XXIV

THE BEGINNING OF THE END

1650–1705

RAY, THE SON of a village blacksmith, is the final protagonist in this story. He was just five years old when Thomas Johnson brought out his edition of Gerard's *Herball*, twelve when John Parkinson published his *Theatrum botanicum*, seventeen when Johnson died in the Siege of Basing House. After a lifetime of study and observation, John Ray (see plate 147), solitary, modest, principled, persistent, was the man who, two years before his death in 1705, provided the means to answer Theophrastus's second question.[1] His Six Rules for Classification finally showed how future scholars must proceed in this ever more complex investigation.[2] In a series of propositions, carefully revised over more than twenty years, he set out his principles for a method of classification that could embrace not only the known plants of Europe but also the vast numbers of plants from the tropics and the New World that were now finding their way to England. In an age badly infected with astrological absurdities, he understood that the study of plants should not be tied to magic, but could in itself be a profound and philosophical discipline. Once 'one of the handmaids of physick' as William Coles described it in 1656, the study of plants had now outgrown this constraint. Like Theophrastus, Ray understood that a method (and method had to come before system) was only likely to be valid if it was suggested by the plants themselves, not imposed upon them. Like Theophrastus, he looked for innate similarities, distinct differences, the most important characteristics of the plants he surveyed. Though fully acknowledging the achievements of both Cesalpino and Lobelius, he saw that their systems had

foundered because both had relied on a single characteristic to delineate their various groups of plants. They had forced the plant to fit one over-riding idea, rather than allowing the idea to arise naturally from the plant. Lobelius had tried leaf form, Cesalpino was closer to a valid scheme in fixing on seed and fruit as the defining features. In his *Pinax theatri botanici* of 1623, Gaspard Bauhin, professor of medicine at Basel, had already set out the different synonyms attached to plants, made a choice between them, introduced more compact descriptions, and tried to stem the prevailing tendency to long plant names – *Lilium montanum rubrum praecox* (an early red lily generally found in mountains), *Jasminum indicum flore rubro et variegato* (a jasmine from the Indies with flowers that can be either red or striped) – names that described rather than denoted. Bauhin used the binary system of nomenclature with a great degree of consistency: a generic name (a kind of surname), followed by a specific epithet which becomes the distinguishing mark, as our own Christian names are. That was a great advance, a preliminary clearing of the jungle for subsequent explorers such as John Ray. But like all those who had gone before him, Ray was hampered by the lack of a specific vocabulary to describe and evaluate plants. There was still no word, for instance, to describe such a simple concept as 'petal'. It was John Ray who, from Fabio Colonna's notes on Hernandez's *Rerum medicarum Novae Hispanicae thesaurus* (1649), took the suggestion that 'flower leaves' as they were called, could be distinguished from true leaves by a new term taken from the Greek *petalon*. Then, in 1682, the year that Ray published his first thoughts on the correct classification of plants,[3] his contemporary Nehemiah Grew made a huge leap forward with the startling suggestion that the stamens of a flower were in fact male sexual organs. Cesalpino had called them *flocci* and thought they must be the means by which plants breathed. Subsequent writers had frequently described stamens and stigma – Gerard, for instance, had noted the centre of the potato flower and its 'pointell, yellow as golde, with a small sharpe greene pricke or point in the middest thereof' – but nobody had given them names before and nobody before Grew had worked out their significance. But where Grew exploded like a rocket, scattering unconnected bright stars of insight randomly over the universe, Ray's intellect burned more discreetly, more methodically, less showily perhaps but in the end to greater purpose.

John Ray was unusual in that he became a plantsman not because he had trained as a physician or an apothecary or pharmacologist, but because of a deep, quietly passionate response to the beauties of the natural world. At Cambridge, where he arrived with a scholarship in 1644, he studied theology and made himself a master of Hebrew and Latin composition. Like William Turner before him, he searched in vain for a mentor who might teach him something about plants. And like Turner,

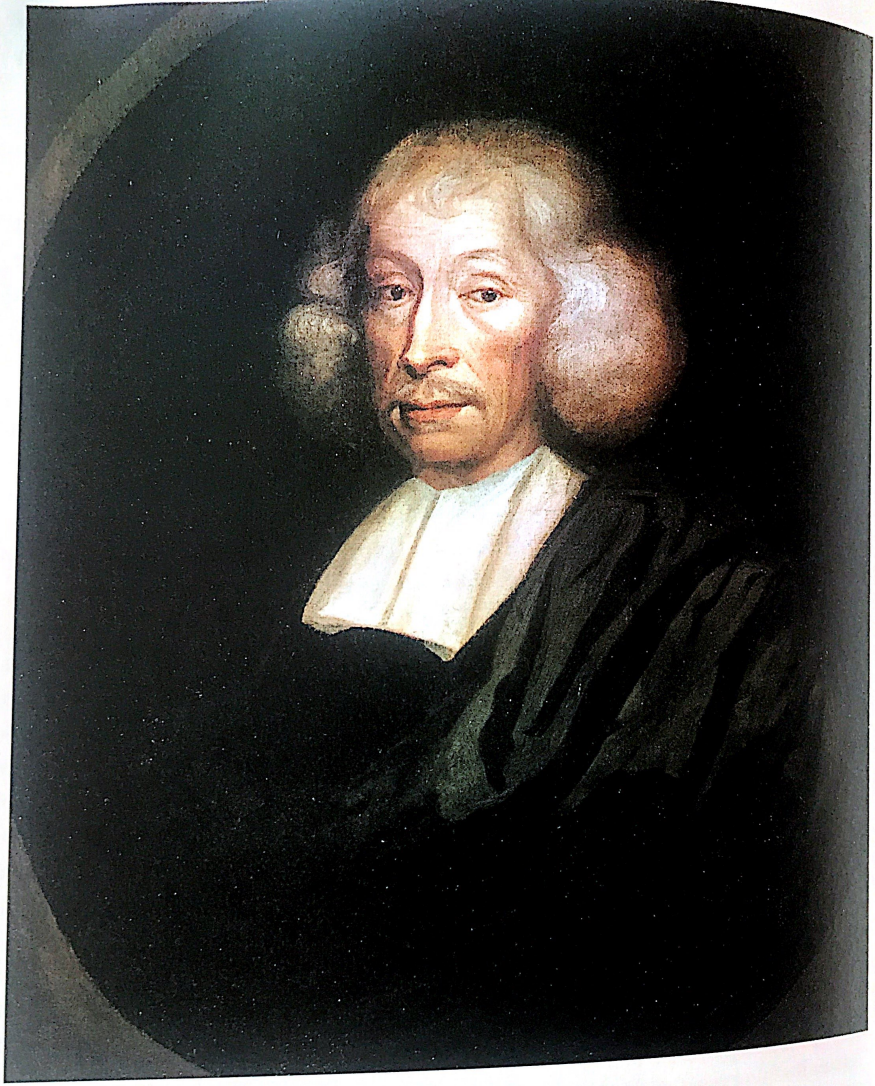


Plate 147: The English plantsman John Ray (1627–1705), whose Synopsis methodica *of 1690 laid down the rules for a modern system of nomenclature*

he was largely self-taught. 'I had been ill, physically and mentally,' he writes in the Preface to his first book, the *Catalogus plantarum circa Cantabrigiam nascentium* of 1660, 'and was forced to rest from more serious studies, and to spend my time in riding or walking. I had leisure in the course of my journeys to contemplate the varied beauty of plants and the cunning craftsmanship of Nature that was constantly before my eyes, and had so often been thoughtlessly trodden underfoot. First I was fascinated and absorbed by the rich spectacle of the meadows in spring-time; then I was filled with wonder and delight by the marvellous shape, colour and structure of particular plants. While my eyes feasted on these sights, my mind too was stimulated. I became inspired with a passion for plants.'[4]

With his Cambridge *Catalogus*, Ray finally achieved what Thomas Johnson had set out to do twenty years previously. Johnson's purpose had been to publish a series of books listing and describing the plants that grew in the different areas of England. His expedition to Kent in 1629 was the first English journey ever undertaken with the specific purpose of recording plants. His death in the Civil War left a gap that took a long time to fill. Johnson, though, could not have wished for a better successor than Ray, who, before publishing his list, spent six years plant-hunting in the fields and fens around Cambridge; another three years passed as he put the resulting material in order. He had hopes that his 'little book' would encourage others to make similar surveys of their own localities. United, these would then give a complete picture of all the plants in Britain. 'I should like to enter a plea', he wrote, 'that men of University standing to whom God has given leisure and a suitable education and intelligence, should spare a brief interval from other pursuits, and, without in any way neglecting their other studies, that they should develop the habit of examining Nature, and compile a comprehensive account of its creatures so that they can begin to gain wisdom by their own experience rather than from somebody else's brain, and learn to read the leaves of plants and interpret the characters impressed on flowers and seeds.'[5]

