sometimes it is apparent that Chambers and Miller were both copying from the same source. Both men copied an extensive section of "Prognosticks of the Weather from Vegetables" in their respective entries on WEATHER from John Pointer's *Rational Account of the Weather* (1723), Chambers anonymously and Miller with an acknowledgment; similarly, in FREEZING, Miller identified George Cheyne as a source for some of the material duplicated in Chambers. In the entry on BAROMETER, he added more details of Martin Lister's experiments than could be found in Chambers. In some cases, the overlap of wording is a consequence of the fact that both Miller and Chambers were copying from Boerhaave, and in these instances Miller appears to have bypassed Chambers and gone straight to the Boerhaave text, since he retained details that Chambers omitted when abridging the material for his *Cyclopaedia*. There are other duplicated passages that can be found in the 1724 *Dictionary*, pre-dating Chambers, and therefore indicating a source common to both. One such source is John Quincy's *Lexicon Physico-Medicum* (1719), a one-volume pocket medical dictionary.

What were the works that Miller read in order to gather the data for his scientific entries? In the earlier *Gardeners and Florists Dictionary*, he drew heavily on Georg Andreas Agricola and Stephen Switzer; but far better literature had become available by 1731, and they were largely dropped. Sometimes he named specific titles, and not only when they were cited in Chambers: Newton's *Opticks* and *Principia*, Hales' *Vegetable Staticks*, Hooke's *Micrographia*, Borelli's *De Motu Animalium*, Boyle's *Mechanical Origin of Heat and Cold*, 's-Gravesande's *Physices Elementa*, Mariotte's treatise on hydrostatics. I think it is safe to assume that Miller did not chase up the various cited papers in the *Mémoires de l'Académie des Sciences*, or the Leipzig *Acta Eruditorum*, let alone such obscure items as the anonymous "Nouvelle Conjecture pour expliquer la Nature de la Glace", published in the *Journal de Trévoux* in 1701 (FREEZING). On the other hand, Miller cited so many papers from the *Philosophical Transactions of the Royal Society*, usually giving the numbers of the parts they appeared in, that he probably looked up those referred to less precisely by Chambers.

After Chambers' *Cyclopaedia*, the authors most often copied by Miller were Stephen Hales and Hermann Boerhaave. His article on VEGETABLE

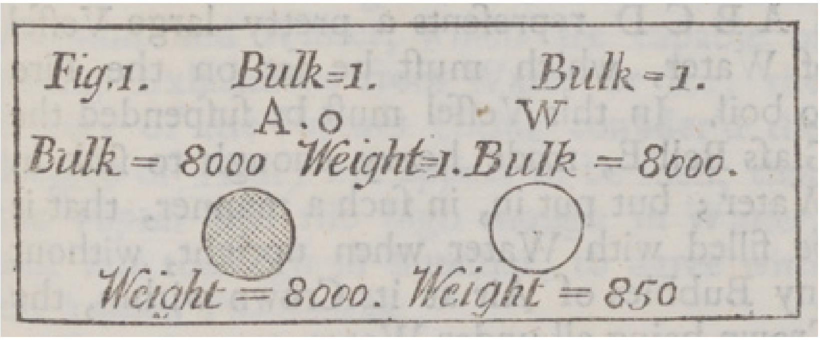


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Fig. 2. **Miller, *Gardeners Dictionary* (1731), diagram from the entry on VAPOURS, copied from Desaguliers 1729, showing the comparative density of air and water.**

STATICKS consisted largely of a detailed summary of the experiments Hales reported in his book *Vegetable Staticks* (1727);[1] in addition, detailed accounts of Hales' experiments made up large portions of the entries on AIR, COLD, DEW, RAIN, and THERMOSCOPE. Hales applied Newton's methods and principles to the study of air and water movements in plants, and in the process, as Miller said, "He has illustrated, and put past all Doubt, several Truths mention'd in Sir *Isaac Newton's* Queries" (VEGETABLE STATICKS). Boerhaave, the professor of botany, medicine, and chemistry at Leiden, was one of the most respected authorities of the period on those subjects. His theories of chemistry were published in his *Elementa chemiae* (1732), after the first edition of the *Gardeners Dictionary* had appeared, and were not translated into English until 1741; Miller must therefore have been drawing on the *Institutiones et Experimenta Chemiae* (1724), based on Boerhaave's lectures but published without his permission (Lindeboom, 1968: 177–179), and translated in 1727 by Peter Shaw and Ephraim Chambers. Passages from Boerhaave are transcribed in the entries on AIR,

[1] The most recent study of Hales gets off to a bad start by seeing the *Gardeners Dictionary* as an influence on Hales rather than vice versa (Allen & Schofield, 1980: 18); for reasons unstated, the authors think that Miller's work was published in 1711 rather than 1731. Elsewhere they note the fact that Miller often cites Hale (*ibid*.: 128). Hales was later to be one of Miller's proposers as a Fellow of the Royal Society (Le Rougetel, 1990: 46).

EARTH, FIRE, SUN, and WATER (in the last-named entry, Miller transcribed the same material more fully than Chambers' *Cyclopaedia* did).

There are other instances of extensive copying in individual entries. Over half of the article on VAPOURS consisted of a copy of Desaguliers' paper on vapours in the *Philosophical Transactions* of the Royal Society (Desaguliers, 1729), and Miller reproduced the diagram of comparative bulks and weights from p. 11 of that article. Most of the weather lore in WEATHER and WIND was copied from Pointer's *Rational Account of the Weather*; most of the article on ICE , and part of that on WATER, from Mariotte's *Motion of Water*; part of the entry on WIND from Derham's *Physico-theology*. Articles by Halley and Boyle were drawn on extensively.

Table 3 (p. 53) provides a list of the scientific sources Miller used, with the names of the articles in which they are cited. I have excluded works which were cited in Chambers or Boerhaave, and which there is no reason to believe that Miller attempted to look up independently: so, for example, although their works were available in English, I have omitted Rohault and Malebranche (whose *Recherche de la Verité* was available in two different translations). For the reasons given above, I have included all the articles cited from the *Philosophical Transactions*.

In addition to writers, Miller made a number of references that must have been based on personal communications. In the entry on SUN, Miller includes a table of notations of the angle of the sun's rays, compiled by Timothy Sheldrake. Sheldrake did not, as far as is known, publish anything on the subject until two decades later, when his pamphlet *The causes of heat and cold in the several climates and situations of this globe* appeared – and then it did not include the table that Miller printed. Blanche Henrey reported that Sheldrake could be documented as a correspondent in the 1730s (Henrey, 1975: II 15–17), but very little is known of his life and activities; this table could be regarded as his first publication.

So far, I have been able to trace the sources which Miller copied for between a third and a half of the scientific material Miller included in his *Dictionary*. No doubt there are still more original sources lurking just outside my field of vision, but for the purposes of this article Miller's originality is unimportant. Miller himself made no claims for originality in his treatment of physical and chemical matters, saying in his preface that "it would have been a Presumption, were I capable, to offer any thing of my own". The question to be answered here is, What does the *Dictionary* tell us about the assumptions of the period, the early-to-mid eighteenth century, about the scientific background to gardening?

Newtonianism and physico-theology

Miller's work, like virtually all English scientific work of the previous generation, was carried out in the shadow of Isaac Newton. Newton's achievements were immense: he had created a new branch of mathematics and solved the problems of motion and light. Even those without the skills to interpret the equations of the *Principia* held him in awe. First of all, Newton exerted a dictatorial control over British science: he was not merely the country's most famous "natural philosopher" (the term "scientist" not being coined until the 1830s), he was a hero of the Glorious Revolution for his defiance of James II's attempt to impose Catholic governors on the University of Cambridge, and most recently he had been President of the Royal Society. Secondly, he represented England embattled by the Continent: he had led the assault on the physical theories of Descartes and his followers;[1] he had had a running battle with Leibniz over his priority in developing the calculus, and from the English point of view had won; and every succeeding year seemed to bring more proofs of the accuracy of Newton's theories, and the failure of his continental rivals'. So not only his specific theories, but his basic approach to scientific matters (he claimed that – unlike Descartes – he did not propose hypotheses, but restricted himself to facts), had been placed virtually beyond question for Miller's generation.

> The incomparable Sir *Isaac Newton* has not only shorten'd the Geometrician's Work, by his wonderful Discoveries in abstract

[1] The very title of Newton's masterpiece delivered a snub to the Cartesians. Descartes' major work, in which he offered his explanations of the physical world, was entitled the Principles of Philosophy – *Principia Philosophiae*. Newton entitled his work the *Mathematical* Principles of *Natural* Philosophy – *Philosophiae Naturalis Principia Mathematica* – and in the first edition those additional words were printed in red to emphasise the difference, and distance, between him and Descartes.

> Mathematicks, but has also taught us, by his own Practice, how to make and judge of Experiments and Observations with the utmost Accuracy: And as he avoided making *Hypotheses*, he was so cautious as to deliver only by way of Queries several Truths which he was convinc'd of, because he wanted a sufficient Number of Experiments to make them as evident as those others, whereby he has so far improv'd and advanc'd natural Knowledge (VEGETABLE STATICKS).

Newton's principal work, the *Philosophiae Naturalis Principia Mathematica*, had been published in 1687, and reached its final revision in 1726; for forty years it was directly available only to readers of Latin, and even then only to those with an appetite for equations. The first English translation was published by Andrew Motte in 1729, in time for Miller to read it, though every reference in Miller is to the Latin version, as cited in Chambers or paraphrased by him. But the content of the *Principia* had quickly been made available to the public. Newton gathered around himself a circle of publicists, among them William Whiston, John Keill, George Cheyne, Richard Mead, Edmund Halley, David Gregory, and Fatio de Duiller, who made the Newtonians' first foray into horticulture in 1699 with his *Fruit-walls Improv'd* (Elliott, 1991); sometimes he obligingly wrote parts of their promotional works for them, as with the preface for Gregory's *Elementa Astronomicae* (1702). These men promulgated the principles of Newton's *Principia*, applied them to problems in mechanics, chemistry, medicine, and biology, and launched attacks on rival theories and critics of Newton, especially foreign critics (Thackray, 1970: 43–82).

Newton's *Opticks*, on the other hand, was originally published in English (in 1704); its international impact was delayed until Samuel Clarke published a Latin translation in 1706. The *Opticks* had far fewer equations, and more accounts of experiments that could be duplicated by the curious reader; so by the 1720s it had become Newton's best-known work, and the one particularly celebrated, and drawn on for material, by poets and publicists (Nicolson, 1945). Unlike the *Principia*, the *Opticks* dealt with matters that everyone could examine without special training: light and colour, the phenomena of the spectrum and the rainbow. (The explanation of the RAINBOW Miller regarded as "one of the Glories of the *Newtonian* Doctrine of Colours".) Not that the disparity in subject matter between the two works was absolute, for Newton attached to the end of the *Opticks* a series of Queries, setting out an agenda for future research, which moved beyond the ostensible subject of the book into matters of chemistry and physics more generally.

At the time Miller was compiling his *Dictionary*, the philosophies of Descartes and Malebranche were still competing for preference on the Continent; the Newtonian movement which eventually swept them away only began in the 1730s. One of Newton's major French promoters was Voltaire, whose description of the rival philosophies does a good job of conveying the intellectual atmosphere in which Miller grew up:

> A Frenchman who arrives in *London*, will find Philosophy, like every Thing else, very much chang'd there. He had left the World a *plenum*, and he now finds it a *vacuum*. At *Paris* the Universe is seen, compos'd of Vortices of subtile Matter; but nothing like it is seen in *London*. In *France*, 'tis the Pressure of the Moon that causes the Tides; but in *England* 'tis the Sea that gravitates towards the Moon; so that when you think that the Moon should make it Flood with us, those Gentlemen fancy it should be Ebb, which, very unluckily, cannot be prov'd. For to be able to do this, 'tis necessary the Moon and the Tides should have been enquir'd into, at the very instant of the Creation.
>
> You'll observe farther, that the Sun, which in *France* is said to have nothing to do in the Affair, comes in here for very near a quarter of its Assistance. According to your *Cartesians*, every Thing is perform'd by an Impulsion, of which we have very little Notion; and according to Sir *Isaac Newton*, 'tis by an Attraction, the Cause of which is as much unknown to us. At *Paris* you imagine that the Earth is shap'd like a Melon, or of an oblique Figure; at *London* it has an oblate one. A *Cartesian* declares that Light exists in the Air; but a *Newtonian* asserts that it comes from the Sun in six Minutes and a half…
>
> How furiously contradictory are these Opinions! (Voltaire, 1733: 109–111)

Nonetheless, Newtonianism was not slavishly followed in England, and the impact of Boerhaave's theories in the 1720s ensured that alternative theories of matter were available and debated seriously. Ephraim Chambers helped to spread the word by translating the Boerhaavian *Institutiones* in 1727, and Miller followed him, copying a remarkable passage which declared that “we should be inexcusable if we should absolutely acquiesce in what [Newton, Boyle *et al.*] have done, and shut the Door against farther and better Information” (FIRE).

Newtonianism had additional nuances less familiar today than the material covered in the *Principia* and the *Opticks*. The closing years of the seventeenth century had seen the rise of a genre of philosophical writing called physico-theology (the name having been coined by John Ray in his *Three Physico-theological Discourses*, 1693).[1] Much of this writing emanated from the circle of Newton’s associates. The purpose of physico-theology was to apply the discoveries of modern science to the question of origins: now that so much had been learned about the functioning of nature, to examine the Biblical narrative of the creation of the world and assess how much of the story could be accounted for as natural phenomena, and how much was miraculous. The initial work, a bestseller of the 1680s, was Thomas Burnet’s *Sacred Theory of the Earth*, which accounted for the Flood by using Cartesian vortex theory; this, naturally, had to be put right by using Newtonian theory instead. John Woodward, in his *Natural History of the Earth* (1695), and William Whiston, in his *New Theory of the Earth* (1696), tackled the questions of the Flood and creation, Whiston proposing that the earth had originally been a comet that did not start to rotate on its axis until it had been caught into an elliptical orbit by the sun’s gravity.

The heyday of speculative physico-theology had passed by Miller’s time; William Derham’s *Physico-theology* (1713) and *Astro-theology* (1714), while immensely popular, each going through thirteen or more editions, toned down the creation science and concentrated on finding evidence for the existence and power of God by surveying the wonders of the creation. Physico-theology was modulating into natural theology (Richard Bradley is another such transitional figure, with more particular links to botany). Miller knew and drew on Derham’s work (Derham’s books originated as series of sermons, but their copious footnotes served as a good guide to current scientific thinking), and generally neither he nor Chambers

[1] Originally entitled *Miscellaneous Discourses concerning the Dissolution and Changes of the World* (1692); retitled in the second edition.

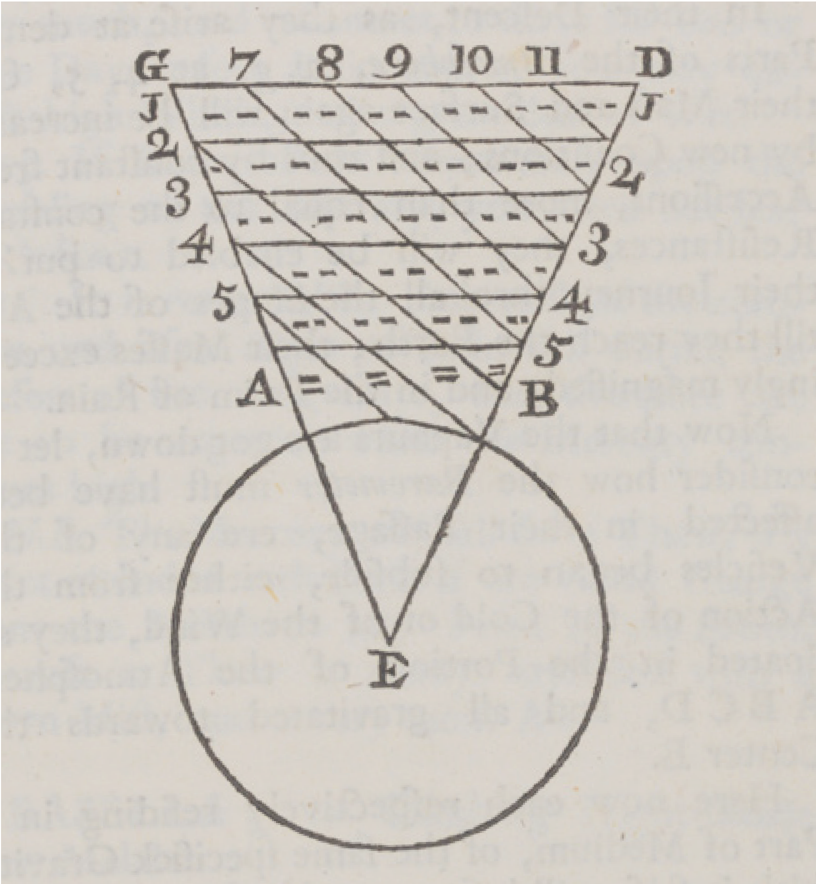

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Fig. 3. **Miller, *Gardeners Dictionary* (1731), diagram from the entry on BAROMETER, copied from Chambers' *Cyclopaedia*, illustrating a hypothesis to explain fluctuations in air pressure by the descent and progressive coalescence of particles of moisture in the atmosphere.**

indulged in speculation about the origins of natural phenomena; but when it came to the principles of botany, the lingering influence of physico-theological thinking can be seen in the treatment of plant generation.

