EARLY BOTANY AT OXFORD*

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JOHN JACOB DILLENIUS was born at Darmstadt, Germany, in 1684. He studied at the University of Giessen, like several of his family before him. At an early age he became a member of the Academia Naturæ Curiosorum and contributed several papers to the *Miscellanea Curiosa* of that Society from the year 1715 onwards: among other matters these dealt with American species of plants which had become naturalized in Europe; Arabian coffee and his own *ersatz* preparations made by roasting peas, beans, kidney-beans and rye, the last being barely distinguishable from the real thing; the examination of mosses and other cryptogams with the view of ascertaining their sexual organs; and an experiment made with opium he had prepared from *Papaver somniferum* grown in Europe. He also wrote on leeches and butterflies.

In 1719 he published his "Catalogus plantarum sponte circa Gissam nascentium", a work which immediately established his reputation. It contains a list of plants gathered within a circuit of about a German mile and a half—approximately 980 species of flowering plants, 200 species of Musci and 160 species of Fungi; a large proportion of the Cryptogams had not previously been described. There is a critical examination of the systems of Ray, Knaut, Rivinus and Tournefort. Dillenius himself followed Ray's system throughout his career.

It was as a direct result of the catalogue that Dillenius was invited to Great Britain. William Sherard was at that time eminent in botany, so much so that Dawson Turner called him "the Sir Joseph Banks of his time". He had studied under Tournefort at Paris and later in 1704 was appointed Consul at Smyrna and there made a collection of plants and also did antiquarian exploration. At Tournefort's suggestion he undertook the continuation of Casper Bauhin's "Pinax", and on his return to England in 1716 he devoted himself to completing the work. The neglect of Cryptogams in Great Britain led him to enter into correspondence with Dillenius in 1718, and three years later, after sending for him, brought him over. Dillenius was engaged upon naming Sherard's collection of Smyrna plants and also on the "Pinax".

*From the presidential address delivered before the Linnean Society of London on May 24, which dealt with a collection of drawings recently acquired by the Department of Botany, British Museum.

By that time the second edition of Ray's "Synopsis Methodica Stirpium Britannicarum", published in 1696, had become scarce, and Dillenius was employed in helping to prepare a new edition. This was published on July 17, 1724.

In 1726 Dillenius made a tour of the west of England and Wales in company with Samuel Brewer; Littleton Brown made part of the journey.

William Sherard died in August 1728 and left his books and plants and £3,000 for the maintenance of a professor of botany at Oxford. He nominated Dillenius to be the first professor for life.

Dillenius was fully satisfied with his work on the "Pinax", but James Sherard, after his brother's death, persuaded him to write an account of the plants cultivated in his garden at Eltham. "Hortus Elthamensis" appeared in 1732 in two folio volumes of 437 pages and 324 plates drawn and engraved by Dillenius. A large number of the then known species of Mesembryanthemum are figured and also some rare British plants. Sprengel described it as a most splendid work and Linnæus as "a botanical work such as the world had not seen". But Dillenius grudged the time he had spent on it. Further, he was shabbily treated by James Sherard, who complained that "he has not studied either to adorn his book or my garden; his chief care having been to improve and advance the Knowledge of Botany"—and Dillenius had to bear the cost of the production of a work James Sherard had designed "to make himself known". Many of the type specimens are preserved at Oxford. The drawings appear to have been lost.

There was difficulty over the Oxford appointment because of James Sherard's executors going to law, and Dillenius did not take up residence in Oxford until 1734, six years after William Sherard's bequest. In 1741 he published his "Historia Muscorum", a quarto volume of 576 pages and 85 plates—mosses including Bryophytes, Hepatics, Lycopods, Algæ and lichens. The original drawings of the figures on the first seventy-nine plates are in the Department of Botany; the remaining six plates were apparently drawn and etched directly on the copper. Dillenius died in April 1747 at the age of sixty-three—the great "Pinax" unfinished.

Such in outline is the life of one of the foremost systematists of his time—Linnæus says of the genus Dillenia, "of all plants the most distinguished for the beauty of its flower and fruit, like Dillenius among botanists".