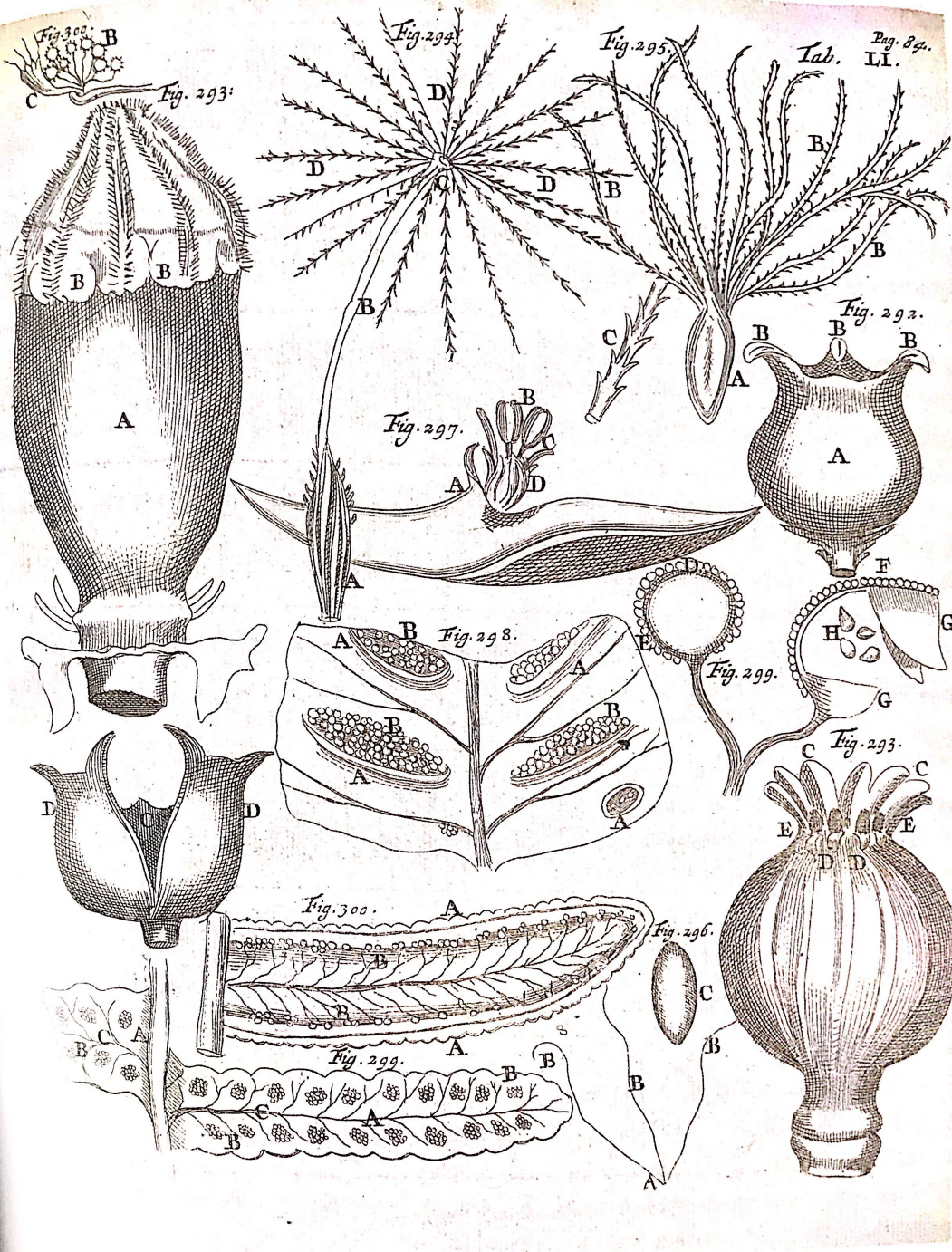
Ray's purpose in his Cambridge *Catalogus* was to identify and describe plants, rather than to arrange or order them. In this first book, he set out his plants in alphabetical order, not because he thought that was the best way to organise them, but because he had not yet worked out any better method. At the end of his list (it finished with the plant he called *Xyris* and which we call *Iris foetidissima*, the gladdon or stinking iris) he included an Outline Classification, almost identical to the one that Jean Bauhin, elder brother of Gaspard, had laid out in his *Historia plantarum universalis* published posthumously in 1650. Jean Bauhin had trained at Tübingen under Leonhart Fuchs and later at Montpellier under Rondelet; though his scheme presented difficulties, Ray was not alone in considering him 'the Prince of Herbarists'.

Following Bauhin, in a fundamental division that had remained unchanged since Theophrastus, Ray splits the plant world into trees, shrubs, sub-shrubs and herbs. He points out that trees could be evergreen or deciduous and then, taking their fruit as the defining characteristic (as Cesalpino had done) divides them into eight groups: *Pomiferae*, which bore fruit without stones (apple, lemon, fig, pomegranate etc.); *Pruniferae*, which bore fruit with a stone (plum, peach, date, olive etc.); *Nuciferae*, which bore nuts (walnut, chestnut, hazel, nutmeg, pistachio etc.); *Bacciferae*, which bore berries (laurel, mulberry, juniper, box, myrtle, elder etc.); *Glandiferae*, which bore acorns (oak, ilex, beech); *Coniferae*, which bore cones (pine, fir, larch, cypress, cedar etc.); *Siliquosae*, which bore their fruit in pods (laburnum, Judas tree, cassia etc.); and then, at the end, the difficult ragbag containing trees such as birch, willow, ash, elm and lime that did not fit neatly into any of the other categories. Shrubs he disposes of very quickly, dividing them merely into those with thorns (berberis, buckthorn, gooseberry etc.) and those without (broom, jasmine, privet etc.). He understands how unsatisfactory this is and hints at other possible divisions: shrubs that flower, shrubs that bear fruit, shrubs that climb. Nowhere does he admit groups based on *accidentia* such as scent or taste. The sub-shrubs can be lumped together into one group, as they are mostly aromatic garden plants such as lavender, wormwood, hyssop, savory and sage. Herbaceous plants, being so numerous, are the most difficult to sort. It was, as he acknowledged, difficult if not impossible to arrange them 'so that no plant belongs to more than one class, or is classified ambiguously'. The pack could be dealt in many different ways, but for the moment, Ray follows Bauhin in proposing twenty-two groups, some defined by their roots, some by the form of their leaves, some by flower, some by usage, others by habitat.

By the time the *Catalogus* was published, Ray was well established in his Cambridge life. He had been appointed as a tutor at Trinity in 1653, where he lectured on Greek, mathematics and humanities. He had begun the series of long summer journeys in search of plants which he undertook in the company of similarly minded friends such as his young patron, Sir Francis Willughby (1635–1672), the heir to extensive estates in the Midlands. On 23 December 1660, Ray was ordained. A comfortable life stretched ahead of him: paid employment, secure lodgings, good libraries, social status, the company of men with whom he could discuss the pioneering work in which he was engaged. But on 24 August 1662, he forfeited his Fellowship and all the comforts it promised. Proud, independent, moral, principled in a way that is scarcely understood in our less honourable age, he found himself unable to take the oath required by the Act of Uniformity that Charles II had brought in at the Restoration. Both in a spiritual and an intellectual sense, he was a man of the Commonwealth and, rather than giving lip service to an Act of which he

disapproved, he resigned from Trinity and left Cambridge, his home for the past eighteen years. For the next seventeen years, he was effectively without a base, relying on the kindness of friends such as Willughby who, at his Middleton estate, provided as much of a home as Ray could call on. Only in 1679, after the death of his mother, did he move to the house that he had built for her at Black Notley, the Essex village in which he himself had been born. Called Dewlands, it is commemorated now only in the name of a close of modern brick houses leading off the main street through the village. Close by the village hall, a Millennium Green has been dedicated to Ray's memory. Though his picture is already fading from the information board, oak and hornbeam, poplar and ash, white campion, creeping buttercup, tufted vetch and cranesbill flourish in the grass. The forge and adjoining cottage, Ray's birthplace, stand on the northern edge of this scattered village, a couple of fields away from the small flint church with its shingled spire.

Free of Cambridge, Ray intended, he wrote, to cast himself 'upon Providence and good friends'.[6] Providence, aided by his good friend Willughby, almost immediately afforded him the opportunity of a Continental tour through the Low Countries, Germany, Italy and France, which occupied the next three years. Leaving Dover on 18 April 1663, Willughby and Ray went by way of Calais and Dunkirk to Ostend. From there they moved on to Rotterdam, Delft, Haarlem and Amsterdam. In Germany they 'first began to have feather-beds laid upon us instead of blankets' and travelled up the Rhine 'in a boat drawn by men'. They went to Heidelberg, Strasbourg, Basel, Zurich, Munich and Augsburg, by boat to Vienna, then by coach to Venice, the coachman hiring 'ten oxen to draw his coach to the top of the hills'. From Venice they went to Padua, where Ray attended anatomy lectures at the university. Then they moved on to Ferrara and Bologna, where they visited Aldrovandi's famous museum. They missed the great Marcello Malpighi, lecturer at the university, whose illustrations of plants (see plates 149 and 157), showing their anatomy in unprecedented detail, were published just five years after Ray returned to England. Via Parma, they went to Milan, Turin and Genoa, then on to Lucca and Pisa. They sailed to Naples, and climbed Vesuvius, where Pliny had lost his life in AD 79. From Naples, Willughby returned to England, where on 4 January 1665, he gave a report of the journey to the Royal Society. Ray went on to Sicily, Malta, and then to Salerno, site of the famous medical school. In Florence, an English doctor, John Kirton, treated him with cucumber pulp for a fever. On 1 September he started for Rome, where he stayed until the following January. Then, crossing the Apennines, he went by way of Bologna, back to Venice and from there on to Trent, Lucerne, Berne, Lausanne, and Geneva where he arrived on 20 April 1665. By late July he was in France, visiting Lyons, Avignon and Montpellier, still a centre of intellectual life, still a magnet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for English scholars. Pierre Magnol, successor to the great Rondelet at Montpellier, impressed Ray greatly and he might have stayed longer at the university had not Louis XIV ordered all Englishmen to leave France within three months. On 26 February 1666, Ray left Montpellier for Paris and got finally to the ferry at Calais, travelling from the capital in a fish cart.