New technologies

The scientific world of the late seventeenth and early eighteenth centuries was characterised not only by its theories, but by its technology. A series of inventions had been introduced, changing the conduct of both experiment and measurement. The first to become important was the air-pump, a device for emptying air out of a container in order to study the phenomena of the vacuum. The first demonstration of an air-pump had been made in a public experiment by Otto von Guericke in 1654, when two copper hemispheres were fastened together and the air pumped out of the resulting sphere; two teams of horses had been unable to pull the hemispheres apart. Robert Boyle developed an improved air-pump, publishing his experiments as *New Experiments Physico-mechanicall, touching the Spring of the Air* (1660) and its sequels. There followed a little pamphlet war with Thomas Hobbes, who attacked the new tendency to rely for experiments on equipment that was expensive and accessible only to a minority (Shapin & Schaffer, 1985), but also condemned Boyle and his colleagues for surreptitiously redefining the accepted vocabulary of philosophy. "Vacuum", for example, ought to mean empty space, characterised by an absence of matter, whereas Boyle and his colleagues used it to mean merely a volume in which no effective presence of air could be measured using the equipment available. The terms of this debate were still sufficiently current in Chambers' and Miller's time for them to make a great point of the pragmatic, undogmatic nature of Boyle's definition of "vacuum".

Closely allied to the air-pump, as a device for measuring the pressure of the air, was the barometer. First attempted by Galileo and refined into a workable instrument by Torricelli, who published his experiment in 1644, the barometer was easier to manufacture and therefore available to anyone who wanted to experiment with it. The first barometric experiment in England on the effect of altitude on air pressure was made by an amateur named Henry Power, who climbed Beacon Hill in Halifax with a barometer in 1653; and in the second half of the seventeenth century the barometer was improved and experimented with more in England than in any other

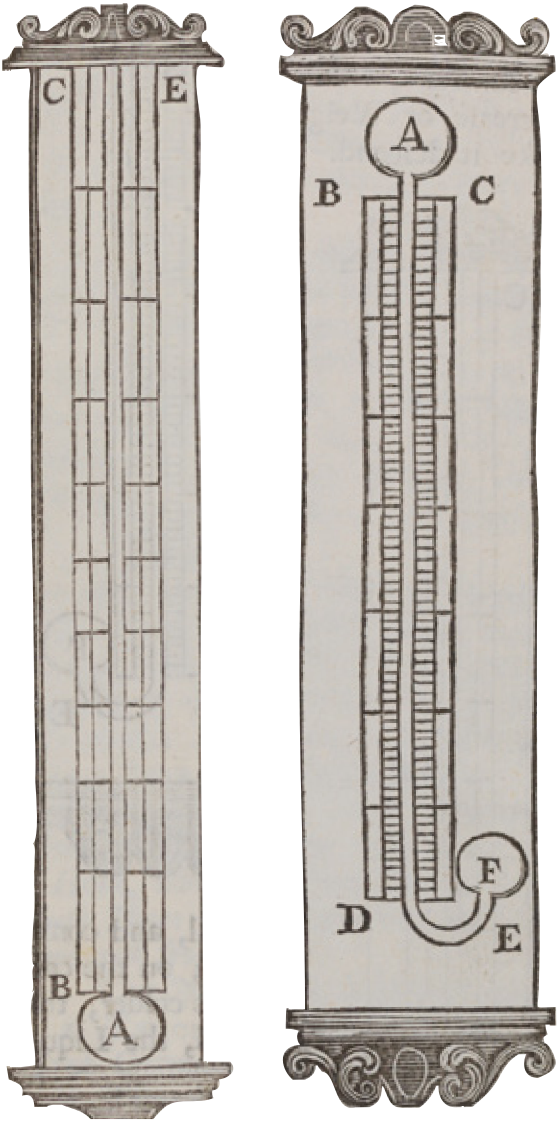

Fig. 4. **Miller, *Gardeners Dictionary* (1731), diagrams of thermometers. The model on the left, a "Florentine thermometer", used spirits of wine, while the right-hand model used water mixed with aqua regia.**

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country (Middleton, 1964: 55, 59–60). Miller's BAROMETER entry covered more than six pages, mostly copied from Chambers, and provides a good conspectus of the state of barometrical research, including Leibniz's first proposal for an aneroid barometer (dismissed by Chambers/Miller as impractical).

The third piece of new technology was the thermometer, which Chambers and Miller treated in two articles, on THERMOMETER and THERMOSCOPE, the latter term eventually being phased out. The first thermometers, pioneered in the 1620s by Galileo and others, consisted of a bowl of liquid, in which a columnar tube of the same liquid was inverted; but the device could give only a crude indication of rise or fall in temperature, because the results could be distorted by changes in air pressure. The air thermometer was succeeded in the 1630s by devices which sealed the column of liquid within a glass tube. By the 1660s, there was a sufficient variety of thermometers available for the Royal Society to commission a survey by Robert Boyle and Robert Hooke; they pointed out that the lack of an agreed temperature scale caused great difficulty in comparing different people's measurements. This problem had not been resolved at the time that Chambers and Miller published their first editions (Middleton, 1966: 3–64). Miller took over Chambers' discussion, but added illustrations of three different types of thermometer in common use in the 1730s, without being overly enthusiastic about the consistency and quality of measurement of any of them.

Miller cited Henry Telende, the gardener to Sir Matthew Decker at Richmond, who had made a two-foot thermometer for his pineapple bed (personal communication no doubt, as Telende did not publish):

> It is mark'd for *hot Air* at twenty Inches, and *sultry hot* at twenty-one and a half: But in the common *English Thermometers*, these Degrees are differently mark'd; his *temperate Air* is about our *warm*; his *warm Air* our *hot*; and our *hot Air* is about the same as his *sultry* (THERMOSCOPE).

What this suggests is that English gardeners were busy experimenting with the use of thermometers, frequently home-made and without any uniformity of calibration, as guides for hot-house and hot-bed temperatures.

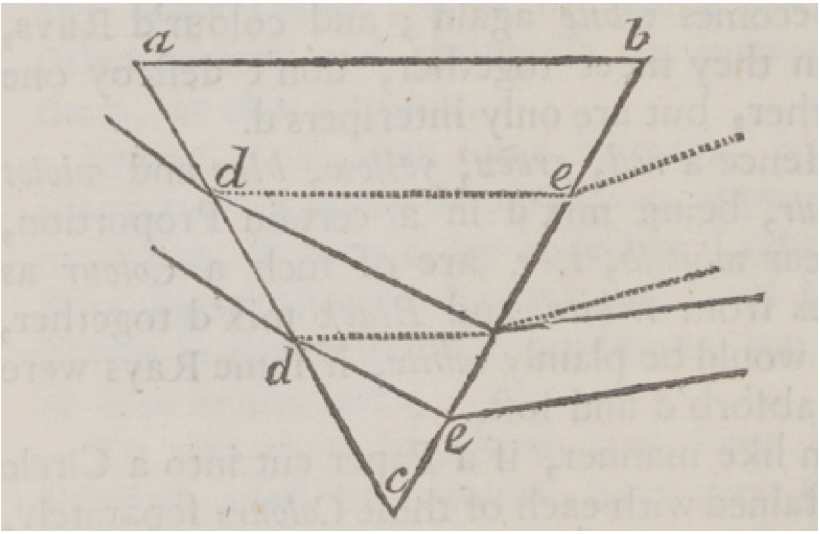

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Fig. 5. **Miller, *Gardeners Dictionary* (1731), diagram from the entry on VARIEGATED, copied from Chambers' *Cyclopaedia*, showing the refraction of light through a prism.**

Sixty years before, Hobbes had complained about the employment of high technology effectively abstracting natural philosophy from the common understanding, and restricting it to a privileged minority. By Miller's time, the new technology was not merely accepted, but had come to be employed as a standard in the definition of basic terms: "*Heat* is something, the Presence of which is best perceiv'd by the Dilatation of the Air or Spirit in the Thermometer" (FIRE).

The system of the world

A modern textbook on science for the gardener would not spend much time on the solar system, but the discoveries of astronomy over the preceding two centuries (the Copernican system and the re-ordering of the cosmos; Kepler's elliptical orbits; the telescope and its revelations of other planetary moons, sunspots, and the rings of Saturn; the inverse square law; the calculation of a cometary orbit) had set the standard for scientific achievement, and in some cases were still novelties. The third section of Newton's *Principia* had been titled "The system of the world", and any attempt to explain science had to give some account of that system.

Miller's most emphatic presentation of Newton's work appeared in the entry on NATURE. After a review of the multiple meanings of the word "nature", copied from Chambers, Miller added a paragraph of his own: "In speaking of the Action of *Nature*, no more is to be understood, but that *Bodies act on one another*, in a Manner, *agreeable to the general Laws of Motion which the Creator has established*". He then returned to Chambers for an explanation of Newton's three laws of motion, or "laws of nature", the wording of which differs from Motte's translation (as noted above, Chambers published before the Motte translation was available, and Miller retained Chambers' version):

> 1. Every Body perseveres in the same State, either of Rest, or Uniform Motion; except so far as it is forced to change that State by some foreign Force.
> 2. The Change of Motion is ever proportional to the Moving Force, whereby it is effected, and in the Direction of the Right Line, wherein that Force is impress'd.
> 3. Reaction is always contrary and equal to Action; or the Actions of two Bodies upon one another are always mutually equal, and directed contrary Ways.

(Contrast Motte's more elegant phrasing: "To every action there is always opposed an equal reaction".) The asserted equality of, or rather indifference between, rest and uniform motion Miller explained by saying "There is as much Force requir'd to stop a Body in Motion, as is requir'd to put it into Motion"; "neither *Motion* nor *Rest*… is essential to Matter".

> It is also plain from hence, that no Body, when it is once put *into Motion*, will of itself naturally move in a curve Line. All Motion is naturally forward in the same strait Line with the Direction of the Moving Force…
>
> Hence it appears, that those great Bodies, the *Planets*, their *Satellites*, and *Comets* (though they are at first put into Motion) do not naturally, and of themselves, move in their respective Orbits, which are curve Lines, returning into themselves; but are kept in them by some attracting Force; which if it were once suspended, they would run out in right Lines for ever (NATURE).

Miller did not include an entry for Gravity, but he did offer one on LEVITY, arguing against the idea of "Positive and Absolute *Levity*", and asserting that "*Levity* is only a relative term".

Ptolemaic astronomy was quickly dismissed ("SUN, has usually been reckon'd among the Number of Planets, but he ought rather to be numbred among the fix'd Stars"); the sun was the centre of "the planetary and cometary System". The motion of sunspots, first observed by Galileo, showed that the sun rotated on its axis; having copied that passage from Chambers, Miller added a summary of Robert Hooke's conclusions that the sun was a solid body with an atmosphere, possibly 80 times thicker than the earth's but still undetectable by telescopes: "he says, That all the *Phaenomena* of the *Maculae* and *Foeculae* of the *Sun* will be solv'd, and that they are only Clouds or Smoaks in this Atmosphere" (SUN). And what was the point of introducing this sort of discussion in a gardener's dictionary?

> The *Sun's* attractive Virtue is very conspicuous, in the Exhalation of those crude and unwholsome Vapours, with which the Earth is often infested; which, if they were suffer'd to continue long upon the Face of the Earth, would render it a miserable Desart (SUN).

And the entry on SUN went on to give details of diurnal and seasonal alterations of the angle of the sun's rays, with some relevance to greenhouse design in particular.

The modern concept of radiation had to wait for the twentieth century, so Miller explained the effects of the sun by supposing that particles of fire were flung out into space by the sun's rotation on its axis, and then proceeded in all directions "in parallel Lines".

> And from thence it is that the *Fire* is perceiv'd by us when the Sun is above; but that when he disappears, his Impulse or Pression being then taken away, the Fire continues dispers'd at large through the Ethereal Space.
>
> There is not in effect less Fire in our Hemisphere in the Night-time than there is in the Day-time, only it wants the proper Determination to cause it to be perceiv'd (FIRE).

The atmosphere, defined as the "whole Mass or Assemblage of ambient Air" surrounding the earth, was calculated by Halley to extend for about 45 miles from the surface, at which distance it was "so rarefied, as to take up 3000 times the Space it occupies here". The outer reaches of the atmosphere were "suppos'd" to consist of the elementary air or aether, but for practical purposes the immediate atmosphere was limited to "that Part of the Air which is next to the Earth, which receives the Vapours and Exhalations, and which is terminated by the Refraction of the Light of the Sun" (ATMOSPHERE). Miller claimed that "none of [the] Clouds are above an *English* Mile high", and that "our Heat depends more on the Circumstances of the Clouds, and the Bodies that are beneath them, than on all that is above them, taking Sun, Moon, Stars and all" (AIR).

Miller greatly abridged Chambers' lengthy account of the earth, eliminating a large number of theories and calculations about its size and shape. His discussion of EARTH veered instead toward a consideration of what we would now call soil types generally. While there had been speculation (the foremost example being Athanasius Kircher's *Mundus Subterraneus*, 1664) about the internal structure of the earth, largely stimulated by attempts to explain volcanoes, Miller limited himself to copying Boerhaave's inferences, based on the reported phenomena of mines. ("Fossil", in what follows, is a word referring to anything found in the earth, not yet restricted to prehistoric remains – the very concept of which was, if not unheard of, generally dismissed.)

> Thus they who dig Mines, Wells, &c. constantly observe, that while they are but a little below the Surface, they find it a little cool, and as they proceed lower it proves much colder, as being then beyond the Reach of the Sun's Heat, insomuch that Water will freeze almost instantaneously; and hence is the Use of Ice-houses.
>
> But a little lower, about forty or fifty Foot deep, it begins to grow warmer, so that no Ice can bear it; and then the deeper they go, still the greater the Heat; till at length it endangers the Stoppage of Respiration, and puts out their Candles…
>
> Therefore it seems as if Nature had lodg'd another Sun in the Center of the Earth, to contribute on its Part to giving of Motion to Bodies, and

> for the promoting of Generation, Nutrition, Vegetation, Germination, &c. of Animals, Vegetables and Fossils.
>
> As to the Origin of this subterraneous Sun, some doubt whether it were form'd there in the Beginning, like the Sun in the Firmament, or gradually produc'd by a secondary Collection of vague *Fire* into this Place (FIRE).

The phrase "another Sun" must be taken as meaning simply "another major heat source", and the argument is of course open to the standard criticism that, the earth being some 8,000 miles in diameter (Chambers, in a passage omitted by Miller, gives "7967 Statute Miles" as the best current estimate), none of this evidence is more than skin-deep from a planetary perspective.

As for the subject of Newton's *Opticks*, Miller had a brief entry on LIGHT, but the major discussion of the content of Newton's *Opticks* appeared, oddly enough, in the entry on VARIEGATED. The entry began reasonably enough with a discussion of variegated plants and their popularity among collectors, attributing variegation to a distemper or weakness in the plants, but then headed off at a tangent in order to explain why plants have colours in the first place. "In order to understand this, it may not be improper to say something concerning the *Phaenomenon* of *Colours*, as it hath been discover'd by the late excellent Philosopher Sir *Isaac Newton*." He then ran through the history of theories of colour – was it a property of the objects, or of the light reflected from them, or of the nervous system (or soul) of the observer? – before presenting an abstract of Newton's experimental results:

> 1. That Light consists of an infinite Number of Rays, right-lin'd and parallel; but of different Degrees of Refrangibility, when meeting with a different Medium.
> 2. Each Ray, according to its Degree of Refrangibility, when so refracted, appears to the Eye of a different Colour.
> 3. The least refrangible Rays appear of a deep Scarlet colour; the most refrangible appear of a Violet Blue: The intermediate proceeding from Scarlet to Yellowish, then light Green, and so to Blue…
> 5. Whiteness, (such as the Sun's Light appears), containing all those Degrees of Refrangibility; and mix'd Colours are such as are produc'd by Rays of different Refrangibility (COLOUR).

Miller copied from Chambers the definition of light: "certain very small Particles … [thrown] off from the luminous Body", and added Rømer's calculation (which he could have found in Derham) that the speed of light was more than 100,000 miles per second (LIGHT).

A little over half of Miller's entry on RAINBOW was copied from Chambers; the remainder was a list of nine properties of the rainbow, based loosely on Newton, but incorporating the strange statement that "the constant Order of the Colours is, that the outmost is *Red* or Saffron-colour, the next is *Yellow*, the third is *Green*, the fourth and inmost is *Violet* or *Blue*". Why four colours? Aristotle (*Meteorology* III:4) recognised only three colours in the rainbow (red, green, blue), a fact that might have more to do with the late development of colour terminology than with any deficiencies of vision. Newton, of course, differentiated the spectrum into seven colours, and his own discussion of the rainbow in *Opticks* (I: 2, proposition 9, problem 4) lists all seven, working from inner to outer, in the opposite direction from Miller. I have not so far found any authority from whom Miller might have copied his four-colour sequence, and can only conclude that it must reflect naïve personal observation.

The nature of matter

Descartes, and a number of associated philosophers (Hobbes, Spinoza, Malebranche, Leibniz), denied the possibility of a vacuum: the world was composed entirely of matter, and if there were not some form of matter, no matter how fine and unmeasurable, pervading all space, motion would be impossible. The rival philosophy was atomism, derived from Democritus and revived in the first half of the seventeenth century by Gassendi, but when it came to producing experimental evidence, this was a crude theory. Precisely in order to distinguish them from Gassendi's atoms, the fundamental particles posited by Newton were called corpuscles: "The Corpuscular Philosophy … was wonderfully improv'd by Sir *Isaac Newton*" (FLUIDITY). Miller used the term "atom" in one passage in his entry on WATER, based on Halley, but otherwise stuck to "corpuscles".

Miller unhesitatingly accepted the modern corpuscularianism, with its implication of the existence of a vacuum. "It seems requisite to *Fluidity* that there be store of Vacuities, or vacant Spaces interspers'd between the Corpuscles of the fluid Body, for else there will not be Room for each

Particle to continue its Motion and agitation on the Surfaces of the neighbouring ones" (FLUIDITY) – even if "the Particles of such fluid Bodies, do in some measure cohere", as in capillary action, and the rise of mercury in a thermometer.