Although Dillenius gained a considerable reputation from his Giessen Catalogue, this was chiefly because of the prominence he gave to Cryptogams. His Musci include not only the true mosses but also the lichens and some Algæ. For the first time mosses were split up into genera and names such as Mnion, Hypnum, Polytrichum, Bryum, and Sphagnum he took from Theophrastus, Dioscorides and Pliny.

Three years before the appearance of the Catalogue, Marsigli and Lancisi had published their letters on the nature of Fungi. Dillenius adopted their ideas, and his opinion is often quoted in the discussions which went on for a century or so. "A fungus," he says, "is a sterile kind of plant, that is to say destitute of flower and seed, arising from putrefactive fermentation, wherefore they arise chiefly during a moist and rainy period and consist for the most part of a soft and spongy substance yet retaining its characteristic look which it owes to a definite and specific juice of decay from which it originated ; and so, since by this putrefactive process the texture and elements of vegetables are considerably altered and almost destroyed, Fungi do not possess a green colour or have leaves, or even texture like other plants. Another consequence is that they usually spring up in a short space of time and are of equally short duration, or become the habitat and food of grubs and beetles, with the exception of not a few arboreal species that spring from the less liquid juices of wood and therefore last longer."

In spite of this belief which, logically, means that Fungi have no separate entity, Dillenius paid considerable attention to them and describes 162 species in his Catalogue. Drawings of 114 of these are in the present collection with 52 additional drawings. They are painted on separate pieces of paper and stuck on sheets on which the details are given. These drawings serve as the types of Dillenius's species and give his interpretations of previous descriptions.

Dillenius was recommended to Sherard "as a person very curious in mushrooms and mosses, as I perceive he is," and later Sherard writes : "I have brought over with me Dr. Dillenius who has with him most (if not all) of his *Fungi* painted". These drawings must be the ones mentioned. They are not of high artistic merit.

There is also a set of wash drawings of Fungi, all mounted on the same size of paper and arranged as if for publication. They seem to be copies, but they are from no work I know and, so far, I have not been able to match a single one of them except in Dillenius's own drawings. Can it be that they are the drawings mentioned by Sherard in a letter to Richardson dated December 26, 1723 ? "Dr. Dillenius has much improv'd in his painting. He has copied for me all Mr. Dandridge's *Fungi* and as many as he has been able to procure about London". Or are these, as Dr. Druce suggested, included in the drawings of Fungi at Oxford. These latter number 264 : the printed matter in Druce's "The Dillenian Herbaria" does not appear to support the suggestion for Dandridge's name is scarcely mentioned ; some of the Fungi are said to be from Giessen.

Another set of drawings, also in wash, is entitled "Plantæ novæ aut rariores ex Ephem. Nat. Curiosorum". It will be remembered that Dillenius himself was a member of the Academia Naturæ Curiosorum. These drawings on sixty-four sheets are copied from various plates which appeared in the Ephemerides together with full notes, and from Mentzel's "Pugillus" and Alpinus and Vesling's "De Plantis Aegypti". These, I imagine, date from his Giessen days, indeed probably when he was a student.

Although Dillenius's name is not on the third edition of Ray's "Synopsis" it would have been possible to guess that he was the editor even if it were not known for certain otherwise, for the classification adopted is practically that of the Giessen catalogue. It is common knowledge, however, that his name was omitted as "there was some apprehension (me being a foreigner) of making natives uneasy, if I should publicate it in my name". He had wished to dedicate it to Sherard and R. Richardson, "two persons that have contributed the most to its perfection", but the dedication being anonymous was "to all those Lovers of Botany, who contributed the most to the edition". There was even a suggestion that Isaac Rand's name should be given as editor, which apparently Sherard approved of, though he had himself done far more work on the "Synopsis", having on occasion worked ten hours a day on it. The "Synopsis" was illustrated with twenty-four plates. The only reference I have found to the fact that Dillenius did these is in a letter from Sherard to Richardson in which he says : "I know nothing further Dr. Dillenius has to do to the *Synopsis*, but the getting grav'd a few more plates, which may be done whilst 'tis printing". Richardson sent the money to pay for two plates, but Sherard returned it saying that it was a proper charge upon the publisher. The present collection contains the original drawings of all the plates except plate 1, though a few of the figures are missing ; the drawing for plate 23 is in pencil in an unfinished state. The original figures of plate 1,

which illustrate Fungi, are amongst the Oxford drawings, according to Druce. Most of the drawings have the red chalk used in engraving still showing on the reverse side. But the interesting fact is that apparently it was intended that there should be sixty-eight plates. I have not traced any reason why all were not published.