The Royal Society, founded to promote research in the sciences, provided to some extent a new fulcrum for Ray's intellectual life. Formally set up in 1660, it had its origins in the Oxford Philosophical Society and a nucleus of men with enquiring minds who had met regularly in London since 1645. The Society offered its members a meeting place, the opportunity for regular discussion and debate, a vehicle for the publication of research (its magazine *Philosophical Transactions* appeared on the first Monday of each month). John Evelyn and Ray's friend Sir Francis Willughby were founder members, Samuel Pepys its president. The Society encouraged a direct approach to the natural sciences, insisted on studies in the field. It embraced astronomy, chemistry, engineering, mathematics, physics, physiology, as well as the study of plants and animals. The 200 members were mostly gentlemen rather than players, too few of them capable of initiating work of real worth; they needed John Ray, who was elected to the Society on 7 November 1667. In accordance with the rule that required members 'to entertain the Society once a year with a discourse grounded upon experiment', Ray sent his 'Discourse on the Seeds of Plants' and 'The Specific Differences of Plants' to the Society on 30 November 1674. He apologised for his first paper being 'inchoate and imperfect', explaining that he hoped in the following year 'to prosecute and perfect' his plan 'of distinguishing plants by the content of the seed'.[7] Nehemiah Grew (see plate 150), who had been working on the structure of plants since 1664, had already in May 1671 submitted a paper on 'The Anatomy of Vegetables Begun' to the Society.

The first draft of Ray's thoughts on plant species and the differences between them had appeared in the Preface to his *Observations and Catalogus Stirpium in Exteris Regionibus* (1673), an account of the plants he had seen on his European travels ten years previously. 'Whether my readers will enjoy these bare lists of names, I do not know,' he wrote. 'To me to gaze at the plants themselves freely growing on the lavish bosom of mother earth was an unbelievable delight; I can say with Clusius that I was as pleased to find for the first time a new plant as if I had received a fortune; to discover very many daily that were unknown to me and strangers to our Britain was an ample reward for travel.'[8] The Alps had been particularly satisfying. But the paper presented a year later to the Society crystallised even more cogently his argument for fixing different species. 'Having observed', he writes in his paper, 'that most herbarists, mistaking many accidents for notes of specific

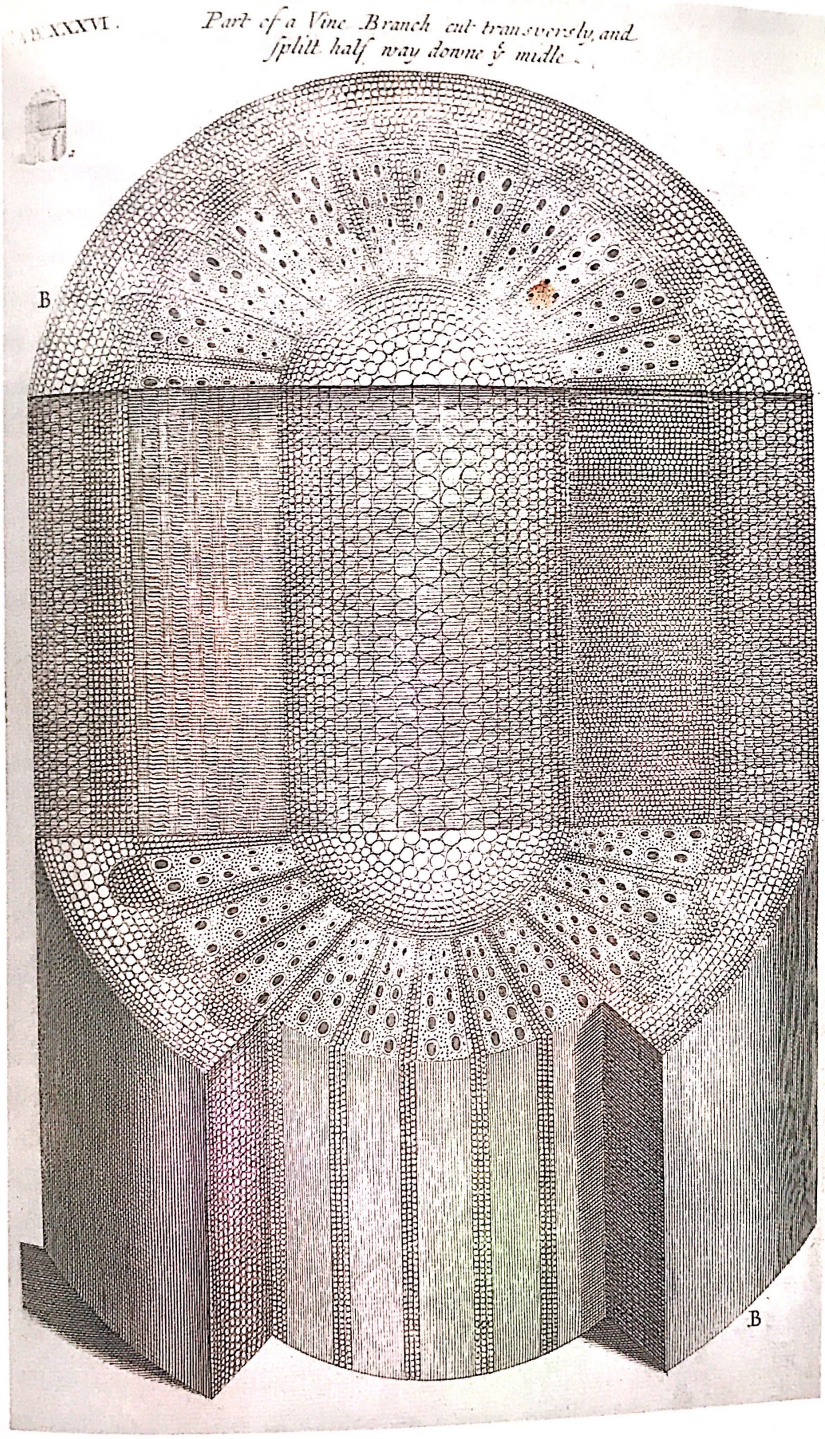

Plate 150: 'Part of a vine branch cut transversely, and splitt half way downe ye midle', one of the illustrations in The Anatomy of Plants *(1682) by Nehemiah Grew*

distinction, which indeed they are not, have unnecessarily multiplied beings, contrary to that well known philosophic precept; I think it may not be unuseful, in order to the determining of the number of species more certainly and agreeably to nature, to enumerate such accidents and then give my reasons why I judge them not sufficient to infer a specific difference.' We are back with the all important difference between *substantia* and *accidentia* debated at length by Andrea Cesalpino. The vast numbers of new flowers – anemones, ranunculus, auriculas – now being raised by enthusiastic gardeners, were in danger of swamping such systems as presently existed. Some scholars made a species out of each new arrival, a tulip flamed more outrageously than another, a ranunculus of a different colour from its predecessors. A good proportion of the 6,000 plants listed by Gaspard Bauhin in his *Pinax theatri botanici* (1623) were no more than varieties of existing species, though the concept of a variety was only slowly beginning to be understood. Ray saw that the rush by some plantsmen to ascribe new species names to each slightly modified flower had to be stopped. Differences in size, scent, taste, colour, the doubling of a flower, the variegation of a leaf, were not in themselves characteristics of sufficient importance to determine a separate species. 'God having finished his work of creation', he believed (and it was then a staple of Christian belief) that the number of species is 'in nature fixed and determinate'. Though it was possible that a species might have been lost, it was, he argued in that optimistic age, 'highly improbable'. They could be found, of course – no age had found more – but they could not be made.

During his long journey through Europe, Ray had seen and noted more wild plants growing in their native habitats than any other man in England. The dried plants he collected at that time and sewed on sheets of paper fill twenty large books.[9] No one perhaps was better equipped to find a method of organising them into a system. Method was the key and Ray was in no hurry to rush into print. Writing earlier to his friend Martin Lister, whom he had first met at Montpellier, he had resolved 'never to put out anything which is not as perfect as possible for me to make it'.[10] Nine years after his preliminary notes in the Preface to his *Observations*, and now with a settled, permanent home in Black Notley, Ray brought out his *Methodus plantarum nova*. 'Nothing is more helpful to clear understanding, prompt recognition and sound memory than a well ordered arrangement into classes, primary and subordinate,' he wrote in the Preface.

> But I would not have my readers expect something perfect or complete; something which would divide all plants so exactly as to include every species without leaving any in positions anomalous or peculiar; something which would so define each genus by its own characteristics that no species be left, so to speak, homeless or be found

Plate 151: The exotic produce – bananas, pineapples, coconuts – of a market stall in the East Indies, painted in the mid-seventeenth century by Albert Eckhout

> common to many genera. Nature does not permit anything of the sort. Nature, as the saying goes, makes no jumps and passes from extreme to extreme only through a mean. She always produces species intermediate between higher and lower types, species of doubtful classification linking one type with another and having something in common with both . . . In any case I dare not promise even so perfect a Method as Nature permits – that is not the task of one man or of one age – but only such as I can accomplish in my present circumstances; and these are not too favourable.[11]

As well as showing, way ahead of Darwin, that he grasped the concept of the evolution of species, Ray reviews the three possible ways in which plants might be grouped and sorted: by habitat, by use or 'from the likeness and agreement of the principal parts'. Our concerns in the twenty-first century make sorting by habitat an attractive option. But, in the very different parameters of the late seventeenth century, Ray rejects the first two options because they separated plants that were obviously alike and united those which had equally obvious differences. He pays a generous tribute to Andrea Cesalpino 'the first so far as I know to classify plants by the number of seeds and seed-vessels developed from each flower', but gives cogent reasons why he cannot agree wholeheartedly with his method: the form of the flower, the corolla and calyx must also be taken into account. He is too modest to suppose that his own new Method can be comprehensive, for he understands that thousands of plants are not yet known or described. The third of Ray's introductory essays deals with the structure of the seed and its embryo. He makes a seminal distinction between plants such as the lily, whose seeds produce seedlings with one leaf, and those such as mustard or cress, which sprout with two. The two different groups acquired names – monocotyledon and dicotyledon – still in use today. Lobelius had arrived at a similar distinction when he differentiated beteen plants whose leaves had long thin parallel veins, like those of the grasses, and those whose leaves were netted all over with veins leading to a central, strong midrib. But Ray knew that the outward appearance of a plant's leaves did not provide a strong enough foundation for the method he was seeking. The distinction between the two types of embryo he described put the difference on a more profound footing. It is as valid today as it was in 1682. He sees that the traditional divisions of trees, shrubs, sub-shrubs and herbs, are 'popular and accidental rather than accurate and philosophical' but accepts the customary usage, though he abandons sub-shrubs as a separate section. He divides trees into eight classes, shrubs into six (an improvement on the previous cursory separation into spiny and non-spiny). Herbs, always a problem, have expanded from the twenty-two classes listed in the Cambridge *Catalogus* to an unwieldy forty-seven. Only Nehemiah Grew, Secretary of the Royal Society by