References to "elements" generally implied the theory of four elements inherited from Aristotle, which had to be overthrown. The four-element theory had been challenged in the sixteenth century by a three-element theory put forward by Paracelsus, which survived in some quarters into the eighteenth; Boyle's splendid invective in *The Sceptical Chymist* both outlines the theory and reveals the grounds for its rejection:

> …in the last century *Paracelsus* and some few other sooty Empiricks, rather then (as they are fain to call themselves) Philosophers, having their eyes darken'd, and their Brains troubl'd with the smoke of their own Furnaces, began to rail at the Peripatetick Doctrine, which they were too illiterate to understand, and to tell the credulous World, that they could see but three Ingredients in mixt Bodies; which to gain themselves the repute of Inventors, they endeavoured to disguise by calling them, instead of Earth, and Fire, and Vapour, Salt, Sulphur, and Mercury; to which they gave the canting title of Hypostatical Principles (Boyle 1661: 24).

There was no theory of chemical elements in Newtonianism. For Boyle and, after him, the Newtonians, the very idea that all things were composed of corpuscles occupying otherwise empty space meant that all substances were in principle permeable, and therefore impure in composition (Thackray, 1970: 162–171).

Matter is today commonly divided into solids, liquids, and gases;[1] Boerhaave divided matter into solids and fluids, the latter subdivided into liquids and vapours. The word "gas" had been coined by Van Helmont, but it was at first linked too closely to his discredited theories, and did not achieve widespread use until the late eighteenth century. So Chambers and Miller defined FREEZING as "the fixing of a *Fluid* … by the Action of

[1] And plasma – but that concept was inconceivable before the development of subatomic physics, so we'll just ignore it for the duration of this article.

Cold", even though they could give no examples of vapours freezing, and it was one particular liquid, water, that provided most of the evidence. (Admittedly, much of the discussion focused on the role of air bubbles in water, and their behaviour in freezing.) Miller tended to use adjectives like "firm" instead of solid; but whatever the terminology, the solid state was assumed to be the most fundamental state of matter: "*Ice* is said to be the natural State of Water, which remains firm and not liquid, when no external Cause acts upon it" (ICE – a passage adapted from Mariotte, 1728: 2).

The properties of air

Let us begin the examination of individual states of matter at the gaseous end of the scale.

> By *Air* is meant all that fluid expanded Mass of Matter which surrounds our Earth, in which we live and walk, and which we are continually receiving and casting out again by Respiration.
>
> The Substance whereof *Air* consists, may be reduced to two Kinds, *viz.*
> 1. The Matter of Light or Fire, which is continually flowing into it from the heavenly Bodies.
> 2. Those numberless Particles, which in Form either of Vapours or dry Exhalations, are raised from the *Earth*, *Water*, *Minerals*, *Vegetables*, *Animals*, &c. either by the *solar*, *subterraneous* or *culinary* Fire.
>
> *Elementary Air*, or *Air* properly so call'd, is a certain subtil, homogeneous elastic Matter, the Basis or fundamental Ingredient of the atmospherical *Air*, and that which gives it the Denomination (AIR).

This "subtil Matter" was elsewhere referred to as the Aether, and Miller's discussions of it are brief, as of tangential relevance to horticulture. The most important point was that air was not an element, "no where consists in its Purity", in that it could be broken down into simpler substances. "Light or fire" will be dealt with in the next section, and in any case is a Boerhaavian concept, one which would not have been accepted by strict Newtonians. With the "numberless Particles" Miller was on safer ground; he described them simply as "floating Particles … raised from terrestrial Bodies". Boerhaave was more entertainingly emphatic than Miller would be: "The atmosphere... may be looked on as an universal receptacle, a chemical vessel, wherein all the bodies in nature actually float" (Boerhaave, 1727: 281), giving details of all the vegetable and animal substances that, as a result of decay and fermentation, were released into the air.

Vapours were "those watry Particles which are severed from others by the Motion of the Air, and are carried about it in several Ways, according as the Wind, or Warmness of the Air serves: They rise out of the Sea, Rivers, Lakes, and other Waters" (VAPOURS). It must be understood that this is not a way of referring to water vapour: discussions of water listed only its solid and liquid states. The gaseous state was apparently not thought of as being any longer water as a distinct substance, but rather a mixture of particles of water with particles of other substances to form a more generalised vapour. Miller pointed out the relevance of this discussion to the horticulturist: "To the Pressure of the *Atmosphere* Plants owe their Vegetation, as well as Animals do their Respiration, Circulation, and Nutrition" (ATMOSPHERE).

The properties of fire

Probably nothing is so disconcerting to a modern reader of Miller as the discussion of FIRE, which is treated as a substance ("*Fire* is a Body, and a Body in Motion too") and a component of other substances. Surely the demolition of Aristotelian theory meant that fire could no longer be regarded as one of the four elements? Hadn't Donne said, as early as 1611, that "The element of fire is quite put out?" Hadn't Newton effectively killed off the idea of fire as a separate element in queries 9–10 of his *Opticks*?

> 9. Is not Fire a Body heated so hot as to emit Light copiously? For what else is a red hot Iron than Fire? And what else is a burning Coal than red hot Wood?
>
> 10. Is not Flame a Vapour, Fume or Exhalation heated red hot, that is, so hot as to shine?

But Miller did not propose that fire was an element in the Aristotelian sense, merely that it was a physical substance and not, as Bacon, Boyle, and Newton argued, an effect of motion. This is the point of which Miller rejected the Newtonian cosmology and adopted instead the ideas of Boerhaave:

> Altho' this Doctrine of *Fire*, here laid down by *Boerhaave*, seems new and extraordinary, at least to those who have been us'd to consider Fire in the Light that it has been set in by the Lord *Bacon*, Mr. *Boyle*, and Sir *Isaac Newton*; and tho' we ought to pay great Veneration to those illustrious Authors: yet, in the Judgment of themselves, we should be inexcusable if we should absolutely acquiesce in what they have done, and shut the Door against farther and better Information (FIRE).

Boerhaave regarded fire as a cause rather than a product of motion. "*Elementary* or *Pure Fire* is of it self imperceptible, and only discovers it self by certain Effects that it produces in Bodies; and these Effects are only to be learnt by the Changes which arise in Bodies: These Effects are three; 1st, *Heat; 2dly*, *Dilatation* in all solid Bodies, and Rarefaction in all Fluids; *3dly*, *Motion*." Inheriting but adapting Descartes' idea of the plenum – the absence of genuinely empty space, space filled with some subtle form of matter – Boerhaave posited fire as the substance that permeated everything, "the general Instrument of all the Motion in the Universe… if there were no *Fire*, all Things would instantly become fix'd and immoveable." Miller therefore treated it as analogous to those cruder vapours that flowed through the pores of others, and helped to make all material substances impure mixtures: "That there is Fire contain'd in all *Air* is demonstrable, in that it is evident, that there is Fire existing in all Bodies" (AIR).

Boerhaave's theory was acknowledged by Lavoisier as a predecessor of his caloric theory. Today the views of Bacon and Boyle are rather forgotten, and the theory of heat as a consequence of motion (friction) is generally attributed to Count Rumford, who at least produced some experimental results. Reading Miller is a salutary reminder that the categorisation of heat as a form of energy rather than matter had some distinguished anticipations.

What applied to heat, however, did not apply to cold. Miller gave no indication that cold was a positive quality: it must be either a negative one (absence of heat) or a relational one (a state in which the particles of a body are "agitated more slowly" than those of our sensory apparatus). Remember Sir Francis Bacon's famous argument, in the *Novum Organum* (1620), that lukewarm water will seem hot or cold depending on the temperature of the perceiving hand. Boerhaave had argued against the existence of an "absolute Cold" in nature. Miller concluded that cold could not be "a mere relation or comparison" because condensation and freezing had such specific effects, and having finished an extensive quotation from Chambers with his observation that plants may burst as a result of the freezing of the water they contain, Miller launched into an account of the effects of frost at the Chelsea Physic Garden in 1728 (COLD). And when they came to consider FREEZING, Chambers and Miller inclined toward the hypotheses (a) that the action of cold was due to "frigorifick particles", as proposed by Gassendi, and (b) that it was to some degree influenced by airborne salt particles: this position may be regarded as a halfway house between those of Newton and Boerhaave.

Miller concluded his treatment of FIRE by stressing its relevance to practical gardening:

> However foreign, at the first View, this Article may seem to our present Purpose; yet I am of the Opinion, that a tolerable Acquaintance with its Nature, as far as it can be attain'd, and its Effects, will contribute no small Assistance to forwarding the Work of Vegetation. And tho' the Theory of *Fire* is indeed Philosophical; yet the Consideration of its Effects, and how it operates on Vegetables, will be of no small Use in the Culture of them.

And he concluded that since "all Vegetation, Putrefaction, Fermentation, Animal Heat, &c." depended on fire, "these few Hints… would not be unacceptable to the ingenious and studious Practicers of Horticulture". A direct horticultural consequence (copied, alas, from Chambers) is the process of compost-making:

> The second Manner of Increasing the Effect of *Elementary Fire*, is by throwing a Quantity of moist or green Vegetables, cut down while full of Sap, into a large Heap, and pressing them close down; by which they grow warm, hot, smoak, and break out into Flame (FIRE).

The properties of water

The relevance of water to horticulture is obvious, and WATER formed the longest of the physical entries in Miller's early *Gardeners and Florists Dictionary*, much of which was retained in the *Dictionary*:

> Sir *Isaac Newton* defines *Water* (when pure) to be a very fluid Salt, volatile and void of all Savour and Taste; and it seems to consist of small, hard, porous, spherical Particles, of equal diameters, and equal specifick Gravities; and also that there are between them, Spaces so large, and rang'd in such a Manner, as to be pervious on all Sides.
>
> Their *Smoothness* accounts for their sliding easily over the Surfaces of one another.
>
> Their *Sphericity* keeps them from touching one another in more Points than one; and by both these, their Frictions in sliding over one another, is render'd the least possible.
>
> The *Hardness* of them accounts for the *Incompressibility* of *Water*, when it is free from the Intermixture of Air.
>
> The *Porosity* of *Water* is so very great, that there is at least forty times as much Space as Matter in it; for *Water* is nineteen times specifically lighter than Gold, and of consequence rarer in the same Proportion: But Gold will, by Pressure, let *Water* pass through its Pores, and therefore may be suppos'd to have (at least) more Pores than solid Parts (WATER).

Noting Boyle's opinion that "Ice is commonly reputed to be *Water*, brought into a praeternatural State by Cold", Miller countered that "it might as justly be said, that *Water* is Ice, praeternaturally thaw'd by Heat" – a concept derived from Mariotte. He then proceeded to discuss the different types of water, fresh and salt, and the treatment of salt water shows the lingering traces of physico-theology in its discussion of origins:

> *Sea-Water* is an Assemblage of Bodies, wherein *Water* can scarce be said to have the principal Part; 'tis an universal Colluvies of all the Bodies in Nature, sustain'd and kept swimming in Water, as a Vehicle.

VE VE

This will be made plainer by the following TABLES.

Weight of the Plant when first put into Water.	Weight of the Plant when taken out of the Water.	Weight gain'd by the Plant during the 77 Days.	Weight of the Water expanded upon the Plant.	Proportion of the Increase of the Plant to the Expence of the Water.
		A *Common Spearmint,*	*Spring Water.*	
27 *Grains.*	42 *Grains.*	15 *Grains.*	2558 *Grains.*	*as* 1 *to* 178 8/17.
		B *Common Spearmint,*	*Rain Water.*	
28 1/2 *Grains.*	45 3/4 *Grains.*	17 1/4 *Grains.*	3004 *Grains.*	*as* 1 *to* 171 23/37.
		C *Common Spearmint,*	*Thames Water.*	
28 *Grains.*	54 *Grains.*	26 *Grains.*	2043 *Grains.*	*as* 1 *to* 95 23/26.
	Common Solanum or	D *Night shade,*	*Spring Water.*	
49 *Grains.*	106 *Grains.*	57 *Grains.*	3708 *Grains.*	*as* 1 *to* 65 3/57.
	Lathyrus	E *seu Cataputia,*	*Ger. Spring Water.*	
98 *Grains.*	101 1/2 *Grains.*	3 1/2 *Grains.*	2501 *Grains.*	*as* 1 *to* 714 4/7.

Fig. 6. **Miller, *Gardeners Dictionary* (1731), table from the entry on VEGETATION, summarising the experiments of John Woodward (Woodward, 1699) on water ingestion by plants.**

> Dr. *Lister* considers it as the Fund or Source out of which all Bodies arise… *Fresh-Water*, he supposes, to have arose accidentally after the Creation of these, and to owe its Origin to the Vapours of Plants, the Breath of Animals, and the Exhalations raised by the Sun.
>
> Dr. *Halley* is of another Opinion: He supposes, that the Saltness of the Sea arises from the saline Matter dissolved and imbibed by the Rivers in their Progress, and discharg'd with their *Waters* into the Ocean; and consequently that the Degree of Saltness is continually and gradually increasing.
>
> On this Hypothesis he even proposed a Method for determining the Age of the World: For two Experiments of the Degree of Saltness, made at a large Interval of Time, will, by the Rule of Proportion, give the Time, wherein it has been acquiring its present Degree of Saltness (WATER).

In the article on WATER Miller entertains the idea that it is composed of "spherical or cubical Particles", though in the article on FREEZING he had copied from Chambers the speculation that "spherical Particles are much properer to constitute a Fluid than cubical ones".

> [Water] enters the Composition therefore of all Bodies, both Vegetables, Animals and Fossils; and has this Circumstance peculiar to it, that it is easily separable from any of the Bodies it unites withal; which cannot be said of any other Body.
>
> Fire, indeed, will penetrate more than Water, but then 'tis difficult to separate it again from the Bodies it is once fix'd in (WATER).

John Woodward (Woodward, 1699; copied in both Chambers and Miller) and Stephen Hales had demonstrated the movement of water in the tissues of plants, and given an analysis of capillary action. Miller cited his basic principles of hydrostatics without enlarging on their relevance to horticulture, presumably reserving that for the entry on VEGETABLE STATICKS, and ended by leaving the matter to practice:

> How far the Knowledge of any of these Properties of *Fluids* may conduce to the Philosophical Improvement of *Gardening*, and the Business of

> *Vegetation*, will be more clearly perceiv'd, when well consider'd by the ingenious Artist, than being set forth by Words (HYDROSTATICKS).

The properties of earth

Boerhaave had classified the types of fossils as metals, semimetals, salts, stones, sulphur, and earth, this last category further divided into sands and true earths. Miller began his entry on EARTH by offering Boerhaave's definition: "That it is a *Fossil Body, neither dissoluble by Fire, Water, nor Air; that it is insipid, and transparent, more fusible than Stone; still friable, and containing usually a Share of Fatness*". It was not to be considered as an element: "There is no such thing as a strictly simple *Earth*". In a passage not copied from Chambers, Miller offered an analysis of the material content of earth:

> The *Earth* is made up of two Parts: The first the *containing* Part, i. e. the *Body, Bed* or *Couch*; the second Parts *contained*, and those are the *nitrous* or *sulphureous Particles* or *prolifick Salts*. The first is a lifeless inanimate Mass, and is only the Receptacle of the other: For the Earth consider'd simply, and abstracted from the before-mention'd *nitrous* and *prolifick Salts*, is a lifeless, dead and inanimate Mass; but by the Co-operation of Water, Sun and Air, puts, or rather is put by them into Motion, and promotes the Work of Vegetation: But if it were stript of those prolifick Salts and spirituous Particles, would produce no manner of Plant, Herb, &c. that should be planted or sown in it (EARTH).

(The repetition of "lifeless inanimate Mass" in both the definition and the proof of the definition is as classic an instance as one could want of begging the question.)

But after that the discussion of earth as a generalised substance yielded place to an assessment of different types of earths, including Fuller's earth, chalk, pumice, but excluding sand and stone. "Some distinguish *Earths* into three Classes, *Sand, Loam*, and *Clay*": "*Gravel*, and all the open Soils, till the *Loam* is come at, are of the sandy kind. Those binding *Earths* from the *Loam* downwards, till the Stiffness of *Chalk* may be come at, may be reckon'd of the *Clay* kind" (EARTH). Thereafter the entry moves into practical horticulture, with a comparison of the value of different soil types for the gardener.

Weather

First, a couple of definitions, the vocabulary of science having changed in various particulars since Miller's day. "Meteor" was not confined, as today, to shooting stars, but meant any atmospheric phenomenon. "Climate" was not an environmental condition but a geographical area: "Each *Climate* only differs from its contiguous ones, in that the longest Day in Summer is longer or shorter by half an Hour in the one place than the other" (CLIMATE).

The primary phenomena of weather to be explained were clouds, precipitation, thunder, and wind.

Winds, considered as currents of air in motion, required little theoretical exertion. The various attempts in antiquity and since to calculate the number of the winds, ranging from four to 32, Miller dismissed as "of no great Concern in Natural Philosophy, unless it be to give a Hint that the *Wind* blows from all Parts of the Heavens" (WIND). Like Chambers (both copying from some common source), he rejected the Cartesian view that winds were caused by the rotation of the earth, and substituted Halley's argument that they were caused by the differing action of the sun over land and bodies of water.

The entries on WIND and WEATHER proffered much advice about weather prediction, much of it balanced precariously between natural history and old wives' tales. Take as an example some of the following prognostications of rain and fair weather:

> When *Crows* flock together in large Flights, and hold their Heads upwards as they fly, and cry louder than they usually do, it is a Sign of Rain; and when they walk stalking by Rivers and Ponds, it is the same.
>
> When *Swallows* chatter and fly low about Lakes and Ponds (which they do, in order to catch Flies; for the Air being clogg'd with Vapours, hinders the Flies from ascending), it bespeaks *Rain*…
>
> Not only Birds, but Beasts do give Notice of Rain; as *Sheep*, when they leap mightily, and push at one another with their Heads, it denotes *Rain*…
>
> An *Iris* round the *Moon* is also a Sign of Rain, with a *South* Wind.

> If the Horns of the *Moon* at her first Rising, or within two or three Days after her Change, are blunt, it betokens rainy *Weather* for that Quarter, but seasonable *Weather* the other Quarter.
>
> Two or three discontinued and speckled Circles or Rings around the Moon bespeak a Storm (WEATHER).