The collection also includes a number of British plants. The specimens are in the Dillenian Herbarium at Oxford. There are further fifty sheets of drawings of plants probably from Giessen, and also sixty-three drawings of rushes, sedges and grasses.

The most numerous drawings are a set of about 320 labelled "Designationes and Icones plantarum in Horto Oxoniensi crescentium . . . 1744, 1746 dipictae." They are of great artistic merit and it need not be stressed that they are botanical drawings. In my opinion they place Dillenius among the front rank of botanical artists; it scarcely seems possible that they are by the same hand as some of the earlier drawings.

The Oxford Botanic Garden dates from 1621 and had only been planted with "divers simples for the advancement of the faculty of medicine" when the Civil War broke out. Jacob Bobart the elder was the first gardener appointed, though it seems that Lord Danby, founder of the garden, had previously negotiated with John Tradescant. The definite agreement between Lord Danby and Bobart was drawn up in 1641. Under Bobart's care the garden acquired a great reputation, and a catalogue of the plants there cultivated was published in 1648; 1,600 plants are included of which 600 were British. A second edition appeared ten years later with Philip Stephens and William Brown as co-editors with Bobart. Jacob Bobart the younger succeeded his father as keeper of the Physic Garden in 1679. There are two manuscript catalogues of plants growing in the garden and its neighbourhood in the Botanical Library at Oxford, and a number of manuscript lists of seeds and plants mostly sent or received by Bobart, in the Sloane Library.

After Bobart's retirement in 1718 there was no activity until the appointment of Dillenius. Sherard and others sent plants and seeds, but the neglect which had begun as Bobart grew old and feeble continued until 1734. Linnæus's famous visit to Oxford took place in 1736. It is probable that his main object was to see Sherard's herbarium, which in his judgement excelled all others in European plants, but the opportunity of meeting Dillenius was doubtless an additional attraction. There are several accounts of this visit. Dillenius, writing to Richardson, said that the visit lasted eight days, whereas Linnæus says that the learned Dillenius was at first haughty and distant, conceiving the "Genera Plantarum" to be written against him; but that he afterwards detained him for a month, without leaving him an hour to himself the whole day long, and at last took leave of him with tears in his eyes, after giving him the choice of living with him until his death, as the salary he thought was sufficient for them both.

By collating these various lists with the present drawings it should be possible to gain some idea of the plants in cultivation at Oxford when Dillenius was professor.

What was the purpose Dillenius had in mind in preparing these drawings? They were done with such care that it scarcely seems credible that they were drawn merely for amusement. We know that Dillenius regretted every moment away from the "Pinax" and yet here we have an enormous amount of time spent with what seems to be no purpose. Was it that Dillenius had in view the preparation of a volume dealing with the Oxford garden similar to "Hortus Elthamensis"? He certainly would have found it more congenial to work as he pleased than under the selfish criticism of James Sherard.

Dr. Druce overlooked the fact that Dillenius was a correspondent of John Bartram. His letters were usually sent through Peter Collinson, who also distributed seeds collected by Bartram. In 1737 Collinson sends names of his plants from Dillenius, and Dillenius received collections of seeds and plants until 1742. Bartram also collected mosses. "Before Dr. Dillenius gave me a hint of it, I took no particular notice of Mosses, but looked upon them as a cow looks at a pair of new barn doors."