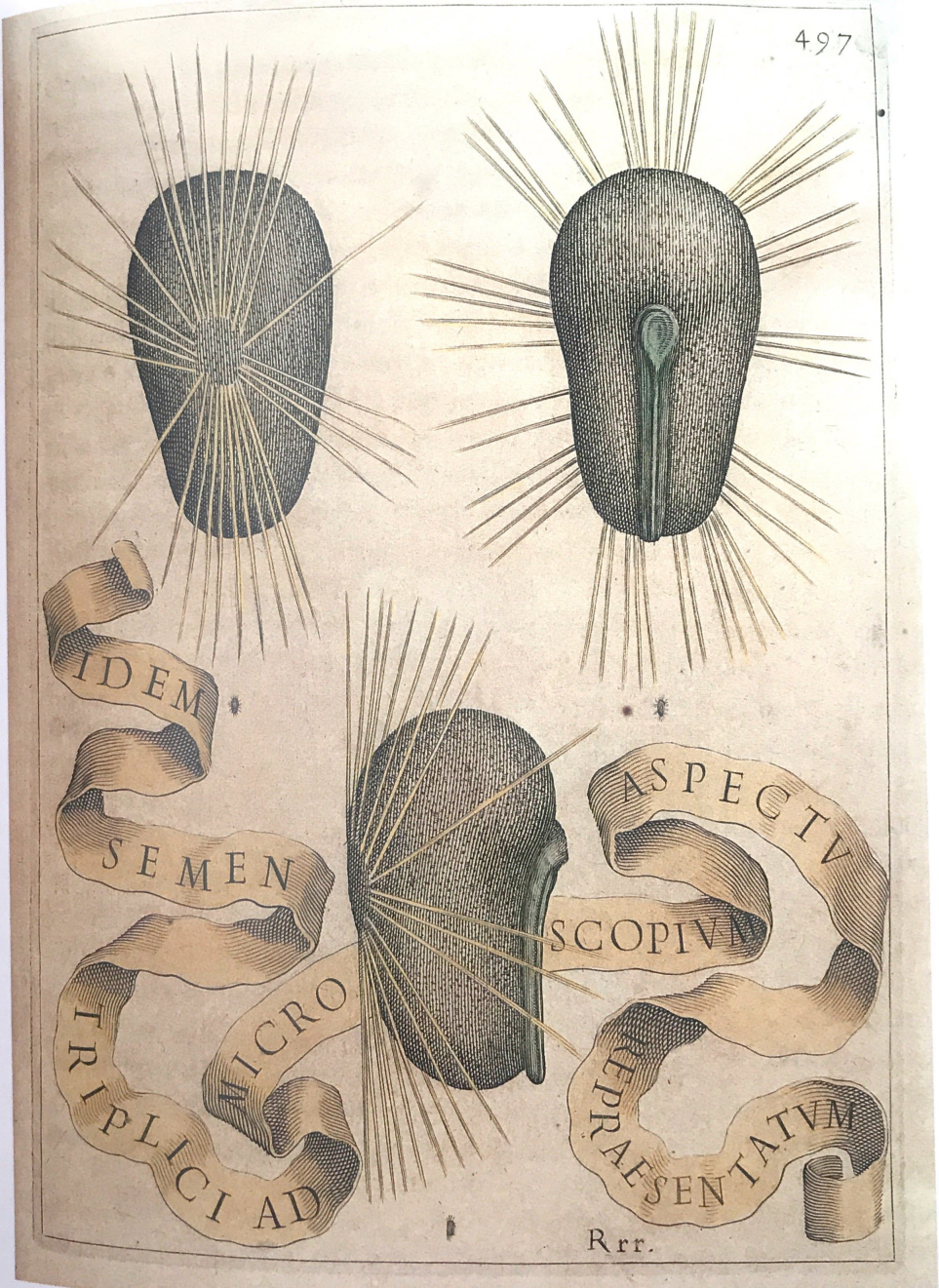

Plate 152: Three different views of an hibiscus seed, seen through the magnifying lens of a microscope. From Giovanni Battista Ferrari's Flora, *published in Rome in 1638*

1677, came anywhere near Ray in effecting a sound method of sorting plants into coherent groups. Grew, though, was still using the colour of a flower or the number of its petals as a basis for classification, characteristics which Ray had expressly dismissed as *accidentia*. Unlike Grew, Ray was working alone, unsupported by the facilities of a university or botanic garden, under conditions which, as he himself acknowledged, were 'not too favourable'. He was always overworked, frequently ill, and the cures recommended by Benjamin Allen, the young Braintree doctor who treated him (crushed woodlice for colic, a decoction of peacock's dung for epilepsy) exacerbated rather than relieved his complaints. The Braintree carrier made weekly trips to London, but travel was still uncomfortable and slow.[12] The immediate neighbourhood was, he wrote to John Aubrey, 'barren of wits, here being few of the gentry or clergy who mind anything that is ingenious'.[13]

Ray, though, maintained a massive correspondence and in these last twenty-five years at Black Notley patrons and supporters such as Sir Hans Sloane, who in 1693 became the new Secretary of the Royal Society, and Tancred Robinson, the *amicorum alpha* who had studied under Tournefort in Paris and with Magnol at Montpellier, became increasingly important to him.[14] Both Sloane and Robinson were important in providing Ray with the motivation and incentive now, in his fifties, to begin the monumental *Historia plantarum*, which eventually filled three volumes of close-set print and ran to more than 2,000 pages. 'Yours and some other friends' opinions and expectations from me do inspire me with such force and courage as not to despair of my abilities,' Ray wrote to Tancred Robinson, 'but to contemn all difficulties and contend even to excel and outdo myself.' Other nations were busy and active in the field, he noted, and he wished to show that 'the English are not altogether idle or asleep but do at least endeavour to contribute something'.[15] Ray intended his work to be an encyclopaedic overview of all the plants known to man. His list of sources includes Willem Piso's *De Indiae utriusque re naturali* published in Amsterdam in 1658, as well as the six volumes of the *Historia naturalis Indiae* written by Jakob de Bondt, who in the 1620s had spent six years working as a doctor in Batavia. He consulted the eight volumes of the *Historia naturalis Brasiliae*, written by Georg Marcgraf, physician to Prince Moritz of Nassau, and published in Amsterdam in 1648.[16] He worked his way through an even earlier work, Francisco Hernandez's *Plantas y Animales de la Nueva Espana* published in Mexico in 1615. He read the Italian author, Paolo Boccone's *Icones et descriptiones rariorum plantarum* (1674) as well as the *Catalogus Monspeliensis* prepared in 1676 by Pierre Magnol, the young lecturer whom he had so admired at the University of Montpellier.

Until this time Ray (and indeed everyone else with an interest in the field) had hoped that the task of compiling a complete encyclopaedia of plants would be

accomplished by Robert Morison (1620–1683), who since 1670 had been Professor of *res herbaria* at Oxford. Morison seemed ideally equipped for the task. After fighting with the Royalists against Cromwell, he left England for Paris, where he studied under Jean Robin, director of the royal gardens. He returned to England as physician to Charles II; the *Plantarum umbelliferarum distributio nova* he published in Oxford in 1672 was to be the first of a series of ambitious monographs, each dealing with one particular family of plants. Eventually, they would cover the entire plant kingdom. The *Plantarum umbelliferarum* (see plate 153) is a large handsome folio with superb copperplate engravings of various umbellifers, which included careful representations of the separate parts of the flower and seed.[17] Tipped into the front of the volume is Morison's PROPOSAL, addressed to the 'Noblemen, Gentlemen and others' who may be willing to subscribe towards his 'New Universal Herbal, ordering Plants, according to a new and true Method never mentioned heretofore'. Morison explained that he was now 'desirous, for the advancing and facilitating that part of Natural History, which hath hitherto been so tedious and discouraging to Students of that Science', to publish his encyclopaedia with all possible speed. Unfortunately the 'Excessive Charge of Designing, Graving, and Printing' means that he cannot proceed 'without the assistance of such Noblemen and Gentlemen as are desirous to further and encourage this Great Work. He therefore doth Engage hereby to every Nobleman and Gentleman, or other, who will be pleased to favour him with one Plate of Five Pounds, that an Honourable Memorial shall be made of him, by Engraving his Coat of arms on their respective Plates.' Morison had in mind a work that would eventually cover 2,450 plants with fine plates cut in Taille Douce. When they had laid down their five pounds, Morison contracted to supply his sponsors with a complete set of the 'Great Work'. But following the Proposal is a slightly desperate Addendum. Morison explains that it has taken nearly three years to complete the first section of 108 plates. For the first two years, work was extremely slow, 'partly for want of good or excellent, yea, and the more diligent Gravers; and now this last Year, finding some Strangers both diligent and able, who join'd with some of our own, we want now onely Encouragement of Subscribers, for the paying of the Painters and Gravers, to finish the whole Work, in as short time as can be possibly allowed'. Despite the delicate appeal to the aspirations and snobbery of those who might back his project, Morison's great enterprise collapsed. In the year following the publication of Ray's *Methodus*, he died.