All this material was taken straight from Pointer's *Rational Account of the Weather* (1723), but it is odd to find it being adopted by the man who two pages earlier had said "the imaginary Prognostications of Almanack Writers have been found to be a mere delusive Cant and Jargon".

Clouds were accounted for by the ascent and condensation of vapours. Miller opened the discussion with a statement that seems too obvious to be needed: "It is not to be doubted, but that *Rain* drops out of the Clouds; because we don't find it rain, but where Clouds are to be seen" – even Aristotle (*Meteorology*, I: 9) knew that rain involved vapour condensing into water and falling ("air condensing into water is cloud", in the Oxford translation).

> Thus if the *Air* be full of Vapours, and the Cold succeeds, those Vapours before dispersed are congregated and condensed into Clouds, and thus fall back again in the Form of *Water*, *Rain*, *Snow* or *Hail*.
>
> From the Time of the Entrance of the Spring till Autumn, the Evaporation is constant; but then it begins to fail, and in the Winter ceases to lay up fresh Matter for the coming Season.
>
> And thus it is that frosty Winters, by congealing the Waters, and by covering the Earth with a Crust, and thus imprisoning the Exhalations, make a fruitful Summer.
>
> And this seems to be the Reason, why in some Countries, where the Winter is severer than ordinary, the Spring is more than ordinarily fruitful: For in such Places the Exhalations being pent up a long time, are discharged in the greater Quantity, when the Sun makes them a Passage; whereas under a feebler Cold, the Flux would have been continual, and consequently no great Stock reserv'd for the next Occasion.

> This vapourous Matter then being at length received into the Atmosphere, is return'd again in the Form of Rain, a Forerunner of a cheerful Crop…
>
> Collections of Vapours make Clouds, which being farther and farther condensed, turn to Snow, Rain or Hail.
>
> The subtiler Oils are always rising into the Air: Now two Clouds, partly form'd of such Oils, happening to meet and mix, by the Attrition the Oil frequently takes Fire, and hence proceeds Thunder, Lightenings, and other Phaenomena; which may be farther promoted by the Disposition of the Clouds to favour the Excitation.
>
> And hence arise great and sudden Alterations in the Air; insomuch that it shall now be intensely hot, and raise the Spirits perhaps to 88 Degrees in a Thermometer; and yet after a Clap of Thunder with a Shower, it shall fall again in a few Minutes no less than 20 or 30 Degrees (AIR).

The content of clouds was thus explained, but their cause was still "a little controversial": were they collected together by the wind, or did they condense naturally when the particles of vapour came into contact with colder air (RAIN)? And how did clouds stay up, if they were full of rainwater? Winds and the continued pressure of new exhalations and vapours, Miller suggested, were capable of overcoming the weight of the particles (VAPOURS) –

> This is demonstrable by Paper Kites, which after they are rais'd to about sixty Feet high, do rise easier and with greater Swiftness, and the higher, still the better and stronger they fly (RAIN)

– and he cited Halley's speculation that enough vapour was produced every day to fill 129,796,219 cubic miles of the atmosphere (WIND). The form of raindrops prompted Miller's speculations, in a way that the shape of snowflakes did not:

> If any ask how the Drops of falling Water come to be round, as in Rain? It is answered, That this does not happen by any Disposition peculiar to the Water; but because the Drops are equally pressed by the Air on every Side, and thereby forced into a round Figure (RAIN)

Miller and Chambers had little difficulty in accounting for snow and hail as wintry or arctic variants of rain; dew offered a greater challenge, because of the difficulty in observing it in the process of settling.

> Dew, is by some defin'd to be a Meteor bred of a thin cold Vapour; or, compos'd of the Steams and Vapours of the Earth, which being exhal'd by the Heat of the Sun, and kept suspended during his Presence, do, upon his Absence, convene into Drops, and than fall down to the Earth again.
>
> Others define it, a thin, light, insensible Mist or Rain falling while the Sun is below the Horizon (DEW).

Miller copied from Chambers a paragraph which says that Dew "is without doubt from Vapour and Exhalations of the Earth and Water rais'd by the Warmth of the Earth", then added a paragraph of his own to explain that "There being many Vapours in the Air, tho' not always visible, hence it comes to pass… that the scatter'd Vapours are collected and condens'd together, and forc'd downwards, they must needs fall and bedew the Plants and Grass" (DEW).

The final phenomenon of weather to be considered was thunder. After treating various past definitions, Chambers, as copied by Miller, declared, "this only reaches to the *Phaenomena* of *Thunder* heard without *Lightning*; and, in effect, we have now a better solution". Thunder was caused "by the kindling of sulphureous Exhalations in the same manner as the Noise of *Aurum Fulminans*" (literally "fulminating gold", the first artificial high explosive, produced by the reaction of gold to nitro-hydrochloric acid – the subject of a great deal of late seventeenth-century experiment). Newton was cited to the effect that exhalations from the earth, ascending into the air, sometimes "ferment with the nitrous Acids", with lightning as a result. Miller added a speculation from Hooke:

> The Air is continually furnish'd with spirituous, nitrous Parts, and the *Summer* Heat, whenever extraordinary, raises up out of the Earth… a great Quantity of sulphureous Vapours, which are of such a Nature, as that meeting with the Nitre of the Air, they work upon each other, and thereby begins a farther Degree of Heat, which gradually increases, till at last it arrives at a certain Pitch, and then they fall upon, and work

> upon one another, producing an actual Fire and Flame, which with wonderful Swiftness fires the whole Train, and so produces a Flash and Noise (THUNDER).

Miller then expanded the argument about sulphur to include hot springs and volcanoes.

One of the great issues in meteorology today is the changing of climate over time, and it is worth considering to what extent this would have been a meaningful concept in Miller's time. The Royal Society at the beginning of the eighteenth century attached considerable importance to the compilation of weather records, in the hope that general principles could be deduced from collected observations. Miller copied from Chambers a passage, partly based on Derham (Derham, 1709), that listed the weather records then published:

> *Eras*. *Bartholinus* has Observations of the Weather every Day throughout the Year 1671. And Mr. *Werle*[1] made the like at *Oxford* for seven Years, from the Year 1337 to 1343. Dr. *Plot* did the same at the same Place for the Year 1684. Mr. *Hiller* at *Cape Corse* for the Years 1686 and 1687. And Mr. *Hunt*, &c. at Gresham College for Years 1695, 1696. Dr. Derham At *Upminster* in *Essex*, for the Years 1691, 1692, 1697, 1698, 1699, 1703, 1704, 1705. Mr. *Townley* in *Lancashire* for the Years 1697, 1698. Mr. *Cunningham* at *Emin* in *China* for the Years 1698, 1699, 1700, 1701. Mr. *Lock* at *Oats* in *Essex* 1692. Dr. *Scheuchzer* at *Zurich* in 1708. And Dr. *Tilly* at *Pisa* the same Year. ….
>
> Indeed there have been some Essays made this way by the Members of our *Royal Society*, the *French Academy of Sciences*, and divers other Persons of Note; but the Driness of the Subject has put a Stop to their Progress in that Matter (WEATHER).

William Derham, the author of *Physico-theology*, was a pioneer in the international comparison of weather records; noting that "the extraordinary Colds, *December* 1708, and the Relaxations thereof were felt at *Italy* and

[1] "*Werle*" is a mistake for "W. Merle", as cited in Chambers; the mistake was not corrected in any subsequent edition.

Switzerland several Days before they reach'd us", he concluded that "they were driven from them to us" (WEATHER). It is tempting to say that the movement of weather patterns over space was a sufficient discovery for the time being, and variation over time had to wait for future generations. And yet Miller, in a passage copied from Woodward (also copied by Chambers), drew specific attention to the effect of human activity on climate:

> The great Moisture of the Air was a great Inconvenience and Annoyance to those who first settled in *America*; which at that Time was overgrown with Woods and Groves: But as these were burnt down, and destroy'd, to make Way for Habitations and Culture of the Earth, the Air mending, changed into a Temperature more serene and dry than before (VEGETATION; see Woodward, 1699:209).

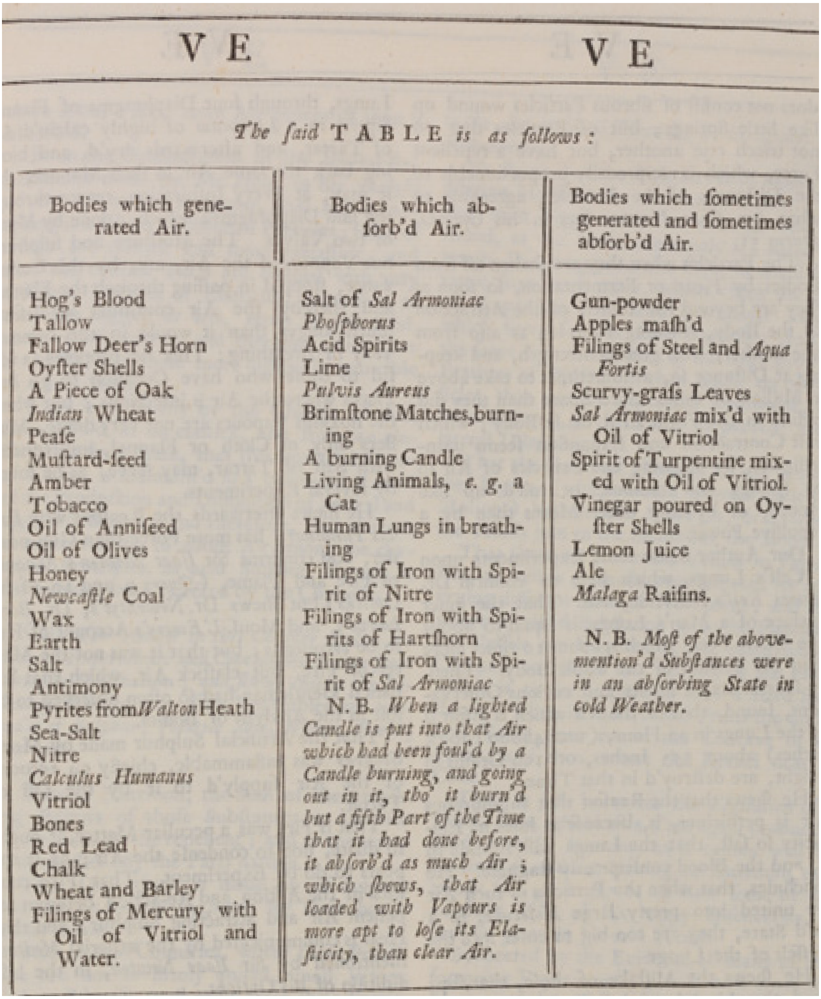
Ironically, the various editions of his *Gardeners Kalendar* (fifteen in his lifetime, from 1732 to 1769) could have revealed to Miller a shift in the flowering times of various garden plants, that might have indicated a general warming of the English climate (Elliott 2009, 2010).

The nature of vegetation

Even in some purely botanical entries, Miller copied extensively from Chambers. The entry on ANATOMY consists initially of Chambers' brief statements about the major organs of plants, with paragraphs of added anatomical details in each case; the final page, which summarises Malpighi's ideas about plant physiology, are copied entire. Other copyings occur in FLOWER, VEGETABLE STATICKS, and the entire brief entry on VEGETABLE is copied from Chambers.

The definition of a plant came from John Martyn: "an organical Body, destitute of Sense and spontaneous Motion, adhering to another Body in such a manner, as to draw from it its Nourishment; and having a power of propagating its self by seed" (PLANT; Martyn, 1729: 3). Note that "another Body" meant not another plant – though parasitism was an available concept, and had an entry in Chambers – but rather earth or another substrate.

Miller did not attempt an analysis of the chemical content of plant tissue, remaining content to cite Stephen Hales' conclusion that "*Vegetables*



V E V E

The ſaid TABLE *is as follows:*

Bodies which generated Air.	Bodies which abſorb'd Air.	Bodies which ſometimes generated and ſometimes abſorb'd Air.
Hog's Blood	Salt of *Sal Armoniac*	Gun-powder
Tallow	*Phoſphorus*	Apples maſh'd
Fallow Deer's Horn	Acid Spirits	Filings of Steel and *Aqua Fortis*
Oyſter Shells	Lime	Scurvy-graſs Leaves
A Piece of Oak	*Pulvis Aureus*	*Sal Armoniac* mix'd with Oil of Vitriol
Indian Wheat	Brimſtone Matches, burning	Spirit of Turpentine mixed with Oil of Vitriol.
Peaſe	A burning Candle	Vinegar poured on Oyſter Shells
Muſtard-ſeed	Living Animals, *e. g.* a Cat	Lemon Juice
Amber	Human Lungs in breathing	Ale
Tobacco	Filings of Iron with Spirit of Nitre	*Malaga* Raiſins.
Oil of Anniſeed	Filings of Iron with Spirits of Hartſhorn	N. B. *Moſt of the abovemention'd Subſtances were in an abſorbing State in cold Weather.*
Oil of Olives	Filings of Iron with Spirit of *Sal Armoniac*	
Honey	N. B. *When a lighted Candle is put into that Air which had been foul'd by a Candle burning, and going out in it, tho' it burn'd but a fifth Part of the Time that it had done before, it abſorb'd as much Air; which ſhews, that Air loaded with Vapours is more apt to loſe its Elaſticity, than clear Air.*	
Newcaſtle Coal		
Wax		
Earth		
Salt		
Antimony		
Pyrites from *Walton* Heath		
Sea-Salt		
Nitre		
Calculus Humanus		
Vitriol		
Bones		
Red Lead		
Chalk		
Wheat and Barley		
Filings of Mercury with Oil of Vitriol and Water.		

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Fig. 7. **Miller, *Gardeners Dictionary* (1731), table from the entry on VEGETABLE STATICKS, summarising the results of Stephen Hales' experiments reported in chapter 6 of his *Vegetable Staticks* (1727).**

are compos'd of Sulphur, Volatile Salt, Water, Earth, and Air" (VEGETABLE STATICKS). The reader will by now have realised that none of these categories can be considered as the equivalent of a chemical element as understood today, so it is difficult to imagine how the analysis could have been refined further at the time.

Miller's entry on PLANT listed the parts of the plant as the root, stalk, leaf, flower, and fruit, though in his entry on ANATOMY he subsumed the stalk under the heading of root. His discussion itemised the bark and the "Aerial Vessels, or *Tracheae*" (phloem and xylem), and described their composition as consisting "of mere Earth, bound or connected together by Oil, as a *Gluten* or Glue". Thanks to Stephen Hales, there was now a fair amount of information about the movement of water and sap through the stem. "Anatomists have observ'd a great Similitude betwixt the Mechanic Frame of Plants and Animals" (ANATOMY) – among them Patrick Blair, who forcefully expressed the matter:

> It may be admir'd how prying and inquisitive Persons should still be so ignorant of the *Circulation* of the *Sap*, or *Nutritive Juice* of *Plants*, if the World had not remain'd ignorant for many Ages of a *Circulation* of the *Blood* in *Animals*, before the famous Dr. *Harvey* discovered it. The great Obstacle I suppose, for finding out the same in Plants too, must be the want of a due Consideration of this *Analogy* (Blair, 1720: 331–332).

With apparent reluctance, Miller rejected the notion of a circulation of sap within the plant comparable to Harvey's demonstration of the circulation of the blood in animals; he was convinced by Dodart's argument that plants took in nutrition by their leaves and roots alike, so that there must be two "juices" spreading through the plant from either end rather than a single juice continually circulating. "In Animals it is the Heart which sets the Blood in Motion… but in Vegetables we can discover no other Cause of the *Sap's* Motion, but the strong Attraction of the Capillary *Sap* Vessels, assisted by the brisk Undulation and Vibrations caus'd by the Sun's Warmth" (SAP). A further interesting argument came from observations on an ilex (*Quercus ilex*) grafted onto an English oak: "if there were a free uniform Circulation of the *Sap* through the *Oak* and *Ilex*, why should the Leaves of the *Oak* fall in Winter, and not those of the *Ilex*?"

As a result of Hales' experiments, Miller was able to pronounce decisively on the function of the leaves:

> We may therefore reasonably conclude, that one great Use of *Leaves*, is what has been long suspected by many, *viz*. to perform, in some measure, the same Office for the Support of the Vegetable Life, as the Lungs of Animals do for the Support of Animal Life; Plants, very probably, drawing through their Leaves some Part of their Nourishment through the Air (ANATOMY).

The definition of "flower" was quoted from John Martyn, and included his dismissive comments on his predecessors' definitions: Tournefort's was "deficient", Pontedera's "scarce intelligible", and while Martyn was fairly complimentary about John Ray, Miller rejected Ray's for unhelpfully using the words "for the most part", thus disqualifying itself as a proper definition. Martyn's definition was: "the Organs of Generation of both Sexes adhering to a common Placenta, together with their common Coverings; or of either Sex separately, with its proper Coverings, if it have any" (FLOWER; Martyn, 1729: 14).

The generation of plants

Chambers printed an extensive discussion of the debate over preformation versus epigenesis: did the seed, whether animal or vegetable, contain within it what was effectively a miniature version of the adult organism (preformation), or did the organism grow in a series of stages, and only gradually take on a recognisable form ("epigenesis", a term coined by William Harvey). During the eighteenth century, preformation seemed to be the best-supported theory, while epigenesis, associated with Harvey and Aristotle, was frequently dismissed, to be revived and become dominant in the nineteenth. Chambers favoured preformation, as seen in his entry on Seed:

> That the whole Plant is contained in the *Seed*, is an opinion as old as *Empedocles*, and is still the prevailing Doctrine among the Generality of Naturalists… In effect, by the Use of good Microscopes, we discover, in the Seed, several of the Parts of the future Tree, only in Miniature; particularly a little Root, called the *Radicle*, and the Stem called the *Plumule*.

Miller alluded to the debate in the *Gardeners Dictionary* by copying from Boerhaave a series of observations of what would later become known as geotropism: where a seed was planted upside down, the roots quickly turned downward.