We know that Dillenius was thoroughly dissatisfied at the loss he encountered by having to finance the publication of "Hortus Elthamensis". At James Sherard's desire he printed off 500 copies, but decided to have only 145 copies of the plates. Half a hundredweight of the paper—best Dutch paper—he sent to Bartram through Collinson, who wrote that it would "make noble books for specimens" and "think will furnish thee with paper for specimens, and for seeds, for thy lifetime". Drawings of some of the plants grown from Bartram's seeds are in the collection.

The last of the Dillenian material about which I wish to speak is the manuscript "Classis of Water Plants". It consists of thirty-two pages evidently written while in England and probably before he went to Oxford. He divides the plants into two groups: (1) such as bear neither (conspicuous) flowers, nor seeds, but propagate themselves by young leaves, growing out of the sides of their mother plants; (2) Apetalous seed-bearing water plants.

The account of each genus begins with the etymology of the Latin name followed by a generic description with references to figures and literature. For each species there is a description, place, use, synonomy, and critical remarks. The strange thing is that the account of Class I (six pages) is in English, that of Class II is in Latin. Obviously the work was intended for publication but, though it seems a fair copy, was never finished.

The full account of these additional Dillenian manuscripts will supplement that given by Druce and Vines in their "The Dillenian Herbaria". At the present time, it is interesting to note that the preface to that work dated 1907 ends: "At a time when two great and partly estranged nations are being brought closer together, may this work, insignificant in itself, yet as being compiled in the twentieth century by a British student to bear witness to the eminent service rendered to Botanical science in this country by a German botanist in the eighteenth, be an augury for their more kindly feeling and cordial co-operation in the progress of science".

OXIDATION OF METALS AND THE FORMATION OF PROTECTIVE FILMS*

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A CHEMICAL process in which one of the reacting substances and also the product of the reaction are solid has one feature not shown when the product is gaseous or liquid; the product must necessarily form a barrier between the reacting substances, so that the reaction can only proceed either if the product is continually removed, or if the reacting substances can penetrate the barrier. In the oxidation of metals the rate of the reaction is almost entirely controlled by the rate at which metal or oxygen can penetrate the oxide layer. In general, as the oxide layer becomes thicker, the rate of reaction becomes slower. In some metals, notably aluminium, chromium and probably zinc below 225° C., oxidation stops altogether when the film has reached a thickness of the order of 10^{-6} cm., the protective film thus formed preventing further attack. The discussion of these protective films will be one of the chief purposes of this article.

Provided that one of the reacting substances can penetrate the oxide layer, we would expect that the primary process would be the formation of a fairly uniform film of oxide over the surface of the metal. In many cases, however, it seems certain that the oxide film breaks up as soon as it is formed, and recrystallizes in little islands scattered about the surface. The oxidation of zinc above 225° C. provides an example[1]. The oxide film shows a granular structure under the microscope, and does not show the interference colours obtained with compact oxide films on copper for example. Both facts point to the presence of a conglomerate of fairly large crystals of the type illustrated in Fig. 1(*b*) rather than a compact film. Electron diffraction experiments, moreover, reveal a well-defined crystalline structure.

The tendency of thin films on a substrate to recrystallize is well known, and is shown by the results obtained at Bristol by Appleyard[2], Lovell[3] and their co-workers on the conductivity of thin metal films evaporated on glass. Whereas it was found that by repeated degassing of the glass surface, and by depositing the metal at the temperature of liquid air, compact films of rubidium and cæsium could be obtained which would conduct electricity at a thickness corresponding to one or two atomic layers, other metals such as mercury, or alkali metals at higher temperatures, did not conduct until a thickness of about 500 A. was reached. It was concluded that the surface tension of the metal caused the splitting up of the

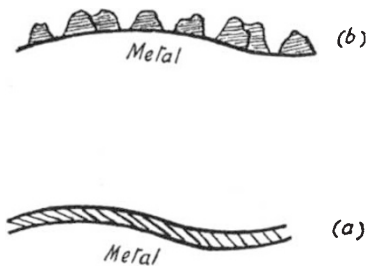

Fig. 1.

(*a*) A COMPACT FILM AND (*b*) A FILM THAT HAS UNDERGONE RECRYSTALLIZATION.

* Substance of a lecture delivered before the London Branch of the Institute of Physics on April 30.