Ray, too, had hoped that his own massive *Historia plantarum* would be illustrated. He understood how helpful pictures could be, how much easier they made an understanding of the various parts of plants. A history of plants without illustrations was, he felt, as opaque as a book of geography without maps. But Morison had bankrupted

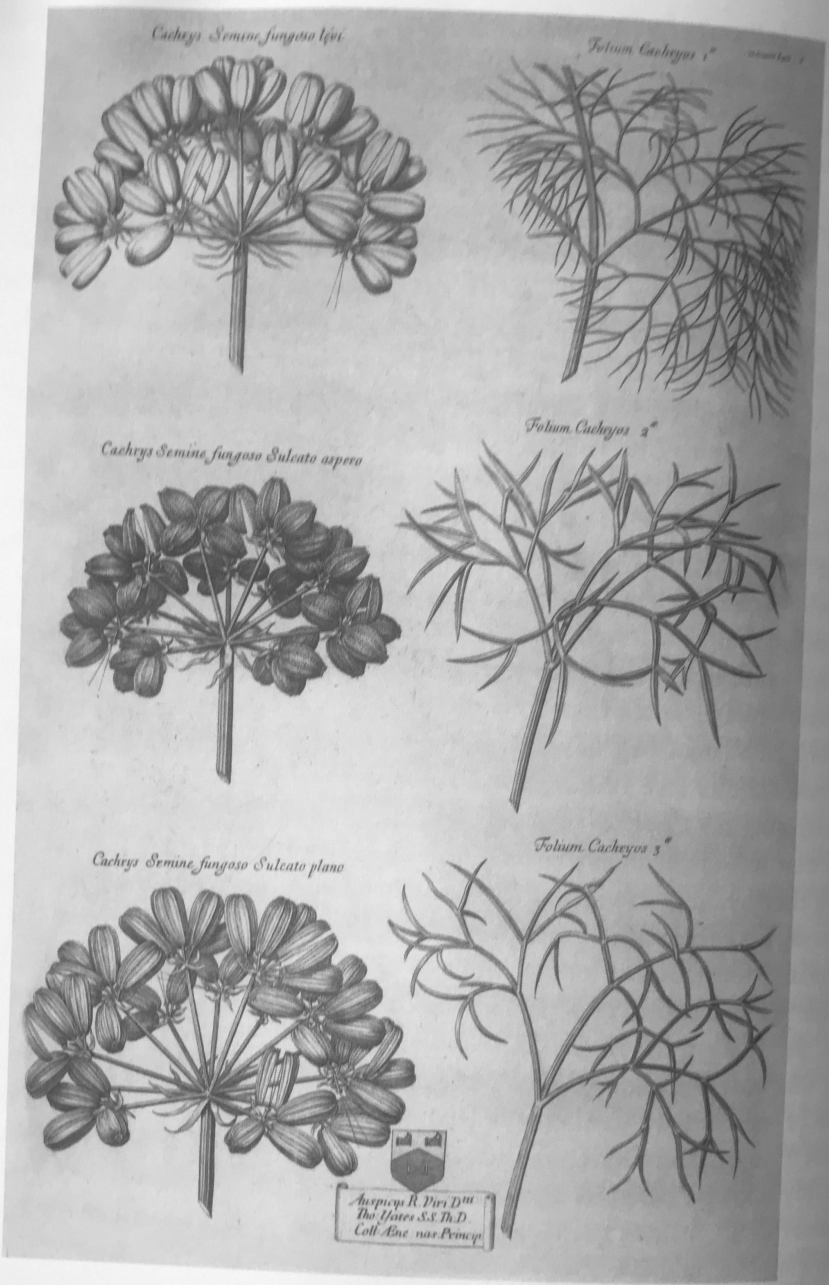

Plate 153: Various umbellifers, beautifully engraved in Robert Morison's doomed Plantarum umbelliferarum distributio nova, *published in Oxford in 1672*

himself in producing the fine copperplate engravings for his book on umbellifers. The Royal Society was too stretched to be able to help. 'I am so teased about cuts for my History of Plants,' Ray wrote to Tancred Robinson on 12 May 1685, 'all my friends condemning wooden and telling me I had better print it without any.'[18] So Ray was persuaded to do without illustrations, but he never ceased to hope that they might be included in future editions. On 15 September 1685, Samuel Pepys, President of the Royal Society, issued an instruction to Henry Fairthorne, the Society's printer, to put the *Historia plantarum* in hand. Every week for next six months, bundles of copy were taken by the Braintree carrier up to the London printer, and bundles of proofs returned to Ray in the country. The first volume was published in June 1686; at the end of the book was an appeal for subscriptions to fund the engraving of plates family by family, as Morison had hoped to do. It never happened.

'I know that there are other species, new and undescribed, in the gardens of Universities and of the great,' Ray wrote in his Preface. 'These must some day be published: I have dealt chiefly with those already recorded: even here I am conscious of omissions through lack of enquiry, negligence, forgetfulness or haste: my readers will perhaps notice more such: what else can be expected from one mere man who had not even a secretary but must needs plough the whole field with his own hand.'[19] He had not seen the tropical plants now being grown by Jacob Bobart, curator of the Oxford Botanic Garden.[20] He had, however, grown persicaria and sneezewort from Virginia,[21] as well as the now ubiquitous golden rod.[22] In the matter of plant descriptions, he acknowledges a major debt to the books of the Bauhin brothers, the Italian plantsman, Fabio Colonna, and the industrious Carolus Clusius. He recapitulates the reasons for sticking to the method of classifying plants that he had already proposed and published four years earlier. His first volume covers four classes of what he calls the 'imperfect plants' (corals, seaweeds, fungi and mosses) and follows on with a treatment of ferns. Then he turns to the vast tribe of flowers, finishing this first volume with the pea family, the *Leguminosae*. In his second volume, published in 1688, he considers trees, first the monocots such as palms and then the dicots. He goes right back to Theophrastus for an account of the way in which female palm trees can be fertilised by the male, finishing with his own opinion 'that the apices supported by the stamens take the place of male seed in plants and serve for fertilising the females'. It was one of the boldest statements about the sex life of plants that anyone had yet made in print.[23] Although products such as quinine, sago, chocolate, coffee and tea were now familiar in England, (Samuel Pepys wrote of his first taste of tea, taken on 25 September 1660; Ray describes how its leaves can be prepared as an infusion, but evidently does not regard it as a safe drink), the trees from which they came were not. Often there were no reports or accurate descriptions on which

he could rely. Though he does not know them at first hand, he is, nevertheless, filled with a general sense of wonder at the strange exotics of the tropics, so different from the plants of the temperate world. 'If a man were carried there in his sleep he would not believe his eyes when he woke up,' he wrote and I remember how it was on the trail to the Orinduik waterfall, how unreal, how disorientating, how mesmerisingly strange. 'If any European travelling through woods saw the bark of trees shining by night so brightly as to light up the path and enable him to read letters, would he not be astounded?' he asks.[24] But once again he states his conviction that the number of plant species in the world must be fixed and limited, 'constant and unchangeable from the first creation to the present day'.

When, in September 1687, Ray had finished work on the second volume of his mammoth encyclopaedia, he went up to London to look at the collection of foreign seeds and nuts that William Courten had amassed at his private museum in the Middle Temple.[25] He also admired the exotic trees and shrubs newly planted in Bishop Compton's garden at Fulham Palace, then the finest arboretum in England. Tancred Robinson writes to Sir Hans Sloane, now in Jamaica, promising to send him a copy of Ray's book on the next available ship. But the vast enterprise (a third volume was finally printed in 1704, a year before Ray's death) did not have the popular success that Ray, in those long years of lonely labour, must have hoped for. Like his other books, it was written in Latin, now not so exclusively the language of scholarly discourse. William Turner, writing more than a hundred years earlier in the middle of the sixteenth century, had the opposite problem: he published a book written in English that was all but inaccessible to the Continental scholars among whom he spent so much time.[26] But at this end of the seventeenth century, Ray complained that there was scarcely a printer left in London who could be trusted to set up accurate text in Latin. Ray's book was dauntingly enormous and it was set in very small type, unrelieved by any pictures. And, like others before him, he was perhaps unlucky in his timing. Many of the Englishmen to whom Ray's great work might have appealed were preoccupied with politics. (The first volume of the *Historia plantarum* came out the year after the Duke of Monmouth's rebellion; the second volume was published in the year that the Whig Lords invited William of Orange to take over the English crown.) And, after its promising start, the Royal Society had got into difficulties. Ray's friend Tancred Robinson resigned as Secretary, and shortly after signing the order to print Ray's *Historia plantarum* Samuel Pepys had resigned as President, to be succeeded by the third Earl of Carbery, whom Pepys called 'one of the lewdest fellows of the age'. There was no money to commission research and no new papers were published in the *Philosophical Transactions*. The Society only recovered when, after his return from Jamaica, Sir Hans Sloane took

Plate 154: 'Flos Africanus' the African marigold from De Koninglycke Hovenier, *a Dutch treatise on gardening published in 1676*

on the job of Secretary. 'As for cuts for my *History of Plants* there are none to be expected,' wrote Ray to his friend Edward Lhwyd on 2 August 1689. 'The book sells not so well as to encourage the undertakers to be at any further charge about it. The times indeed of late have not been very propitious to the booksellers' trade.'[27] Ray got twenty free copies of the *Historia* and was paid £30 for each of the first two volumes.

Ray's final, seminal word on order (the *Methodus plantarum emendata* published in Amsterdam in 1703) was honed by a sharp exchange of views with the French plantsman, Joseph Pitton de Tournefort (see plate 155). He'd read Tournefort's new book, the *Élémens de botanique* during the summer of 1695, though in the French language, Ray was, he said, 'but a smatterer'. Tournefort was an important adversary – professor at the university in Paris, curator of the Royal Garden – and Ray was dismayed that Tournefort, who had read his *Historia* closely, dismissed his method and was proposing a system he could not agree with.[28] The whole cause for which he'd fought so long could be set back if it was adopted. He had to reply. Tournefort's chief criticism was that Ray used too many characteristics to define his various groups of plants. Tournefort was proposing one single defining feature: the number and relative symmetry of the petals of a flower. It wouldn't do, argued Ray. It forced too many unnatural groupings: the narcissus with the reed, the rose with the poppy. Tournefort could not ignore the wider structure of plants, or disregard their natural relationships. And so, his legs now covered in running sores which he bathed in a mixture of dock root and chalk, and with gangrene spreading on the undersides of his feet, Ray, isolated in his Essex cottage, set down his last words on the subject that had intrigued and sustained him for more than thirty years. In the *Methodus plantarum emendata*, he lists his rules for grouping plants according to their natural affinities. Plant names must be changed as little as possible to avoid confusion and mistakes; the characteristics of a group must be clearly defined and not rely on comparison (this had been a marked feature of early descriptions when there were no agreed standards – leaves were 'bigger than box' or 'not so indented as ivy'); characteristics must be obvious and easy to grasp; groups approved by most plantsmen should be preserved; related plants should not be separated; the characteristics used to define should not be unnecessarily increased. The six Rules Ray proposed provided the vital underpinning of a new discipline which would later acquire a new name – taxonomy.