> It is very remarkable, how the *Plumule* or future Stem should always get uppermost, and the *Radule* or *Root* be turn'd downwards… and not only this, but if by any external Means the Stem be diverted from this Perpendicular, and bent, for Instance, towards the Earth, instead of persevering in that Direction, it makes an Angle or Elbow, and redresses it self…
>
> Now the *Seed* from which a Plant arises, being the Plant it self in Miniature, 'tis easy to suppose, that, if it be deposited in the Ground with the *Plumule* perpendicularly upward, and the *Radule* downward, the Disposition should be maintain'd in its future Growth (SEED).

So Miller fell into line with the preformationists. The only question was, whether it was in the male pollen or the female seed that the miniature plant was contained? Miller presented the two possibilities (note that pollen was a term used in Latin, but seldom in English until after Linnaeus, and that Miller tends to say farina):

> In this Hypothesis, the Plant in Miniature is suppos'd to be contain'd in the Seed, and to want only a proper Juice to unfold its Parts, and make them grow.
>
> The second Opinion is, That the *Farina* of the Male Plant is the first Germ or Semen of the new Plant, and stands in need of nothing to enable it to grow or unfold, but a suitable Nidus with the Juice it finds prepar'd in the Embryo of the Seed or Ovary.
>
> It may be observ'd, that these two Theories of *Vegetable Generation* bear a strict Analogy to those two of *Animal Generation*, viz. either that the young Animal is in the *Semen Masculinum*, and only stands in need of the Juice of the Matrix to cherish and bring it forth; or that the Female *Ovum* contains the Animal, and requires only the Male Seed to excite a Fermentation.

> Mr. *Geoffroy* rather takes the proper Seed to be in the *Farina*; inasmuch as the best Microscopes don't discover the least Appearance of any Bud in the little Embryo's of the Grains, when they are examin'd (GENERATION).

And thence into the mysteries of parthenogenesis and vegetative reproduction. Miller concluded that the union of male and female was necessary for reproduction, and that flowers were the medium of this union.

It is in the entry on GENERATION that the lingering impact of physico-theology can most clearly be seen:

> Mons. *Perrault*, and some of the modern Naturalists after him, maintain'd, that there is not properly any new Generation; that God created all Things at first; and that what is by us call'd Generation, is no more than an Augmentation and Expansion of the minute Parts of the Body of the Seed: So that the whole Species which are afterwards produc'd, were in Reality all form'd at the first, and inclos'd therein, to be brought forth and exclos'd to View in Time, and according to a certain Order and Oeconomy.
>
> And accordingly Dr. *Garden* says, It is most probable that the Stamina of all the Plants and Animals that have been or ever shall be in the World, have been form'd, *ab Origine Mundi*, by the Almighty Creator, within the first of each respective Kind…
>
> Dr. *Blair*, treating of the *Generation* of *Plants*, says, That when Almighty God created the World, he so order'd and dispos'd of the *Materies Mundi*, that every thing produc'd from it should continue so long as the World should stand; not that the same individual Species should always remain, for they were, in Process of Time, to perish, decay, and return to the Earth from when they came: But that *every Like should produce its Like*, every Species should produce its own Kind, to prevent a final Destruction of the Species, or the Necessity of a new Creation, in order to continue the same Species upon Earth or in the World.

And the discussion then moved on to the interpretation of the creation story in *Genesis*, as far as plants were concerned. Note, of course, that the modern biological definition of a species is not in question here: “species” means more or less the same as “Kind”. But if it is surprising for a discussion of plant reproduction to modulate, however briefly, into theology, it is only because of the late date of the *Gardeners Dictionary*: thirty or forty years earlier, in the heyday of Whiston and Woodward, not to mention Claude Perrault, it would have been the norm, and the physico-theological legacy was still sufficiently strong for Patrick Blair to carry on the same lines of speculation in 1720.

But to return: the difference of sexes in plants, with its implications for reproduction, was a controversial issue in the late seventeenth century, with Nehemiah Grew of the Royal Society probably the most vocal proponent of the theory of sexuality. By the second decade of the eighteenth, Richard Bradley was sufficiently confident of the public acceptance of the idea of sexual reproduction in plants to say “I believe I need not explain how the *Male Dust* of *Plants* may be convey’d by the Air from one to another, by which this *Generation* and *Production* of new *Plants* is brought about” (Bradley, 1719: I 23). Miller, who was stimulated by Bradley’s writing to make experiments on pollen, wrote to him on 6 October 1721 a letter which Bradley published in his *General Treatise of Husbandry and Gardening*, recounting the scepticism of his colleagues (“my Friends condemn’d me, and said I had asserted a mere Fiction”), and then reporting the first published account of pollination by insects:

> I planted a Dozen of Tulips by themselves, and as soon as they open’d, took out the *Apices* with a fine Pair of Nippers, lest I should shake some of the Dust off; and by my Microscope I could not discern any Dust that had been left behind. About two Days after, as I was sitting in my Garden, I perceiv’d, in a Bed of Tulips near me, some Bees very busy in the Middle of the Flowers; and viewing them, I saw them come out with their Legs and Belly loaded with Dust, and one of them flew into a Tulip that I had castrated: Upon which I took my Microscope, and examining the Tulip he flew into, found he had left Dust enough to impregnate the Tulip (Bradley, 1726: I 330–332; also Blair, 1721: 216–217).

Later the same month he sent the same information to Patrick Blair, adding some observations about the variability of cabbages, which he attributed to the random pollination of cabbage plants. Blair paraphrased the letter in the *Philosophical Transactions*:

> For he had half of them red Cabbages, and some white Cabbages, and some Savoys with red Ribs, and some neither one Sort nor other, but a Mixture of all Sorts together in one Plant. He went to the Gardener and told him his Tale, who shew'd him, that he was in the same condition, but did not know how it should come to pass, for he was sure he took special care in saving of the Seed… he immediately thought how it came to pass, by the *Effluvia* impregnating the *Uterus* of one another; and it is very common for our Gardeners to plant white and red Cabbages together for Seed, and they are as often disappointed by having a Degeneracy of both Kinds, which they attribute to the Soil, and think that is the Cause: They send to *Holland* for a fresh supply of Seeds, and say our Soil will not continue that Sort Good. He told them his Opinion, and they laugh at him for it, and will not be turn'd out of their Road, although they should have never so many Experiments shew'd them (Blair, 1721: 217–218).

Miller's encounters with the loamy empirics (as we may call them, by analogy to Boyle's "sooty empirics" promoting Paracelsianism) show what a novelty the idea was, of pollination as the medium of reproduction; after all, it was little more than a generation earlier that Tournefort had regarded pollen as "only an Excrement of the Food of the Fruit, and the *Stamina*… only excretory Ducts" (GENERATION). Blair commented:

> This Experiment is a most convincing Argument for the *Effluvia*; for did each Grain of the *Farina* enter the *Pistillum* to its proper *Uterus*, this mongrel Kind would never be produced. For if the individual Plant be in each Grain of the Male *Farina*, how can it be so far dismember'd, as that one Part shall go to the making up of the Ribs of red Cabbage, and another to compose the rest of a Savoy Plant…
>
> I could descant yet more upon this Observation, and consider how far this may lead us into the infinite Variegations and Stripes, in not only annual Flowers, such as Poppies, *consolida Regalis*, and Bottles, but also in perennial Roots; such as Auricula's, Cowslips… (Blair, 1721: 218–219).

(The letter, and Blair's remarks, are reproduced in Zirkle, 1935: 124–129.) Miller recounted some of his experiments as the conclusion to his entry on GENERATION.

Conclusion

Nearly three centuries after Miller, the world revealed by modern science looks very different from the Newtonian universe that spread out before the awestruck gaze of his generation. Fire is no longer a substance, heat is a form of energy: the Newtonians would have had no difficulty with this development, though the Boerhaavians would have sulked. Earth, air, and water, let alone sulphur and salts, have lost their former priority as substances, and all but sulphur have joined the ranks of compounds – this again would not have troubled a strict Newtonian. Corpuscles yielded place first to molecules and then to atoms as the fundamental constituents of matter, and the physicists now argue over the components of the atom (the very idea would have struck the Newtonians as a contradiction in terms), though their arguments do not generally affect botany. Universal gravitation is no longer invoked as an explanation for the behaviour of these submicroscopic particles, and electric charge (only discovered toward the end of Miller's life) has taken its place, not to mention more complex and barely comprehensible forces at even finer levels. There are now 90 elements existing in nature, and their classification involves principles unknown until the nineteenth century. The number of the planets has increased, as has the number and variety of astronomical objects generally, and the current understanding of the sun involves processes (nuclear fusion) that were unimaginable before the twentieth century.

The epigeneticists won the argument over generation, but with complications (such as DNA) far beyond the reach of either the microscopes, the chemical apparatus, or the concepts of Miller's day. Nearly every part of Martyn's definition of a plant has been challenged or overthrown. "[D]estitute of Sense and spontaneous Motion"? – after Darwin, Burdon-Sanderson and Bose, let alone all the more recent discoveries summarised in *The Action Plant* (Simons, 1992), the powers and capacities of plants look rather different. "[A]dhering to another Body in such a manner, as to draw from it its Nourishment"? – this was before the discovery of epiphytes. "[H]aving a power of propagating its self by seed"? – the life cycles of fungi and lichens were only sorted out in the nineteenth and twentieth centuries.

Discussions of the origins of the world, or of life, have developed in ways that would have shocked the early Fellows of the Royal Society; "fossil" now means something they would have found profoundly unsettling. If Miller or any of his contemporaries could have been suddenly confronted with the world-view of modern science, the experience might well have been comparable to a few hours of being spun in a centrifuge. I trust that the reverse experience, of a brief exposure to the science of Miller's day, will have been more agreeable.

Table 2. **Miller's duplication of material**

Column 1 shows the title of the entry in Miller's *Gardeners Dictionary* (1731). Column 2 lists the paragraphs in each entry for which sources have been traced. Since Miller's pages are not numbered, I have counted the paragraphs in the text of each entry, treating as a new paragraph every initial indentation, even for single-line numbered items in a series, but not including subtitles. Column 3 gives page references for the sources. Unless otherwise specified, these are from Chambers' *Cyclopaedia*, cited by title of entry. The *Cyclopaedia* is inconsistent in its pagination, and runs: pp. 1–184, 75–368, 161–380, 1–282, 365–1038, 1–392 spread across two volumes. Other works can be identifed by reference to Table 3.

Miller 1731	**Paragraphs**	**Source**
Aether	1 (entire entry)	Aether (p. 41)
Air	3–5	Air (p. 49)
	6–9	BOERHAAVE (pp. 277–280)
	10	Exhalations (p. 364)
	11–34	BOERHAAVE (pp. 280–289)
	40–46	BOERHAAVE (p. 290)
	52	Air (p. 50)
	63–69	Air (p. 51)
Anatomy	4–6; parts of 24, 26, 29, 32, and 39; 45–50, 52–56	Plant (p. 829)
Atmosphere	1–5	Atmosphere (p. 167)
Barometer	1–2	Barometer (p. 83)
	5, 7–13	Barometer (p. 84)
	16–18, 42–43, [44–50 with additions]	Barometer (p. 85)
	54–94 including diagram	Barometer (pp. 85–86)
Climate	1–12 (entire entry)	Climate (p. 237)
Cold	1–14	Cold (p. 253) – 2 copied from QUINCY (p. 78)
Dew	1	Miller 1724 (Dew)
	2–3, 5–6, latter part of 8, 9, 11	Dew (p. 196)
Earth	3–9	Earth (p. 262)
	10–16, 18–19, 22–25	Miller 1724 (Earth)
Fire	2–4	Fire (p. 35)
	5 (first part)	Fire (p. 35, copied from BOERHAAVE, p. 220)
	6–18	BOERHAAVE (pp. 220–221)
	22–24	BOERHAAVE (p. 224)
	25	's-GRAVESANDE (II p. 25)

Table 2. **Miller's duplication of material** (cont.)

Miller 1731	Paragraphs	Source
Fire (cont.)	33–37	BOERHAAVE (pp. 225–6)
	38, 41–48	Fire (p. 35)
	51	Fire (p. 36)
	56, 58	's-GRAVESANDE (II p. 2)
	57	BOYLE 1675 (pp. 100–101)
	58	's-GRAVESANDE (II p. 11)
	60–62, 64–73	BOERHAAVE (pp. 226–237)
	77–81	Fire (p. 36)
Flower	1	Flower (p. 56)
	2–13	MARTYN (pp. 11–15)
	14–16, 20–22	Flower (p. 56)
Fluidity	Part of 2	Fluids (p. 58)
	3–7, 11, 15–23	Fluidity (p. 57) – 10, 16–22 copied from QUINCY (pp. 156–7)
	24–28	Fluids (p. 58)
Freezing	1–19 including diagram, part of 20	Freezing (p. 95)
	21	QUINCY (p. 160)
	22, 24, 26–50	Freezing (p. 96) – 43–49 copied from QUINCY (pp. 160–1)
	51–56, 58–60	Freezing (p. 97)
Humidity	2–4	Humidity (p. 262); Miller 1724 (Humidity) – both copied from QUINCY (p. 199)
Hydrostaticks	1	Hydrostaticks (p. 274)
	4–12	Miller 1724 (Hydrostaticks)
Hygrometer	1	Hygrometer (p. 274) – copied from some common source, as found in Miller 1724 (Hygrometer)
	2–6	Hygrometer (p. 274)
	7–11	Miller 1724 (Hygroscope)
Ice	1	Ice (p. 367)
	3, part of 4, 5, 7–10	Miller 1724 (Ice)
	12–17	MARIOTTE (pp. 6–8)
Levity	1–9 (entire entry)	Levity (p. 449) – copied from some common source, as most is found in 1724
Light	1–6	Light (p. 454)
	7	Miller 1724 (Light)
	8 (last part)–9	Light (p. 455)
	10–21	Light (p. 456)

Table 2. **Miller's duplication of material** (cont.)

Miller 1731	Paragraphs	Source
Nature	1–9, 11–24	Nature (pp. 617–618)
	25–49	Miller 1724 (Nature) – 26–33, 35–39 copied from QUINCY (pp. 302–4), 40–49 copied from QUINCY (pp.
	NB	305–7); 29 also copied in Chambers, Vis (p. 312)
Rain	1–7, 9	Miller 1724 (Rain)
	10–12	Rain (p. 953)
	13	Miller 1724 (Rain)
	14–15	Rain (p. 953)
	16	Miller 1724 (Rain)
	17–28	Rain (p. 953)
	29–35	Miller 1724 (Rain)
	38–39 and table	Rain (p. 954)
Rainbow	1–4	Rainbow (p. 954)
	5–14	Miller 1724 (Rainbow)
	15–19	Rainbow (pp. 956–957)
Sun	1–6, 24–37	Sun (p. 151)
	39–53, 59–62	BOERHAAVE (pp. 236–9)
	83–87	BOERHAAVE (pp. 242–3)
	113–126	BOERHAAVE (pp. 245–8)
	128–148	Miller 1724 (Sun)
Thermometer	1–23 (entire entry) but not diagrams	Thermometer (p. 205)
Thermoscope	1–13	Thermoscope (p. 206)
	21–41 & table	Miller 1724 (Thermometer)
Thunder	1–5, 11–18	Thunder (p. 210)
	21–65	Miller 1724 (Thunder)
	NB part of 46	Thunder (p. 210) – evidently copied from some common source
Vapour	1–2 (entire entry)	Vapour (p. 277)
Vapours	1–23	Miller 1724 (Vapours)
	25–87	DESAGULIERS (pp. 6–22)
	89–91	Vapours (p. 277)
Variegated	33–36, 46–54, 57–60	Colour (p. 259)
	61–70, 73, 75–77, 79–81, 83–84	Prism (p. 880)
	86–107	Colour (pp. 260–1)
	109–119	Miller 1724 (Variegation of Plants)
Vegetable	1–7 (entire entry)	Vegetable (p. 284)
Vegetable Staticks	1–29 (entire entry)	HALES 1727 [summary of entire book]

Table 2. **Miller's duplication of material** (cont.)

Miller 1731	Paragraphs	Source
Vegetation	1–14, 16–23, 26–42	Miller 1724 (Vegetation)
	44–138	WOODWARD 1699 (pp. 195–227)
Water	1–35	Miller 1724 (Water)
	NB 2–6, 26–29	QUINCY (pp. 457–8) – para. 2 copied in Chambers: Water (p. 345)
	31–35	QUINCY (pp. 435–6)
	36–38	Water (pp. 345–346)
	39–53, 55–67, 69	Water (pp. 346–347)
	70–80	BOERHAAVE (p. 309–312)
	NB 73–77	Also copied in Water (pp. 347–8)
	81–93 (with additions), 95–98	Water (pp. 348)
	104–110, 112–113	Water (p. 348)
	115–120, 123–124, 126, 128–129 with additions	Water (p. 349)
	131–142	Water (p. 348)
	143–146	Water (p. 349)
	147–163	Water (p. 350)
	165–170	MARIOTTE (pp. 10–12)
Weather	2–3, part of 4, 5–7, 9	Weather (p. 356)
	8, 10–11	Miller 1724 (Weather)
	12–94	Miller 1724 (Weather), copied from POINTER (para. 12–32 from pp. 1–6; 33–9 from pp. 17–19; 40–43 from pp. 7–9; 44–58 from pp. 9–13; 59–75 from pp. 14–17; 76–94 from pp. 19–24)
	NB 33–35	Weather (p. 357)
	99–112	POINTER (pp. 24–26)
	113–124	Weather (pp. 356–357)
Wind	1–2	Miller 1724 (Wind)
	3–17	Wind (pp. 367–368); 4–17 copied from QUINCY (pp. 458–61
	21–26	POINTER (pp. 31–32)
	27–40	DERHAM (pp. 14–16)
	73–84	Wind (pp. 368–369)
	85–95	Wind (p. 369)
	96–111	Miller 1724 (Wind)
	112–118	Wind (p. 369)
	119–152	Miller 1724 (Wind) NB Partly copied from POINTER (para. 127–135 from pp. 24–6, 136–139 from p. 28, 140–143 from p. 33, 149–152 from p. 35)

Table 3. **Works on physics and chemistry referred to by Miller**

Usually Miller refers to authors by name only; if the work is specified by name, the entry in which it is cited is italicised.