And is that it, you may ask? Yes, that is indeed it. No fireworks, no claps of thunder, no swelling symphonic themes mark Ray's achievement. It is a quiet, lonely, dogged consummation, and, in its insistence on the importance of method before system, critical in shaping future thinking on the subject to which he had devoted

Plate 155: Joseph Pitton de Tournefort (1656–1708), John Ray's rival, whose Élémens de botanique *set out a new system of classifying plants according to the form of the flower*

the whole of his adult life. After his death, Tournefort's system flourished for a while. So did that proposed by the Swedish taxonomist, Carl Linnaeus. But thinking men came inexorably back to Ray. We are so far now from where he was then that it is difficult to fit our minds to his seventeenth-century accomplishments. But he foresaw that too. I have to go, of course, to Black Notley, now almost swallowed up by unlovely Braintree. Ray's grave, close to the church door, is a handsome monument, paid for by Bishop Compton and other rich friends. Drawn to it by its crowning obelisk of stone, I peer at the panels underneath lettered in a close Latin script. They are almost illegible now. It doesn't matter. He is commemorated for ever in horehound and woundwort, purple-crested cow wheat, henbane and hemp agrimony, the native flowers that first awoke in him his lifelong passion for plants. And fittingly, it was he who first used the word which described the subject of his life's work.

The *Philosophical Transactions* in 1691 had described Ray as an 'incomparable botanist',[29] a newly coined term in England in the late seventeenth century. But it was John Ray himself, writing in 1696, who first used the word 'botany'.[30] Here it was at last, riding in on its Greek root, the word to describe the labours of almost 2,000 years, to supplant the *stirpium*, the *planta*, the *res herbaria*, the simpling, the herborising and all the other terms by which generations of earlier plantsmen had tried to describe the substance and focus of their work. The long, careful, patient study undertaken by my heroes Theophrastus, Ghini, Cesalpino, Turner, Gesner and Johnson, to organise and disseminate the naming of plant names, now had its own name. And armed with this name, it crossed into a different world. It left the philosophers behind and instead engaged wholeheartedly with a new breed, the scientists of the Enlightenment. Ray, finally, had worked out the rules that could clarify nature's game. He had provided a more solid foundation for future scholars to build on than anyone else before him. There was still much more to do and he understood that, as well as recognising how his achievements might seem to those looking back over another 300 years of progress. 'I predict that our descendants will reach such heights in the sciences that our proudest discoveries will seem slight, obvious, almost worthless,' he wrote. 'They will be tempted to pity our ignorance and to wonder that truths easy and manifest were for so long hidden and were so esteemed by us, unless they are generous enough to remember that we broke the ice for them, and smoothed the first approach to the heights.'[31]

EPILOGUE

OF COURSE, THE story does not end with Ray. He forges the rules that will steer his successors through the complex maze of nomenclature that lies ahead. He establishes the study of plants as a scientific discipline. He gives this study a new name – botany.[1] Ray is the last of the heroes whose work gradually shifted the study of plants away from superstition and towards science. But this particular story cannot have an end: as ways of seeing change, new things are seen. New relationships are revealed. New ways of sorting plants become possible – inevitable even. Spectacles had helped Fuchs. He's wearing them in the portrait that his artist, Albrecht Meyer, prepared for *De historia stirpium* (1542). The first microscope, invented towards the end of the sixteenth century, showed Ray and his contemporary Nehemiah Grew complexities in the structure of plants that previous scholars could never have dreamed of. But ahead of Ray lay electron microscopes, Watson and Crick, the double helix, DNA. The task of defining and categorising the natural world, previously the domain of philosophers and naturalists, has now, in the twenty-first century, been taken over by physicists, phytochemists, molecular systematicists who are just as driven by the need to sort and order, to find perfection in hierarchy and classification, as Cesalpino ever was.

And somewhere we have to nod, however grudgingly, to Carl Linnaeus (1707–1778), the Swedish botanist who described his own book, *Species plantarum*, published in 1753, as 'the greatest achievement in the realm of science'. Enthroned as professor of medicine at the University of Uppsala, he called his students 'apostles'. Like Mattioli, he had the good fortune to publish the right book at the right time. He captured the *zeitgeist*, understood what was required and, with the ruthless efficiency of a computer programme, imposed brisk two-module name tags on nearly 6,000 plants. Since 1725, the Society of Gardeners had been meeting regularly in London to look at plants, especially those then pouring in from the Cape and the East Indies,

in the hope of bringing some order to their naming. Novelties commanded high prices. Nurseries competed savagely for new plants and sent them out to rich customers under whatever name they fancied. The brilliant glory lily, which created a sensation when it was first brought into Europe from the tropics, had been 'Methonica' to one nursery, 'Lilium zeylanicum superbum' to another, 'Mendoni' to a third. Linnaeus decreed that it should henceforth be called *Gloriosa superba*, one of its earliest names. And, surprisingly, the rest of the world eventually agreed. Just in time, order had been wrested from chaos. Between 1730 and 1760, the number and variety of plants being grown in England increased fivefold.

The binomial naming system that Linnaeus used was not his invention. In a haphazard way, it had been around since the beginning: speaking for instance of poppies, Theophrastus had distinguished different kinds as 'mekon e melaina', 'mekon e keratitis', 'mekon e rhoias'. Brunfels and Fuchs had both used two-part names, but randomly, not as part of a rational plan. Andrea Cesalpino and Gaspard Bauhin[2] had both seen the advantages of the brief surname/Christian name system being applied to plants as well as people. It is a logical way of showing which group a plant belongs to and pinpointing its particular place in that group. But Linnaeus recognised more clearly than anyone else before him that all a name had to do was designate. It did not have to describe. Scholars of the seventeenth and early eighteenth centuries had drifted away from the short, sharp binomial towards much longer polynomial tags that tried to pin down the exact, distinguishing characteristics of the plant in question. In one way that was useful. A name such as 'Plantago foliis ovato-lanceolatis pubescentibus, spica cylindrica, scapo tereti' tells you that this is a plantain with ovate lanceolate leaves becoming softly hairy, a cylindrical head and a smooth stem. But it doesn't fit the mouth as comfortably as *Plantago media*, our hoary plantain. Nor is it as easy to remember.

The binomial system worked too, because it mirrored the way that common names had evolved. Hoary plantain is, in effect, a binomial tag. The collective name is plantain, the distinguishing name hoary, which differentiates this kind of plantain from the ribwort plantain (*Plantago lanceolata*), the greater plantain (*Plantago major*) or the sea plantain (*Plantago maritima*). In the English language the describing word comes before the generic one. In Latin it's the other way around. There will always be a place for common names – they are both vivid and familiar. But they are not universal. When, in 1892, Nathaniel Colgan of Dublin tried to establish the true identity of the shamrock, patriotic Irishmen from twenty different counties inundated him with plants. Some sent white clover, some red, some sent lesser yellow trefoil, some spotted medick. No one sent wood sorrel, which in England is sometimes called shamrock.[3] A widespread flower such as the marsh marigold (*Caltha*

palustris) has about sixty common names in France, another eighty in Britain, and at least 140 in Germany, Austria and Switzerland.[4]

But taxonomy, which distinguishes, names and groups plants in a systematic way to create, in effect, a register of biodiversity, has to operate in a universal language. For centuries scholars had used Latin as the common denominator and, as Mark Griffiths points out, without that 'single accessible text of living things, without a *lingua franca* governed by universal rules, that one "language" would become many tongues, vernaculars, many argots and slangs: biodiversity would be Babel, and then fall silent'.[5] Standardisation was Linnaeus's gift to those still desperately searching for a unifying scheme.

Born in Småland, a province in southern Sweden, two years after John Ray's death, Linnaeus goes on to study medicine at Uppsala. His mentor and benefactor is Olaf Rudbeck, a tutor at the university. In gratitude, Linnaeus later names the daisy-flowered rudbeckia after him (Johann Siegesbeck, who had dared to criticise the great man, gets a small weed, *Siegesbeckia orientalis*). In 1732 he begins a 3,000-mile journey through Lapland and in his *Flora Lapponica* (1737) records the plants he found there. He goes to Hamburg, Amsterdam and London, where he meets Sir Hans Sloane, President of the Royal Society. He is employed by George Clifford, a wealthy merchant banker, to classify and describe all the plants in the garden and herbarium at Clifford's estate, the Hartekamp, near Haarlem. In his spare time, Linnaeus classifies his benefactor's library: I, Patres: Graeci, Romani; II, Commentatores: Theophrasti, Dioscoridis . . . Returning to Sweden, he practises as a doctor, specialising in gonorrhoea. In 1741, he is offered a professorship at Uppsala and devotes himself to his *Species plantarum*, which builds on the *Genera plantarum* he had published in Leiden in 1737. As well as standardising plant names, abolishing the synonyms which since the beginning had been a muddlesome problem for scholars such as Turner and Johnson, he introduces the concept of precedence. The earliest published name of a plant is the one to be preferred. He adopts sixty of the names that Otto Brunfels had used for the plants in his *Herbarum vivae eicones* (1530–36) and eighty of those included by Leonhart Fuchs in *De historia stirpium* (1542). Though some complained that 'he seems so vain as to imagine he can prescribe to all the world', his system of naming plants prevails. The *Species plantarum* is now accepted as the starting point of our present system of naming plant names.

While his system succeeds (the Lee and Kennedy nursery is using it by 1760), his method does not. Linnaeus has proposed a new way of grouping plants based on the number and arrangement of the stamens and carpels within a flower. 'The actual petals of a flower contribute nothing to generation,' he wrote, 'serving only

as the bridal bed which the great Creator has so gloriously prepared, adorned with such precious bedcurtains, and perfumed with so many sweet scents, in order that the bridegroom and bride may therein celebrate their nuptials with the greater solemnity.' Tournefort, whose system had been based on the arrangement of petals, is neatly demolished. The method of classifying plants Linnaeus was taught at high school is replaced by one of his own, which he has been developing since the 1730s and which he calls a 'systema sexuale'. It is considered deeply shocking. The Bishop of Carlisle rails against the 'gross prurience' of Linnaeus's mind. He fears that the book will 'shock female modesty', at the same time doubting whether many 'virtuous students' would be able to follow Linnaeus's analogies. In St Petersburg, Johann Siegesbeck condemns the 'loathsome harlotry' of Linnaeus's method. 'Who would have thought that bluebells, lilies and onions could be up to such immorality?' he asks. In Oxford, Johann Jacob Dillenius, the Sherardian Professor of Botany, writes to a fellow botanist, Richard Richardson, that although Linnaeus has 'a thorough insight and knowledge of Botany' he is afraid his method will not hold. And it does not. Linnaeus's method of classifying plants, the 'systema sexuale' scarcely outlives him.

Since 1867, the actual names that plants bear have been regulated by an International Code of Botanical Nomenclature,[6] which establishes the basic hierarchy of the plant world. At the bottom, in the lowest rank, is the *species* name which distinguishes between plants that are closely related (like our creeping and meadow buttercups, *Ranunculus repens* and *R. acris*). Sometimes the specific names are descriptive, as in *repens* (creeping); sometimes they indicate the country of origin: *sinensis* (Chinese); sometimes they encapsulate a plant's history: *officinalis* (of apothecaries' shops. 'Opificina' – later corrupted to 'officina' – was the original Latin term for a pharmacy).

Above the species is the *genus*, the bigger group in which all the species are combined – the buttercups, which are all *Ranunculus*, the forget-me-nots which are all *Myosotis*, the plantains which are all *Plantago*. Genera vary greatly in their size and distinctiveness. Some, such as the *Ginkgo*, have only one ancient representative. Others, such as *Euphorbia*, have more than 2,000 members, some annuals, some perennials, some succulents, some shrubs, some trees. Theophrastus was right in thinking the simple division of plants he proposed – herbs, sub-shrubs, shrubs and trees – was a device that might not prove tenable. Above the genus is the *family*, which collects related genera together: columbines, monkshoods, spring aconites, hellebores and meadow rues are gathered with buttercups in the family of Ranunculaceae; tulips, fritillaries and erythroniums join lilies in the Liliaceae. Like genera, families vary enormously in size. The family of Orchidaceae accommodates

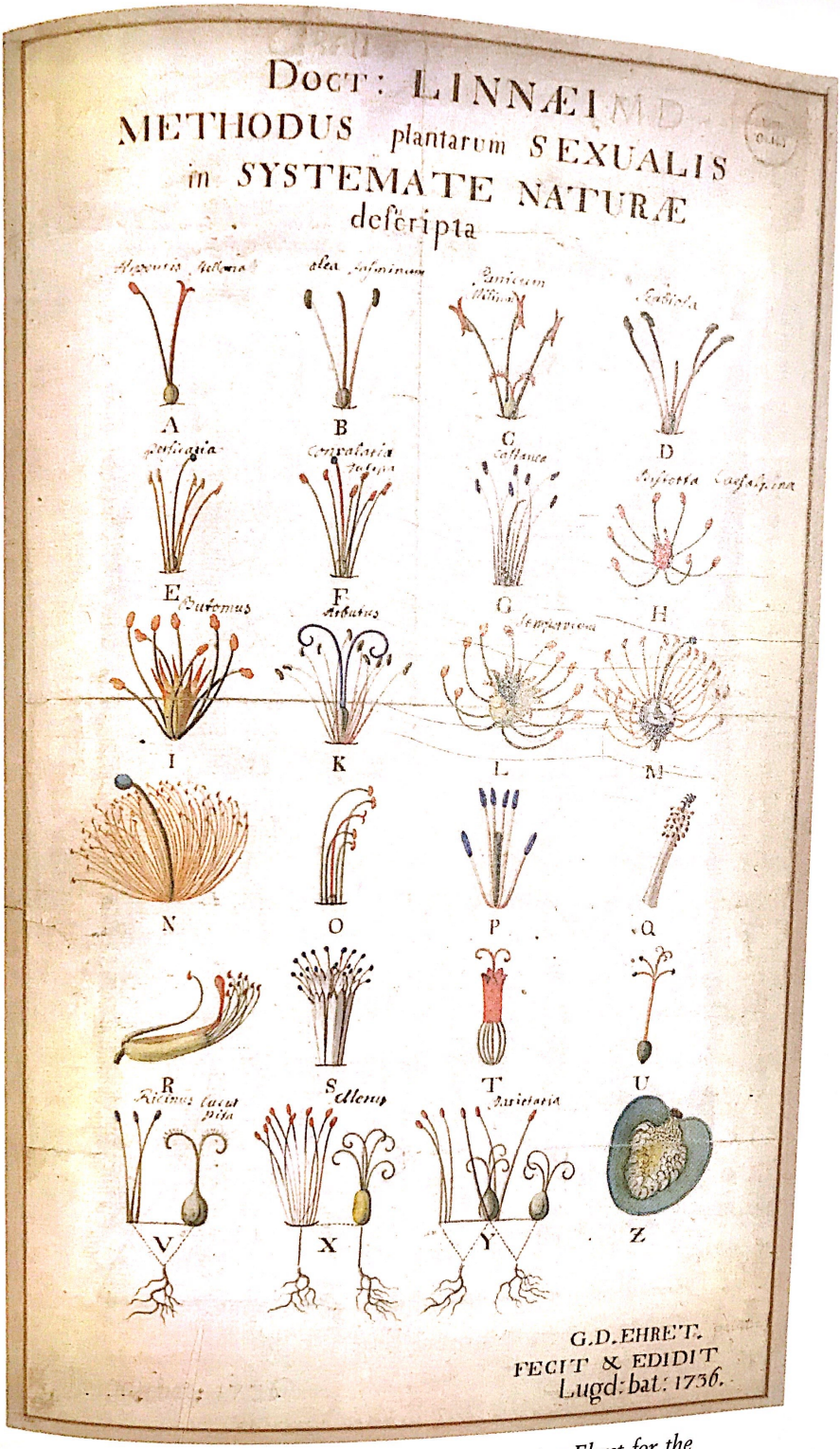

Plate 156: An illustration by Georg Dionysius Ehret for the Hortus Cliffortianus (1735–48) in which the Swedish plantsman, Carl Linnaeus, first began to work out his 'methodus plantarum sexualis', grouping plants according to the number and arrangement of their stamens

around 800 genera, at least 20,000 species. Families, though, shrink and grow as each generation of botanists proposes a new set of defining characteristics. So do the *orders*, which stand above them and which pull various families into cryptic proximity: the barberry family (Berberidaceae) and the akebia family (Lardizabalaceae), for instance, sit with the buttercup family, Ranunculaceae, in an order called the Ranunculales. Finally there are the *divisions*, vast overarching categories, which separate flowering plants from other types of plants such as ferns or mosses.

Ray's Six Rules had provided the conceptual framework for a future system. And the idea of a hierarchy was generally accepted, as was Linnaeus's useful shorthand, the two-name tag. But the classification of plants remained as fluid as ever because nobody could agree on the most convincing indicator of their similarities and differences. Some botanists returned to Lobelius's method and used the leaf as the defining characteristic. Others stuck with the flower. But the form and structure of plants – their morphology – could be influenced to a troubling degree by the environment in which they grew. Theophrastus recognised this: the plane tree by the stream in the Lyceum 'sent its roots a distance of 33 cubits, having both room and nourishment'. The particular silver firs that grew in a sheltered valley in Arcadia, 'excelled greatly in height and stoutness'. Perhaps other characteristics would be more stable? When the delicate, intricate structure of pollen grains was revealed in the vacuum chamber of the electron microscope, some thought that here was a secure indicator of differences. More recently, phytochemical properties have been proposed as the key. By bringing together nasturtium and oil-seed rape (both contain mustard oil), taxonomists have returned to the method of the earliest herbals: grouping by use. So, species have continued to shift from one genus to another. Genera have split and merged as different botanists used different criteria to create different groupings. Some are inclined to be 'lumpers', wanting to create big, baggy, loosely connected genera. Others are 'splitters', seeing each tiny morphological difference as a justification for creating a new species with its own specific name.