Works cited in text copied from Chambers' *Cyclopaedia* are not included unless there is reason to believe that Miller examined them independently; papers in the *Philosophical Transactions of the Royal Society* are included here for that reason even when they appear in material copied from Chambers.

Name	**Title of specific work**	**Author cited in entries**
Bacon, Sir Francis	*Sylva Sylvarum* (1631)	Fire, Weather, Wind
Beal, J.	"Advertisements … upon Frosts in Some Parts of Scotland", *Phil. Trans.* **10**: 357–367 (1675)	Barometer
Boerhaave, Hermann	*A New Method of Chemistry* (1727), translated by Peter Shaw & Ephraim Chambers	Cold, Earth, Fire, Fluid, Sun, Vegetable, Vegetable staticks, [Water], Wine
Bourzes, F.	"A letter … concerning the Luminous Appearance Observable in the Wake of Ships in the Indian Seas, &c.", *Phil. Trans.* **28**: 230–235 (1713)	[Rainbow]
Boyle, Robert	*The Mechanical Origine of Heat and Cold* (1675)	Fire
Boyle, Robert	"On the Temperature of the Subterraneall Regions", in *Tracts… about the Cosmicall Qualities of Things, &c* (1670)	Sun
Chambers, Ephraim	*Cyclopaedia* (1728), entry on Barometer	Barometer
Cruquius, Nicolaus [Nicolaas Kruik]	"Observationes Accuratae Captae, anno xvij=xxiij Lugduni Batavorum, Delphis Bataviae, & in pago Rhenoburgo", *Phil. Trans.* **33**: 4–7 (1724).	Dew
Cunningham, James	"Observations of the Weather, made in a Voyage to China", *Phil. Trans.* **24**: 1639–1647 (1704), and "A Register of the Winds and Weather… with the Observations of the Mercurial Barometer, at Chusan", ibid., 1648–1698.	Weather
Derham, William	"Tables of the Barometrical altitudes at Zurich in Switzerland [&c]", *Phil. Trans.* **26**: 342–366 [sic] (1709)	Weather
Derham, William	"An abstract of the meteorological diaries communicated to the Royal Society," *Phil. Trans.*, **37**:261–279 (1731–2)	Weather

Table 3. **Works on physics and chemistry referred to by Miller** (cont.)

Name	Title of specific work	Author cited in entries
Derham, William	*Physico-theology* (1713 & later eds).	Rain, Weather, Wind
Desaguliers, John Theophilus	"Remarks … concerning the Cause of the Variation of the Barometer", *Phil. Trans.* **30**: 570–579 (1717)	Barometer
Desaguliers, John Theophilus	"An Attempt to Solve the Phaenomenon of the Rise of Vapours, Formation of Clouds and Descent of Rain", *Phil. Trans.* **36**: 6–22 (1729)	Vapours
Descartes, René	*Principia philosophiae* (1644 & later eds.). Not fully translated into English until 1983, but available in French from 1647.	Rainbow, Water, Wind
Gravesande, Willem J 's-	*Mathematical Elements of Natural Philosophy*, translated by J.T. Desaguliers (1720)	Fire
Hales, Stephen	*Vegetable Staticks* (1727)	Air, Anatomy, Generation, Hydrostaticks, Leaves, Light, Rain, Thermoscope, Vapours, Vegetable
Halley, Edmund	"An Account of Dr Robert Hook's Invention of the Marine Barometer, with Its Description and Uses", *Phil. Trans.* **22**: 791–794 (1700); AND "A Proposal for Measuring the Height of Places, by Help of the Barometer of Mr. Patrick, in which the Scale is Greatly Enlarged", *Phil. Trans.* **31**: 116–119 (1721)	Air, Atmosphere, Barometer
Halley, Edmund	"A Discourse concerning the Proportional Heat of the Sun in all Latitudes, with the Method of Collecting the Same", *Phil. Trans.* **17**: 878–885 (1693)	Sun
Halley, Edmund	"An Account of Several Experiments made to Examine the Nature of the Expansion and Contraction of Fluids by Heat and Cold, in order to Ascertain the Deviations of the Thermometer", *Phil. Trans.* **17**: 650–656 (1693)	[Thermometer]
Halley, Edmund	"An Observation of the End of the Total Lunar Eclipse on the 5th of March 1718. Observed Near the Cape of Good Hope, Serving to Determine the Longitude Thereof. *Phil. Trans.* **30**: 992–994 (1717)	Thermoscope

Table 3. **Works on physics and chemistry referred to by Miller** (cont.)

Name	Title of specific work	Author cited in entries
Halley, Edmund	"An Account of the Appearance of Mercury, passing over the Sun's Disk, on the 29th of October, 1723", *Phil. Trans.* **33**: 228–238 (1725)	Vapours
Halley, Edmund	"A Short Account of the Cause of the Saltness of the Ocean, and of the Several Lakes that Emit no Rivers; with a Proposal, by Help thereof, to Discover the Age of the World", *Phil. Trans.* **29**: 296–300 (1715)	[Water]
Halley, Edmund	"An Historical Account of the Trade Winds, and Monsoons, Observable in the Seas between and near the Tropicks", *Phil. Trans.* **16**: 153–168 (1686)	Wind
Hillier, J	"Part of Two Letters, giving an Account of the Nature of the Inhabitants, the Air, &c. [of Cape Corse]", *Phil. Trans.* **19**: 687–707 (1697)	Weather
Hooke, Robert	*Micrographia* (1665)	Fluidity, Thermoscope, Variegated
Hooke, Robert	*Philosophical Experiments and Observations*, edited by W. Derham (1726)	Sun, Thunder
Lister, Martin	"Some Experiments about Freezing, and the Difference betwixt Fresh Water Ice, and that of Sea Water", *Phil. Trans.* **15**: 836–838 (1685)	Water
Lister, Dr Martin	"Concerning the Rising and Falling of the Quicksilver in the Barometer", *Phil. Trans.* **14**: 790–4 (1684)	Barometer
Locke, John	"A Register of the Weather for the Year 1692, kept at Oates in Essex", *Phil. Trans.* **24**: 1917–1937 (1705)	Weather
Mariotte, Edmé	*The Motion of Water and Other Fluids*, transl. by J.T. Desaguliers (1718)	Ice, Sap, Water, [Wind]
Newton, Sir Isaac [anon., but attrib.]	"Scala Graduum Caloris", *Phil. Trans.* **22**: 824–829 (1701)	Vapour
Newton, Sir Isaac	"A Letter … containing his New Theory about Light and Colours", *Phil. Trans.* **6**: 3075–3094 (1672)	Variegated
Newton, Sir Isaac	*Opticks* (1704)	Fire, Light, Rainbow, Sun, Vapours, Variegated, Vegetable

Table 3. **Works on physics and chemistry referred to by Miller** (cont.)

Name	Title of specific work	Author cited in entries
Newton, Sir Isaac	*Philosophiae Naturalis Principia Mathematica* (1687) [translated by Andrew Motte as *Mathematical Principles of Natural Philosophy* (1729)	[Fluidity], [Nature], Vapours
Plot, Robert	"A Letter… concerning… the History of the Weather, made by him at Oxford during the Year 1684", *Phil. Trans.* **15**: 930–943 (1685)	Weather
Pointer, John	*A Rational Account of the Weather* (1723)	Barometer, Weather, Wind
Quincy, John	*Lexicon Physico-Medicum: or, a New Physical Dictionary* (1719)	Cold, Fluidity, Freezing, Humidity, Nature, Water, Wind
Townley, Richard	"A Letter… containing Observations on the Quantity of Rain Falling Monthly, for Several Years Successively", *Phil. Trans.* **18**: 51–58 (1694), AND "An Account of what Rain Fell at Townly in Lancashire, in the Years 1697, and 1698", **21**: 47–48 (1699), AND "A Prospect of the Weather, Winds and Height of the Mercury in the Barometer, on the First Day of the Month, and of the Whole Rain of Every Month in the Year 1703, and the Beginning of 1704", **24**: 1877–1881 (1705)	Weather
Wallis, John	"A Discourse concerning the Measure of the Airs Resistance to Bodies Moved in It", *Phil. Trans.* **16**: 269–280 (1686)	Air
Wallis, John	"A Letter… concerning the Generation of Hail, and of Thunder and Lightning, and the Effects Thereof", *Phil. Trans.* **19**: 653–658 (1697)	Thunder

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Hill's *Vegetable System*

BRENT ELLIOTT
The Lindley Library, The Royal Horticultural Society, London

Sir John Hill's *Vegetable System* (1761–1775) is one of the most ponderous, and least known, of major botanical works. Twenty-six volumes, 47½ cm high, a complete set forming a solid block of some 120cm, seldom examined and still less often read, it is occasionally found worthy of a paragraph amid the other ancillary phenomena of the rise of the Linnaean system. The best account so far is that given by Blanche Henrey (Henrey, 1975: II 103–108; III no. 832). Her volume-by-volume record of the pagination was declared by Stafleu and Cowan (1979: 202–204) to be a "very detailed and informative description"; but there is always more to say.[1] She herself said that she had "no space to criticize *The Vegetable System*, or to give an idea of its scope".

No new information about Hill's life seems to have been discovered since Blanche Henrey's account. He was born around 1716, and died in 1775, and was a prolific writer on botany, the author of a *British Herbal* in folio (1756–1757), a gardening encyclopaedia (*Eden*, 1756–1757), a microscopic study of wood (*The Construction of Timber*, 1770), and a pioneering study of *The Sleep of Plants* (1757), among others. The *Vegetable System* was his largest work, and the one that took longest to complete. He never received a British knighthood, but adopted the title of "Sir" on being invested with the Order of Vasa from the King of Sweden.

The *Vegetable System* as it stands today should be regarded as incomplete; had Hill lived, he would no doubt have carried it on into even more volumes. As the title indicates, it was intended to provide complete coverage of the plant kingdom, and it describes and depicts plants from all over the world, arranged according to a classification scheme that has never been followed by any subsequent botanist.

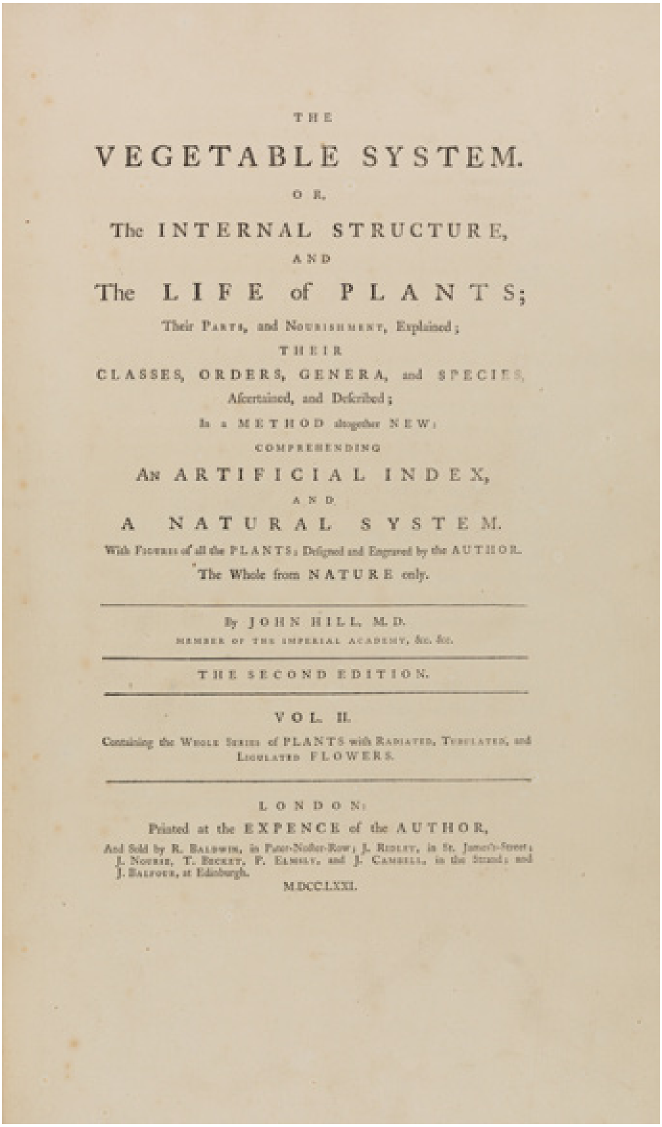
[1] Henrey, for one thing, never gives collations for the works she discusses; what she calls "collations" are only lists of pagination.

Publication history

The imprint statement for the early volumes reads “Printed at the expence of the author. And sold by R. Baldwin, in Pater-Noster-Row, M DCC LXI”.

In the mid-eighteenth century, the modern distinction between booksellers and publishers had not been made. Booksellers paid the author the production costs for the right to sell his work at their shops; where multiple booksellers collaborated on the production, they were listed on the title page in descending order according to the size of their contributions. It is interesting that Hill claims to have paid the printing costs himself; did Richard Baldwin, who maintained a bookshop on Paternoster Row for over sixty years, get the sale rights gratis? Up to volume VII, Baldwin was the only bookseller listed; from volume VIII (1765), he was joined by John Ridley, who started up a bookshop in St James’s Street in that year. By 1770, the prestige of the work – or else Hill’s bargaining skills – had increased, and additional booksellers were named in the imprint statements. Volume XVI adds John Nourse, Lockyer Davis (who, in addition to being a bookseller, was printer to the House of Commons), Thomas Becket, Peter Elmsley (just beginning his prestigious career in Southampton Street, off the Strand), and J. Campbell in the Strand (possibly James Campbell, formerly bookbinder to the King, who had a stationer’s shop in the Strand by 1774 but is otherwise undocumented as a bookseller – see Maxted, 1977: 38). Lockyer Davis disappeared from the imprint statement in volume XVII, but returned in volume XXIV. In volume XIX (1771), an Edinburgh dealer, John Balfour, was added; and finally, in volume XXII, Benjamin White of Fleet Street (alleged to be Gilbert White’s brother) was added. All this panoply of bookseller-publishers disappeared after volume XXV, however; the imprint statement of the final volume (1775) reads: “Printed for the author in St. James’s-Street: and sold by T. Trueman, No 394, in the Strand”. Trueman or Truman is not a well-known figure, being mentioned by neither Plomer nor Maxted in their dictionaries of publishers; but he is listed in the British Book Trades Index as having flourished between 1749 and 1781.

The *Vegetable System* was issued in a second edition, beginning in 1770, the year that the multiple booksellers began to be added to the



THE

VEGETABLE SYSTEM.

OR,

The INTERNAL STRUCTURE,

AND

The LIFE of PLANTS;

Their Parts, and Nourishment, Explained;

THEIR

CLASSES, ORDERS, GENERA, and SPECIES,

Ascertained, and Described;

In a METHOD altogether NEW:

COMPREHENDING

An ARTIFICIAL INDEX,

AND

A NATURAL SYSTEM.

With Figures of all the PLANTS; Designed and Engraved by the AUTHOR.

The Whole from NATURE only.

By JOHN HILL, M.D.

MEMBER OF THE IMPERIAL ACADEMY, &c. &c.

THE SECOND EDITION.

VOL. II.

Containing the Whole Series of PLANTS with Radiated, Tubulated, and Ligulated FLOWERS.

LONDON:

Printed at the EXPENCE of the AUTHOR,

And Sold by R. Baldwin, in Pater-Noster-Row; J. Ridley, in St. James's-Street; J. Nourse, T. Becket, P. Elmsly, and J. Cambell, in the Strand; and J. Balfour, at Edinburgh.

MDCCLXXI.

RHS, LINDLEY LIBRARY

Fig. 1. **Title-page of the second volume of Hill's *Vegetable System*, in its second edition format (1771, originally published 1761).**

imprint statement. Volumes I and II of the Lindley Library's set are of this second edition; the evidence cited by Blanche Henrey (Henrey, 1975: III 58) shows that most of the volumes did not bear the words "second edition", and can only be distinguished by their later publication dates. With most of the copies she examined, the second edition stopped with volume XXI (1775), but the Wellcome copy bears the date 1786 on volumes XXII–XXIII.

Hill's plates

There is no space here to give a complete list of plates; a complete list has been attached to the catalogue record of the *Vegetable System* on the RHS Lindley Library online catalogue, and it runs to 158 pages. There are altogether 933 plates, incorporating 4771 individual plant portraits (45 plates are devoted to classifications or explanations of anatomy). After the first few volumes (volumes II–III have a total of 137 plates in one single sequence; thereafter each volume is numbered separately), they settle down into a regular rhythm of 60 plates per volume, with a few volumes bearing an additional plate, frequently as a result of misnumbering. An appendix of 20 plates, each devoted to a single plant, is divided equally between vols. XII–XIII; these, together with the (renumbered) last five plates of volume XVI, were published separately in 1773 under the title *Twenty-five New Plants, Rais'd in the Royal Garden at Kew; their History and Figures*. (See the Lindley Library online catalogue record of that work for a table giving the plate numbers in both works.[1])

The figures on the plates generally correspond to the text of the facing leaves. Occasionally there is a discrepancy, with the text for one figure appearing on the following page; in vol. IV, p. 23 has text for the final figure on plate 19.

Hill is identified on the title-page as the engraver, but this attribution must raise some questions. The plant names inscribed on the plates differ from those in the text in such matters as hyphens, apostrophes in past participles, etc. There is similar orthographical variation between plates, but for the most part the orthography is consistent within any given plate.