Some families such as the Liliaceae became very baggy indeed. While the American taxonomist Arthur Cronquist (1919–1992), by nature a lumper, could always find reasons to maintain families in fairly large gatherings of different genera, Rolf Dahlgren (1932–1987) argued for more and smaller families with more uniform characteristics. Sitting in judgment at Kew, the Family Planning Committee (it really exists) discusses the arguments for and against. How are we to make sense of it all, when the taxonomists themselves so often disagree? From Bentham and Hooker in 1862–83, to Cronquist in 1988, eight major systems of plant classification have been proposed in the last hundred years alone.[7] But do we now, at last, have incontrovertible proof about the ways that plants relate to one another? Have the complex

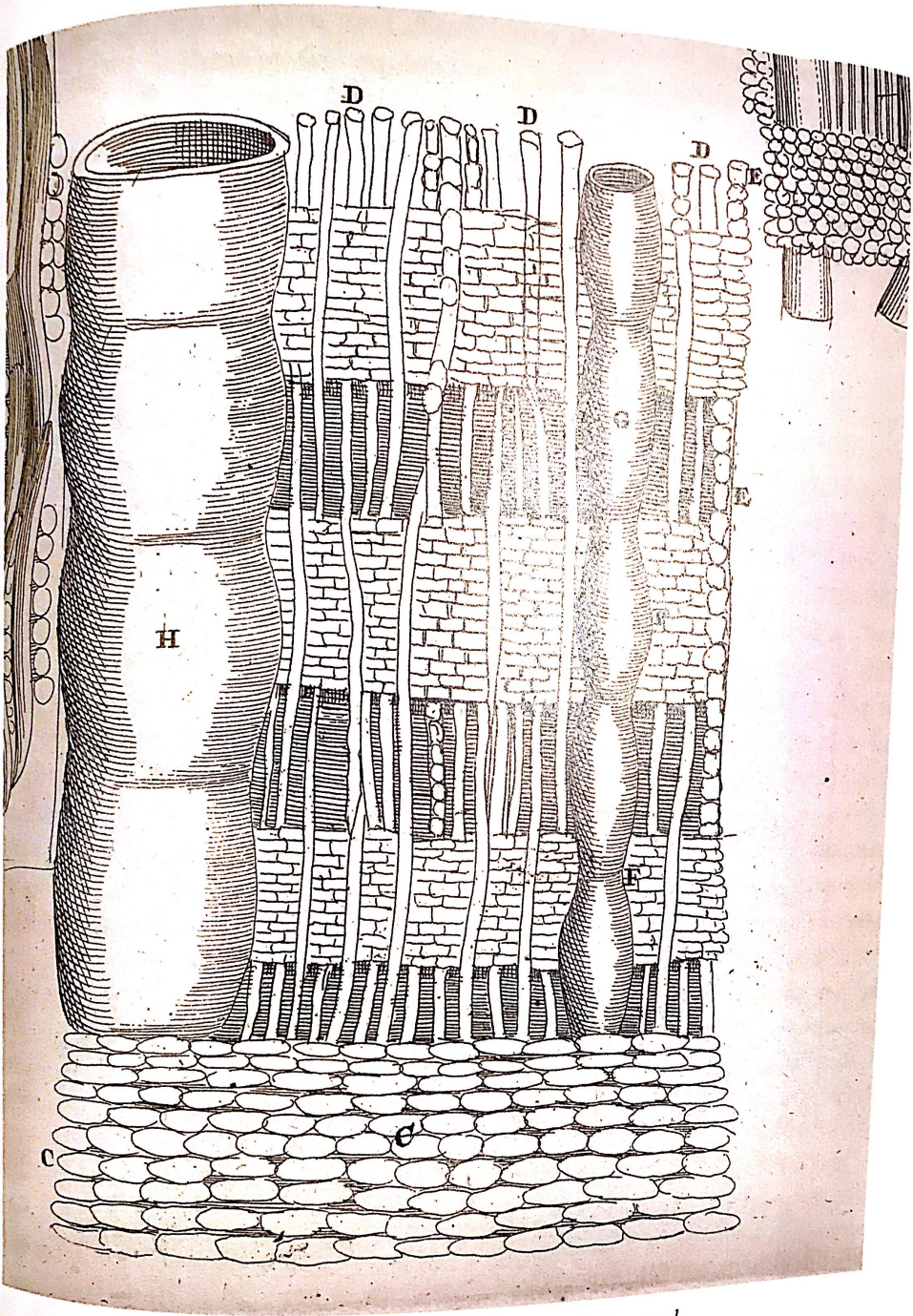

Plate 157: Hugely enlarged by the newly invented microscope, this is the xylem (the tissue that carries water from the roots to other parts of the plant) of an oak, drawn by the Italian plantsman, Marcello Malpighi for his Anatome plantarum *(1679)*

inter-relationships of the natural world finally been decoded, the clues unravelled? Has the essential *psyche* of a plant, the concept that Aristotle and Theophrastus worried away at so long, finally been pinned down?

On a gorgeous May morning in 2005, with great candles of blossom lighting up the horse chestnuts that the Flemish ambassador Ogier Ghiselin de Busbecq introduced so long ago that we've forgotten they were ever strangers, my final pilgrimage takes me to the Royal Botanic Gardens, Kew, where Professor Mark Chase heads the Molecular Systematics Section. The big money that went into the human genome project generated techniques which quickly filtered into other disciplines. By analysing the DNA of plants, scientists can now work out a kind of evolutionary tree, and make clear relationships that no outward character could ever suggest. Flowering plants evolved more than 150 million years ago (inexplicably, I suddenly see a great brontosaurus foot crushing a marestail, as the hoof of my horse had crushed the tulips and Juno irises in the Tien Shan mountains of Kazakhstan); in 150 million years, plants that were once closely related can take completely separate evolutionary paths and end up looking as different as, say, roses and nettles. But the DNA of those two plants, the code that's been hidden within them for millions of years, shows that they actually belong to the same big order, the fabids (it also takes in cannabis, cucumber, pear, strawberry and many other seemingly disparate families of plants). Starting in the 1980s, Chase and his colleagues gathered 500 sequences of one gene to analyse. Their computers weren't up to the task and crashed. By 1993, they'd overcome that problem and it took the newly named Angiosperm Phylogeny Group just two years to amass a second set of data, which gave the same sometimes surprising results. The lotus should not be sitting with the water lily, which it seems so closely to resemble, but with plane trees and South African proteas. Bravely, the group began a major re-structuring of the hierarchy. Cesalpino's umbellifers have a new name, and his pea group is split up. But he himself is honoured at the head of a new family, the Cesalpiniaceae, close to the sweet pea and mimosa. Dioscorides has an order named after him, the Dioscoreales, even further up in the hierarchy. Theophrastus gets nothing.

It is a monumental shift. But Professor Chase argues it is based on incontrovertible evidence. You can't reject it just because it's not what you expect. So, in Leiden, where in 1593 Clusius went to set up a botanic garden, the old order beds are being remade to reflect the new classification. At the university in Oxford, students of systematics and taxonomy are now taught according to the new system. In the Oxford Botanic Garden, founded in 1621 so that 'learning may be improved', the order beds, last remade in 1884 according to Bentham and Hooker's rules, are once again being dug up and rearranged. A new order has begun.

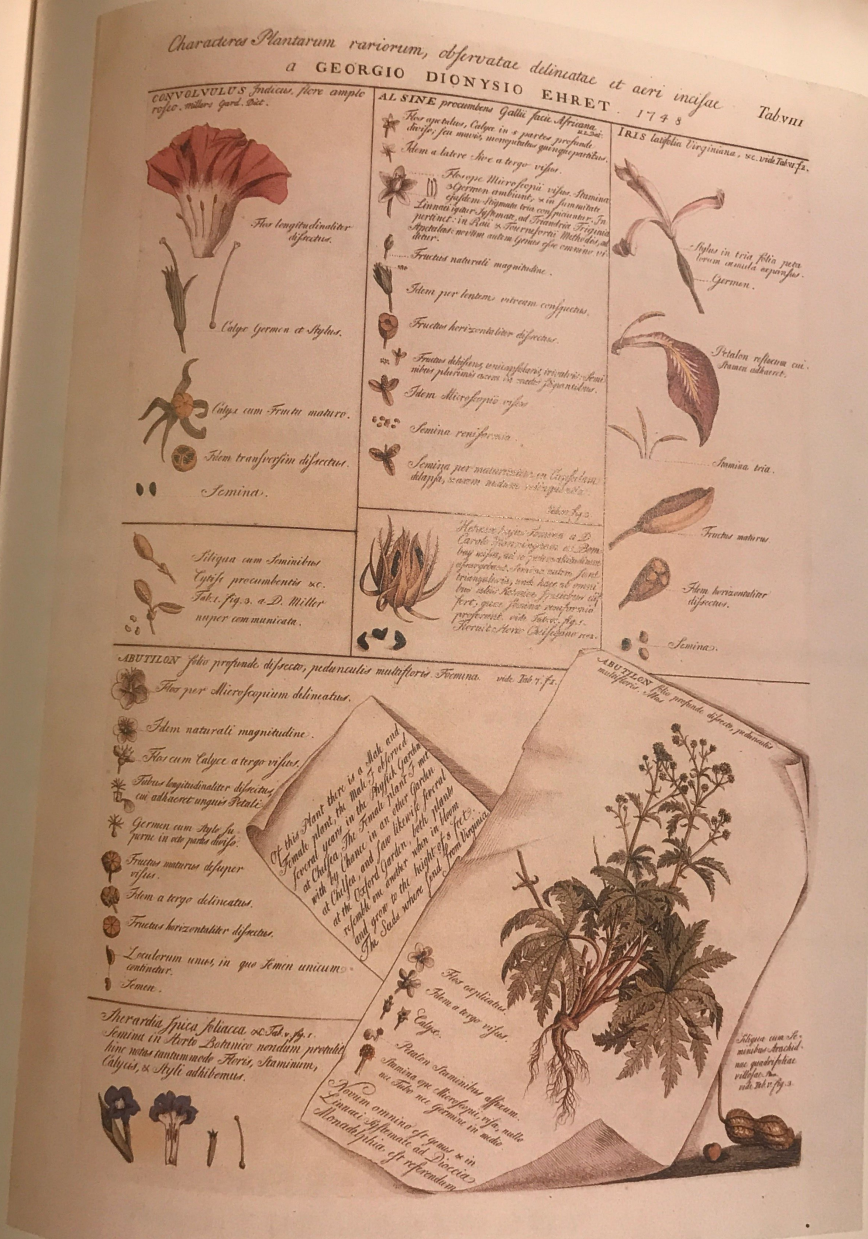

Plate 158: 'Characters of flowers', one of the plates engraved by the German artist, Georg Dionysius Ehret for his Plantae et papiliones rariores *(1748)*