1 www.lindleylibrary.org.uk/uhtbin/cgisirsi.exe/x/0/0/49

Fig. 2. **Hill, *Vegetable System*, vol. 2 (1761), plate 8: comparison of leaves.**

Either someone other than Hill carried out the engraving, or at least the lettering of the engraving, or else the text was corrected for spelling and orthography by someone other than Hill – the printer perhaps? (But there is some evidence that more than one printer may have been used during the course of publication.)[1]

In any significant engraving establishment – and the principle held true for lithographers later on – there was a hierarchy of functions carried out by different people. The most basic tasks, like drawing frames and dividing lines on the copper plates and numbering them, fell to the most junior members (e.g. apprentices); incising the text required greater skills, since the text had to be written backward, and making corrections on copper plates was a tedious and untidy task; the principal illustration fell to the lot of the senior or most skilled. So it is entirely likely that when Hill claimed to be the engraver, he meant that he engraved the figures; he might well have had juniors to carry out the donkey-work of frames and lettering. This would explain such discrepancies of treatment in names as those shown in Table 1.

[1] The evidence for multiple printers takes two forms: press figures and the collation of initial leaves.

Press figures are numerals which appear at the bottom of selected text pages, usually pages which did not already bear printers' signatures. They were common in English books throughout the eighteenth century, and a certain degree of uncertainty attaches to their purpose: they identified the work of particular pressmen, either for wage claims or as a means of checking for quality control by their employers. All volumes except IV include press figures, but XI contains only a single instance, III two, and five others fewer than five; vol. I contains 22, and five volumes contain 16. Discrepancies difficult to explain on the hypothesis of a single printing works.

The initial leaves of the different volumes follow two different patterns. In vols. I–II, V, X, XVII–XXVI, the first leaf forms part of a folio gathering. In all the other volumes, the initial leaf is a standalone leaf that has been pasted onto the opening gathering, and is therefore treated in collation as π. This difference is more likely to result from a change of printers than from failure of procedural memory on Hill's part.

Table 1. **Discrepancies of treatment in names**

Text	Plate
Multifid	Multifi'd
Forky	Forked
Narrow leav'd	Narrow lanc'd
Glandular	Glandula
Malvaviscan	Malvaceiscan
Pinnatifid	Pinnectifed
Bryony	Bayong
Worward	Werwand
Catmint	Calmint
Nissolian	Nipolian
Psoralian	Osoralean
Pallid	Palled

In vol. XIV, plate 51, we can see a Hill vernacular name in the process of formation: the text gives the name Wetweed, and the plate Dampwort. The text gives us presumably the final version of the name, as text was easier to correct than incisions in copperplate.

The plates vary in quality, as might be expected of such a quantity; when they are good they are very very good, and when they are bad they are merely indifferent. Few of them are devoted solely to a single species (and when they are, they are generally superior in quality); in most cases various species of a given genus are assembled together, and the attempt at cramming multiple images together can diminish both the quality and the botanical detail of the plates. Dissections, when they do appear, are of high quality. Some exotic flowers, such as *Dorstenia* and *Echinophora*, are overly geometrised. Linnaeus is recorded to have said, "I fainted at the sight of Hill's great work … with the most beautiful plates of plants on each alternate page, but I could weep when I saw such a costly work without botanical science" (Henrey, 1975: II 108).

Fig. 3. **Hill, *Vegetable System*, vol. 15 (1769) plate 30: Dyeweeds, or Crotons. An instance in which the colouring appears incomplete.**

The major drawback to the plates lies in their colouring. I have never seen an uncoloured copy of the *Vegetable System*, though the attendant publication *Twenty-five Plates* is uncoloured in my experience. Normally at this period plates were sold uncoloured, so colouring varies considerably depending on the whims of the purchasers, though increasingly one can find the possibility of coloured copies being sold for increased prices. In the case of the *Vegetable System*, the colouring that I have seen is so comparatively consistent that I suspect that it was overseen by Hill. The Lindley Library copy has two plates (vol. XV plates 30–31) whose colouring looks unfinished, and two others (vol. XVI plates 13–14) which are crudely coloured: this might be considered as evidence against my hypothesis, but might merely reflect the occasionally slipshod degree of organisation shown above. The colouring relies on a limited range of pigments, yellowish greens in particular, that give the plants an effect of uniformity of colour that reduces their effect en masse; but this is sometimes counteracted by a heightening of colouring and contrast in the larger specimens.

Hill's nomenclature

Hill gives English vernacular names prominence than Latin. The plates consistently show English names for both genus and species throughout; the text begins by giving Latin names as the headings for the discussions of genera, but partway through vol. II (text for plate 69) it shifts to giving them English names instead. Linnaean binomials are consistently subordinated to English names in the discussions of individual species. Hill's names, however, are in large part his own creations, probably never used by anyone but himself (names like Glond and Jericobey do not appear in the *Oxford English Dictionary*), and in some cases he puts more familiar English names alongside the Latin binomials (as in vol. IV, p. 44, where *Centaurea moschata* is named Musky Centaury, with the commoner name Sweet Sultan in reduced type). On vol. IV p. 29 he gives the same Latin binomial for what he distinguishes as two species by their English names; similarly with *Campanula saxatilis* in vol. VIII, and also with the three sorts named *Cyclamen europaeum* (VIII p. 43). In vol. VIII the "scattered rampion" is described in the text as being figure 4 of plate 14, but in fact has a separate plate, 15* [misnumbered 16* on the plate], devoted to it; in the same volume there is no plate 53.

In most cases, the names Hill used for plants with well-known British representatives were traditional English names. The idiosyncrasies generally arose when he came to plants found only overseas, frequently recent introductions, that had never had English names before; in such cases Hill attempted to fill the gaps. There was a well-established tendency to ensure that all plants were given vernacular names, and works such as Sowerby and Smith's *English Botany* (1790–1814) bristle with "book names", i.e. names that were coined in the study for purposes of completeness and were probably never spoken in the field. (Did anyone ever call a plant the "Fallacious Feather-moss",[1] apart from Sir J.E. Smith – and probably his printers, who would have spoken his text during proof-reading? Or the "Brown-headed Bog-rush" for what is now *Rhynchospora fusca*?)

Some of Hill's "English" names were simple transfers from Latin, e.g. Arctotis, Bidens, Chrysogonum, Milleria, Osteospermum, Sigesbeckia, Tetragonotheca, Verbesina. In other cases the Latin names were adapted into English by supplying new suffixes or otherwise anglicising the endings. *Impatiens* became Impatient, *Besleria* Beslerett, *Calla* Callard, *Camphorosma* Camphorelle, *Coronilla* Coronelle, *Sophora* Sophorell, *Hedysarum* Edysare, *Hibiscus* Hibisk, *Linnaea* Linneyswort (that must have pleased Linnaeus), *Medeola* Medeole, and *Clinopodium* Clinopode. Sometimes the Latin name is given a softened termination (*Selago* becomes Sellage, *Smilax* Smilace); in one case it merely changes gender (*Helenium* becomes Helenia); more commonly it is fitted with one of a couple of standard suffixes, either –ine (*Aletris* becomes Aletrine, *Clitoria* Clitorine, *Galeopsis* Gallopsine, *Gerardia* [= *Stenandrium*] Gerardine, *Prasium* Prasine) or –y (*Aralia* becomes Araly, *Bunia* Buny, *Cymbaria* Cimbary, *Costus* Costiny, *Ellisia* Ellisy, *Helonias* Helony, *Martynia* Martiny, *Pedalium* Pedaly, *Torenia* Toreny, *Tragia* Traginy; *Ophrys* becomes Orchidy, since Orchis was already used as a vernacular name for that genus). Anglo-Saxon plant epithets were used occasionally as suffixes (*Dodartia* becomes Dodartswort, *Raiana* [= *Rajania*] Raywort, and *Mollugo* Mollweed), while *Ervum* was interestingly turned into Ervold, a termination not used elsewhere. *Capraria* became Cappary, suggesting

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[1] *Hypnum fallax* (now *Cratoneuron filicinum*), discovered 1806: *English Botany* plate 2127.

Table 2. **Specimen English names given novel uses by Hill**

Hill's name	**Traditional application**	**Hill's application**
Bloodweed	*Polygonum convolvulus*	*Sanguinaria*
Bugle Weed	*Lycopus*	*Tozzia alpina*
Colt's Tail	*Erigeron*	*Myriophyllum*
Field Basel	*Saponaria vaccata*	*Ziziphora*
Fly-flower	*Prunella vulgaris*	*Babiana*, *Gladiolus*, and other Cape bulbs
Goldweed	*Ranunculus* spp.	*Exacum pedunculatum*
Hairweed	*Cicuta*	*Tordylium aegyptiacum*
Hempweed	Kelp, or Hemp-agrimony	*Datisca*
Jointweed	*Equisetum*, *Hippuris*	*Elatine*
Maithen	Various stinking plants (typically *foetida*)	*Knowltonia capensis*, and various species of *Adonis* and *Crepis*
Neckweed	*Cannabis sativa*	*Gnidia*
Redweed	*Papaver* and *Polygonum* spp.	*Dodecatheon meadia*
Sandweed	*Spergula arvensis*	*Anacyclus*
Spikenard	*Nardostachys grandiflora*	*Baccharis* and *Pluchea*
Waterwort	Various ferns, *Elatine*	*Hydrophyllum virginianum*
Wetweed	*Euphorbia helioscopia* or *Taraxacum officinale*	*Centunculus minimus*
Withwind	*Convolvulus*	*Ipomoea*

an abbreviation of the unrelated *Capparis*. *Parnassia* became Poetweed, because of the association of Mount Parnassus with poetry; *Pharnaceum cerviana* (now in *Mollugo*) became Stagwortle, because of the derivation from *cerva*, deer. Bloodweed was a simple translation of *Sanguinaria*, and the relations between Lizard's Tail and *Saururus*, Herb of Threes and *Trillium*, Lionleaf and *Leontice*, can easily be seen. The Resurrection Plant *Anastatica hierochuntica* became Jericobey, probably as a variant of the vernacular name Rose of Jericho.

In other cases, Hill applied traditional English names, or slight variants of them, to foreign plants of recent introduction. In many cases, the names

Fig. 4. **Hill, *Vegetable System*, vol. 2 (1761) plate 54: Asters. Top, *Aster cordifolius*; lower left, *Aster italicus*; lower right, *Aster dumosus*.**

Fig. 5. **Hill, *Vegetable System*, vol. 23 (1773) plate 27: Birthworts or Aristolochias. Left, *Aristolochia bilobata*; centre, *Aristolochia trilobata*; right, *Aristolochia pentandra*.**

were based on fairly close resemblances, and applied to other plants of the same family: thus Bennet, which in one of its meanings was used for *Geum*, was applied by Hill to *Dryas octopetala* (*Rosaceae*); Bulbous Violet, used for *Galanthus*, was applied to *Leucojum* (*Amaryllidaceae*); Burweed, used for *Galium aparine,* was applied to *Xanthium* (*Rubiaceae*); Clareweed, a variant of Clary, was applied to *Horminum* (*Lamiaceae*); Fleabane, used variously for species of *Inula*, *Erigeron*, *Plantago*, and *Pulicaria*, was applied to *Neurolaena lobata* (*Asteraceae*); Karse (Cress) was used for *Lepidium* (*Brassicaceae*); Mariet, used for species of *Campanula*, was applied to the South African *Roella* (*Campanulaceae*); Maudlin, used for the Oxeye Daisy, was applied to *Ageratum* (*Asteraceae*); Simson, used for *Senecio vulgaris*, was applied to various species of *Erigeron* and *Dittrichia* (again *Asteraceae*); Stonehore, used for species of *Sedum*, was applied to *Crassula perfoliata* (*Crassulaceae*); Whort, used for *Vaccinium*, was applied to *Arctostaphylos* (*Ericaceae*). No one but Hill, as far as I can trace, ever called *Heliconia* Adam's Apple.

In some cases Hill drew on old herbals to revive little-used names, which he then assigned to different plants. For *Trachelium caeruleum* he used the name Haskewort, which had been used in Lyte's translation of Dodoens for *Campanula trachelium*. Caul was an old word for Cabbage, still just current in the early eighteenth century; Hill used Caule as a name for a Seakale, *Crambe hispanica*. Gerard had used Glond for *Saponaria*; Hill transferred it to *Subularia*. Other examples are shown in Table 2 (p. 69).

Such devices only took Hill a little distance into the realms of novel plant nomenclature, however, and in many instances he simply coined new names, without offering any explanation. The following are the most ornamental examples, from a list of a few hundred, which I have been unable to trace in the *Oxford English Dictionary*, Britten and Holland, *The Englishman's Flora*, or other directories of plant names: Ayewort (*Aizoon*), Bean Caper (*Zygophyllum*), Berry Mallow (*Malope*), Brightweed (*Phlox*), Cassiney (*Prinos*, now *Ilex*), Childweed (*Collinsonia*), Clearage (*Baeckea*), Corally (*Erythrina*), Daffodine (*Pancratium*), Eastweed (*Morina*), Errowbane (*Loeflingia*), Eveweed (*Hesperis*), Gandolen (*Basella*), Gaper (*Mimulus*), Hollowleaf (*Sarracenia*), Hyssopine and Indibud (*Justicia* spp.), Leanage (*Neurada*), Liquorell (*Glycine*, now scattered

Table 3. **Duplication of vernacular generic names in Hill**
NB The Latin names are those used by Hill himself.

Bur-weed	*Sparganium*	Burweed	*Xanthium*
Crest-wort	*Centaurea* spp.	Crestwort	*Bartsia*
Featherflower	*Celosia*	Feather Flower	*Menyanthes*
Feverwort	*Dorstenia*		*Triosteum*
Heartseed	*Cardiospermum*		*Silphium*
Maithen	*Adonis*		*Crepis*
Palm-weed	*Centaurea* spp.	Palmweed	*Jatropha*
Swansweed	*Buchnera*	Swanweed	*Aretia*
Woollweed	*Eriocaulon*	Wool-weed	*Centaurea* spp.

among several genera), Love Flower (*Eranthemum*), Malvende (*Urena*), Maudlewort (*Erinus*), Mellusane (*Queria*, now *Paronychia, canadensis*), Mercurine (*Theligonium*), Moravell (*Velezia*), Plantanell (*Limosella*), Purslainet (*Isnardia*, now *Ludwigia, palustris*), Rock Mallow (*Sida*), Scordiny (*Stemodia*), Squillany (*Cyanella*), Tufty (*Iberis*), Wolf's Mercury (*Acalypha*), Worm Flower (*Spigelia*), Wrackrod (*Zannichellia*). Most of these innovations of Hill's did not spread into later literature. Britten and Holland incautiously picked up some of his coinages from *The British Herbal* and included them in their *Dictionary* (1886), thus providing the channel for the only case I have found in which a Hill coinage is cited in the *Oxford English Dictionary* (Faverel, in the untraditional sense of *Draba verna*).

Other curiosities of nomenclature may have resulted from the overlong gestation of the project or from bad record-keeping. Some of Hill's vernacular names were used twice, for different genera. In some cases the names were differentiated typographically, by using hyphens or word separations, though that would be no help in distinguishing them in speech. But Feverwort, Heartseed, and Maithen were each used for two different genera.

Hill's spelling of plant names was sometimes erratic, on both plates and text; but at least it may serve as an indication of how the words were pronounced in the eighteenth century: Baum for Balm, Ben for Behen, Fraxinell for Fraxinella, Galangal for Galingale, Knoutberry for Knotberry, Sampire for Samphire, Spinage for Spinach, Teucrine for Teucrin.

Hill's system of classification

The first volume of the *Vegetable System* continued to use the old polynomial nomenclature, but from the second volume Hill introduced Linnaean names, though never accepting the Linnaean taxonomy. In this he took the opposite course from Philip Miller, who adopted Linnaean classification in the seventh edition of his *Gardeners Dictionary* (1759), but did not adopt binomial nomenclature until the eighth edition (1768).

Hill's system of classification is based, like Linnaeus', on the flower, but gives priority to overall floral morphology and then to the numbering of petals rather than making the numbering of stamens the primary distinction. Mouton-Fontenille, in his survey of systems of plant classification, treated Hill's as an artificial system, based on all parts of the fructification, along with those of Albrecht von Haller, Gmelin, Gilibert, and Allioni, and as opposed to Linnaeus, who used a single part of fructification, the stamens (Mouton-Fontenille, 1798: tab. 1, 74–75). So while Hill can be listed among the critics of Linnaeus, he cannot be regarded, like Adanson, as a forerunner of natural classification as that arose toward the end of the century with the work of Jussieu.

There were potentially 43 classes in Hill's system, though in some cases he named no examples in a class. (The *Vegetable System* never proceeded as far as the non-flowering plants.) Table 4 (p. 76) gives a quick conspectus of the system, and Table 5 (p. 78) compares Hill's categories with those of Linnaeus and traditional modern natural classification.

In his *British Herbal* (1756), which had more room for technical discussions than the page-per-plate correspondence of the *Vegetable System* allowed, Hill belaboured the issue of Linnaean classification on several occasions:

> …those who have limited themselves for the classick characters solely to the threads in the flowers of plants, have thrown the

> genera, thus conencted together by Nature, into many different parts of their works, and joined them with plants to which they have no affinity.
>
> Linnaeus led the way to this, compelled by the very foundation of his system: but when that author saw the necessity of thus separating plants evidently joined by Nature in the course of his enquiry, he should have given up the method, not violated her laws (Hill, 1756: 339).

Alas for the common sense of Hill's classification, this passage prefaced a class ("Plants which have a perfect flower, of a plain and regular structure; and have one seed after every flower, standing naked in the cup") consisting of the genera *Agrimonia* and *Sanguisorba* (today in the family *Rosaceae*), *Fumaria* (*Papaveraceae*), *Limonium* and *Statice* (today merged, in *Plumbaginaceae*), *Thalictrum* (*Ranunculaceae*), *Thesium* (*Santalaceae*), *Valeriana* and *Valerianella* (*Caprifoliaceae*). By the time he began the *Vegetable System*, Hill had revised his classes, but as Table 5 shows, they were all too frequently mixtures of plants from what are now regarded as heavily distinct categories.

The system, as one might expect, having made it through the section on nomenclature, did not always work consistently in print, in a multi-volume work compiled over several years; in short, Hill sometimes slipped up. The fact that he used the name *Salvia aegyptiaca* twice for different plants (vol. XVII) was really Linnaeus' fault, since Linnaeus had used the name in his *Mantissa Plantarum*, and afterwards in his *Systema Naturae*, for the plant he had already named *Salvia spinosa* (Jarvis, 2007: 811). The fact that on two occasions he duplicated entries, and reproduced the same genus in two different classes, suggests certain limitations to the clarity of his criteria. (*Jasione montana,* today in *Campanulaceae*, appeared as a representative of class 2, the semiflorets, in vol. III plate 111, and of class 5, the aggregates, in vol. V plate 23, in the latter case as part of a composite plate. The plate of *Uvularia,* today in *Colchicaceae*, appeared in class 12, the "six-petal'd regular perfect flowers", as vol. XVI plate 24, and was duplicated in class 26, the "six-petal'd incompleat flowers without cups", as vol. XXV plate 19.)

Table 4. **Sir John Hill's classification of plants**

Source: *Vegetable System*, vol. 2, p.45.

NB Chives = anthers; pointal = ovary & stigma.

Herbs bearing flowers.		
Visible.		
Assembled together in a common cup		
With united chives:		
Corollae tubulated	**Class 1.**	Florets
Corollae tongued	**Class 2.**	Semiflorets
Corollae radiated	**Class 3.**	Radiates
With distinct chives	**Class 4.**	Associates
Assembled in a distinct cup, forming a head or ball:	**Class 5.**	Aggregates
Separate, on pedicles issuing from one point:	**Class 6.**	Umbrellas
Separate, springing from various points:		
Perfect, i.e. Chives and pointal in the same flower, or separate on the same plant		
Compleat, viz. furnished with both cup and petal		
Regular.		
1 petal	**Class 7.**	One-petal'd
2 petals	**Class 8.**	Two-petal'd
3 petals	**Class 9.**	Three-petal'd
4 petals	**Class 10.**	Four-petal'd
5 petals	**Class 11.**	Five-petal'd
6 petals	**Class 12.**	Six-petal'd
Many petals	**Class 13.**	Many-petal'd
Irregular.		
1 petal	**Class 14.**	One-petal'd
2 petals	**Class 15.**	Two-petal'd
3 petals	**Class 16.**	Three-petal'd
4 petals	**Class 17.**	Four-petal'd
5 petals	**Class 18.**	Five-petal'd
6 petals	**Class 19.**	Six-petal'd
Many petals	**Class 20.**	Many-petal'd

Table 4. **Sir John Hill's classification of plants (cont.)**

Incompleat, viz. only cup or petal, or neither		
With petals without cup.		
1 petal	**Class 21.**	One-petal'd
2 petals	**Class 22.**	Two-petal'd
3 petals	**Class 23.**	Three-petal'd
4 petals	**Class 24.**	Four-petal'd
5 petals	**Class 25.**	Five-petal'd
6 petals	**Class 26.**	Six-petal'd
Many petals	**Class 27.**	Many-petal'd
With cups without petals.		
Of 1 leaf	**Class 28.**	One-leav'd
2 leaves	**Class 29.**	Two-leav'd
3 leaves	**Class 30.**	Three-leav'd
4 leaves	**Class 31.**	Four-leav'd
5 leaves	**Class 32.**	Five-leav'd
6 leaves	**Class 33.**	Six-leav'd
7 leaves	**Class 34.**	Seven-leav'd
8 leaves	**Class 35.**	Eight-leav'd
Neither cup nor petal,		
But a husk	**Class 36.**	Chaffy
Only chives & pointal	**Class 37.**	Thready
Imperfect, viz. Chives on one plant, pointal on the other		
Chives alone	**Class 38.**	Chive-flowers
Pointals alone	**Class 39.**	Pointal-flowers
Invisible to the naked eye.		
Terrestrial		
With leaves	**Class 40.**	Ferns
With articulated scales	**Class 41.**	Mosses
With no sort of leaf, scale &c	**Class 42.**	Mushrooms
Sea-plants	**Class 43.**	Marines
Trees, shrubs, and undershrubs		

Table 5. **Comparison of Hill's classes with those of Linnaeus and currently accepted families**

NB The Vegetable System only covers the first 34 of Hill's classes, and includes no representatives of classes 20, 22, or 30.

Hill's class	Hill's name	Linnaean class	Modern family
Class 1.	Florets	Syngenesia	Asteraceae
Class 2.	Semiflorets	Syngenesia	Asteraceae
Class 3.	Radiates	Syngenesia	Asteraceae
Class 4.	Associates	Syngenesia	Asteraceae: Cardueae
Class 5.	Aggregates	Tetrandria, Pentandria, Syngenesia (*Echinops*)	Araliaceae, Caprifoliaceae, Plantaginaceae
Class 6.	Umbrellas	Pentandria	Apiaceae
Class 7.	Compleat, regular, one-petal'd	Tetrandria, Pentandria, Hexandria, Decandria, Icosandria (*Mesembryanthemum*), Monoecia	Aiozaceae, Boraginaceae, Bromeliaceae, Campanulaceae, Convolvulaceae, Cucurbitaceae, Ericaceae, Primulaceae, & various others
Class 8.	… two-petal'd	Monandria, Diandria, Monoecia	Plantaginaceae, Onagraceae, Amaranthaceae
Class 9.	… three-petal'd	Hexandria	Amaryllidaceae (*Galanthus*), Melanthiaceae (*Trillium*), Polygonaceae (*Rumex*)
Class 10.	… four-petal'd	Tetrandria, Octandria, Dodecandria, Polyandria, Tetradynamia	Mostly Cruciferae, with some Onagraceae, Brassicaceae, etc.
Class 11.	… five-petal'd	Triandria, Tetrandria, Pentandria, Decandria, Icosandria, Polyandria, Monadelphia, Polyadelphia	Cistaceae, Malvaceae, Plantaginaceae, Ranunculaceae, some Rosaceae (*Potentilla*, *Geum*)
Class 12.	… six-petal'd	Dodecandria, Polyandria	Papaveraceae, Lythraceae, Resedaceae
Class 13.	… many-petal'd	Pentandria, Icosandria, Polyandria	Cactaceae, Crassulaceae, Nymphaeaceae, and some stray Ranunculaceae (*Atragene* = *Clematis*)

Table 5. **Comparison of Hill's classes (cont.)**

Hill's class	Hill's name	Linnaean class	Modern family
Class 14.	Compleat, irregular, one-petal'd	Monandria, Diandria, Didynamia, Syngenesia	Lamiaceae and Scrophulariaceae, with significant clumps of Acanthaceae, Campanulaceae, Cannaceae, Zingiberaceae, etc.
Class 15.	… two-petal'd	Gynandria	Orchidaceae (*Cypripedium*)
Class 16.	… three-petal'd	Monandria	Costaceae
Class 17.	… four-petal'd	Diadelphia	Fabaceae
Class 18.	… five-petal'd	Octandria, Decandria, Syngenesia	Balsaminaceae, Violaceae, etc.
Class 19.	… six-petal'd	Triandria	Commelinaceae
Class 21.	Incompleat, without cup but with petals, one-petal'd	Triandria, Hexandria, Octandria, Polygamia, Gynandria	Asphodelaceae, Hyacinthaceae, Iridaceae, Polygonaceae
Class 23.	… three-petal'd	Monoecia	Sparganiaceae (*Sparganium*)
Class 24.	… four-petal'd	Tetrandria, Polyandria	Potamogetonaceae, Ranunculaceae
Class 25.	… five-petal'd	Polyandria, Gynandria	Orchidaceae, Ranunculaceae
Class 26.	… six-petal'd	Hexandria	Alliaceae, Amaryllidaceae, Liliaceae
Class 27.	… many-petal'd	Polyandria	Ranunculaceae (*Anemone*)
Class 28.	Incompleat, with cup but without petals, one-leav'd	Monandria, Pentandria, Gynandria, Polygamia, etc.	Araceae & a smattering of others
Class 29.	… two-leav'd	Diandria	Piperaceae
Class 31.	… four-leav'd	Monoecia	Urticaceae
Class 32.	… five-leav'd	Pentandria, Monoecia, Polygamia	Amaranthaceae, Caryophyllaceae
Class 33.	… six-leav'd	Enneandria	Polygonaceae (*Rheum*)
Class 34.	… seven-leav'd	Dioecia	Dioscoreaceae, Hydro-charitaceae, Smilacaceae

Hill on hybrids

In vol. V, pp. 53–54, there is a digression about hybrids or mules, which neither Roberts nor Zirkle noticed in their surveys of pre-Mendelian literature on the subject. Hill began by describing a curious scabious, to which he assigned the Latin name *Acura* (English: Harp'd Needle-weed) without any specific epithet. He then speculated that his plant had a hybrid origin:

> If I had known such a Plant before, or if any author had described such a one, it would not have appeared very wonderful to me, that it should appear a second year from sowing, though not the first; for a very little practice in gardening, will show how apt Seeds are to lie dormant a longer time than that: but as I know of no such Plant, and as it appeared only a second season; and most of all, as it seems to me in its aspect an unnatural Plant, I have suspicions that it is a Mongrel or Mulish Plant, produced between the flat Eryngio, and some one of the Scabious's.

Scabiosa and an *Eryngium* fell into the same class in Hill's system, and indeed the plates for *Eryngium* followed before long in this volume, but today *Scabiosa* falls into *Caprifoliaceae* and *Eryngium* into *Apiaceae/ Umbelliferae*, so his suggested genealogy may be dismissed. The plant would probably today be treated as a sport. However, more important than the origin of this particular plant is the speculation about hybridisation that Hill then launched into:

> We know these mixtures sometimes happen among Plants; perhaps they are more frequent than we are aware. In general, the Plants thus produced are soon lost, because their Seeds will not grow; but this is not always the case. I have been told that the Dittany produced between the Sypline and Cretan, produces Seeds which sometimes vegetate; and I can speak with certainty of a Plant between the Welch Veronica and the common kind, of which I have many Plants now raised from Seed, and living.
>
> We are not now to learn that a Mulish Plant may be produced between two Plants of different Genera; but as the mixture is less regular, perhaps it is a law of nature, that the Seeds of such shall not grow;

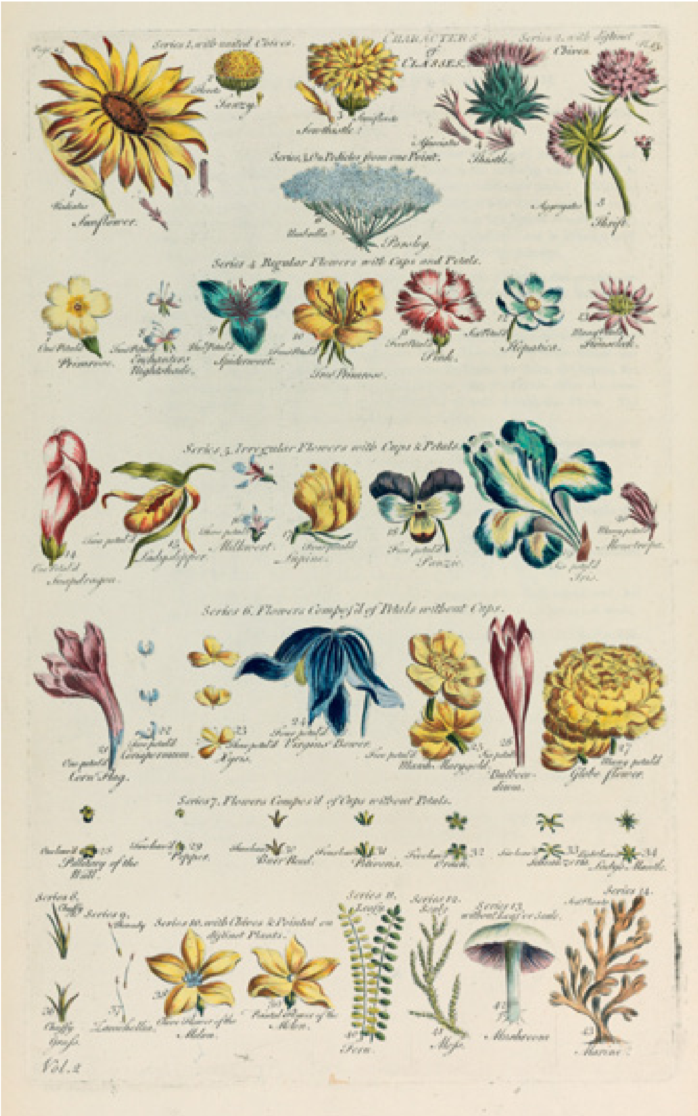

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Fig. 6. **Hill, *Vegetable System*, vol. 2 (1761) plate 13: Characters of classes in Hill's system.**

> we speak much in the dark of these things; for they want much, and have had yet very little observation; but from what I have yet seen, I think it will be found that among Mulish Plants, the Seeds of such as are produced between two species of the same Genus, will sometimes, though but seldom, grow; and that by degrees, the new offspring will lose all that it had of likeness to the female, and become the same with the male Plant entirely: on the contrary, that such of the Mulish Plants, as are produced from a male Plant of one Genus, and a Female of another truly distinct, never produce Seeds that will vegetate, however fair they may look, and that by these means, when the individuals so produced perish, the new Plant is for that time lost.

Hill concluded by promising an experimental study of mules, but either his results were inconclusive, or he never got around to publishing them.

The importance of this passage lies in its suggestion that natural hybridisation was a normal state of affairs, and taking place all around us. Half a century had passed since Fairchild's Mule had been produced, and the reality of hybridisation made incontestable; but all known examples up to that time had a garden origin. Hill's theory was based on a bad example; he was misled in his assessment of possible parentage by the inadequacy of his own system of classification, which grouped taxonomically disparate genera together; his confident assertion of ready hybridisation across generic boundaries was wide of the mark. If his theory had received greater attention it would fairly quickly have been dismissed by the botanical world, at least once natural classification had become the norm. But it must stand as one of the earliest pronouncements on the subject of natural hybridisation, eccentric but interesting, an indication of a road not followed until generations later.

Hill on geographical distribution

Again in vol. V, pp. 13–17, following the end of the entry for *Xanthium*, there is a long digression about American plants and their geographical distribution.

> America furnished us so many new Plants, and we received from thence so little that bore even a resemblance to what we had before

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Fig. 7. **Hill, *Vegetable System*, vol. 23 (1773) plate 5 (detail): Characters of the 21st class (incomplete, with single petal but without cup).**

> in Europe, that imagination, which always outruns judgment, and in its rash haste, generally concludes upon too slight premises, presently declared that there was no Plant common to the new world, as it is called, and the old. …
>
> Farther researches have shewn, that howsoever different the climate may be in Europe and in Asia, yet there are Plants common to both. I have received this Xanthium from China; and Linnaeus declares it native of Ceylon, and of Japan. The Common English Water Lilly, both the white and yellow, grow also in the East-Indies; and the Common Arrowhead, is as frequent in Sumatra as in England…
>
> It should seem in the first place, that there are a number of universal Plants, which grow in every kingdom; and are Vegetables of the Globe, not of this or that quarter of it. … no part of the world has altogether distinct Plants from all others. The Alpine Plants are common to the high mountains, and the underwater Plants to the deep Lakes of Europe, Asia, Africa, and America.

Hill later offered various suggestions to explain the movement of plants:

> Why should it be thought strange a Plant should travel by its Seeds from 73 degrees to 50. We know the great opportunities there are of conveyance by winds and sea; we are sensible that the quantity of Seeds produced by Plants is so great, that if out of ten thousand, one only shall live, the Plant will be preserved, and propagate itself where that shall fall.

Continental drift was, of course, far from his mind, and although his argument seemed open to the idea of pandemic weed spread through human agency, he did not develop it. But his most interesting suggestion was not the simple assertion of an identity of certain plants around the world, but the correlation of plant groups with environmental conditions.

> There is a certain tract about the North Pole, wherein, for the whole circuit, the same Plants are found; perhaps it is the same about the South Pole, but the country is unknown. As it is hard to say how far

> North America extends, or what are the limits where it joins, if it does join, with other northern countries… in a certain latitude, that difference between American and European Plants, which has been fancied so absolute, ceases entirely…
>
> In the Latitude of 83, which is as far as men have sailed, we find Mosses only; the Conferva in the waters; the Ulva in the boggs; the Coralloide Mosses on dry land; these are the simplest of all Plants; and these only are found at that extream North distance, whatever the country… In the Latitude of 82, which is but a very small advance from that most Northern part just mentioned, are found Strawberries. They are found every where round the Pole at this distance.
>
> But this is not all: there are many other Plants which take in larger circles, at more distance, and yet are equally, and as certainly universal. The common Violet is found on the coasts of Baffins Bay, in Greenland, in Nova Zembla, and in Muscovitic Tartary, in the Latitude of 76. This is a Circle, in all parts of which, I doubt not, Violets are found, as we see them in so many places there, and those so distant.

It would be wishful thinking to see here an anticipation of Humboldt and the later science of geographical distribution, but the idea that plant form can be influenced by adaptation to climatic conditions was certainly present in Hill's argument. As with hybridisation, there were nascent ideas in the *Vegetable System* that might have had a beneficial effect on botany had the work been better known and attended to.

Stafleu concluded a brief discussion of Hill by saying that:

> The *Vegetable System* is of great importance because it gave for the first time in the vernacular a comprehensive treatment of the plant kingdom, on a lavish scale and with coloured illustrations, adopting the Linnaean generic names and introducing binary nomenclature (Stafleu, 1971: 210).

All this is true, but there is more to be said in favour of Hill, from a less narrowly Linnaean perspective. His text remains a fascinating period piece from the taxonomic and nomenclatural points of view; it contained important speculations about hybridisation and geographical distribution; and in its attempted coverage of the plant kingdom, it provides a useful source of information about the plants that could be seen, in botanic gardens at least, in the second quarter of the eighteenth century.

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Volume 6 will mark the centenary of the Rock Garden at Wisley, and examine the rock garden in the twentieth century.

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