distribution, especially, suggests that the north Indian deep water flows much farther south in the upper stratum of the warm deep layer, sandwiched between the Antarctic intermediate current and the Atlantic water. A chart of the oxygen distribution in the warm deep layer in the southern part of the Indian ocean, to be published in a forthcoming report by one of us (G. E. R. D.), shows that south of Africa the oxygen content of the deep layer falls rapidly towards the east, indicating that the Atlantic water is joined by a southward movement of water containing less oxygen from the northern part of the Indian Ocean.

A comparison of our section with that of Möller (her Mozambique section is along almost the same line as ours) suggests that the volume and salinity of the north Indian deep current are subject to large variation, probably related to the changes of salinity in the coastal regions and to the current differences brought about by the changes of the monsoon winds and variation in the south Equatorial current. The observations of the *Valdivia* and the *Ormonde* used by Möller show that the deep current fills the northern part of the Ocean with water of 35.00 per mille salinity as far as 8° S. and to a depth of 2000–2500 metres, while our section (Fig. 2) shows that this isohaline is not found south of the equator or deeper than 1500 metres. A strict comparison cannot be made between Thomsen's and our section, since

his is much farther east than ours, but the volume of the deep current seems to have been less when his observations were made, since he did not find the 34.80 per mille isohaline south of a line from Ceylon to Cape Delgado (1933, p. 78), whereas we found it to extend as far as 20° S.

Thus, as a result of the recent observations of the R.R.S. *Discovery II*, the extent of the southward flow of the north Indian deep current appears to be a compromise between the views of Möller and Thomsen. Oxygen observations in particular show (Fig. 4) that this current can be traced southwards as a tongue of poorly oxygenated water sandwiched between Antarctic intermediate water and an eastward current of north Atlantic deep water.

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A Century of Botany*

1835–1885–1935

By Prof. F. O. Bower, F.R.S.

IN 1835 Glasgow already possessed a botanic garden, which had been established in 1818 by Royal Charter. In this same year, the regius chair had also been founded. It was occupied in 1835 by its greatest tenant, Sir William Hooker, who after holding it for twenty years became, in 1841, the first director of the Royal Botanic Gardens at Kew. He was succeeded in that office by his son, Sir Joseph Hooker, who had been educated in this University. Thus Glasgow may be held as the cradle of the national establishment. Under the care of the professor, the Royal Botanic Garden of Glasgow had become a centre of high horticulture, and of the distribution of rare plants, many of them new to science. But there was in

1835 no Department of Botany in the old College. There were no laboratory, botanical museum, herbarium, or library, beyond what Hooker himself possessed, which was accommodated in his own private house. So when he was appointed as the first Director of Kew in 1841 he naturally took his collections with him, leaving the University wholly denuded; though Kew itself absorbed thus the finest private collections in the country.

A brief survey may be made of the state of botanical science in the world at large in 1835, when Sir William Hooker was in his fifteenth year of office at Glasgow, and in the full plenitude of his powers as a man of fifty. Nothing can be more revealing of the time than that while it was pre-evolutionary, it was also pre-protoplasmic. Though plant anatomy was well advanced, with

* From an address delivered on November 8 in the University of Glasgow by invitation, in celebration of the jubilee of Prof. Bower's appointment as regius professor of botany (April 1, 1885) and of Prof. Bower's eightieth birthday (November 4, 1935).

its foundations securely laid by Hooke and Grew in the seventeenth century, and though their observations had been extended in the eighteenth by the phytotomists of the Continent, it was only the scaffold of cell-walls that they knew: the vital body which those walls enclosed was almost wholly missed. Before 1835, sporadic allusions had already been made to a transparent slimy substance contained within the cell-walls. Interest had been taken in the movements of granules within it, and suggestions made of vital motion. But it was only in 1831 that the nucleus was first recognised by Robert Brown as a body of general occurrence in the cells of plants: while the structural correspondence of the cell contents with the sarcode of animals was first published by Schwann in 1839. Finally, it was not until 1846 that the word 'protoplasm' was introduced by von Mohl, to connote that "viscid fluid—of white colour—which occupies the cell-cavity". Thus the year 1835 fell within that short nascent period when the physical basis of life was emerging from obscurity towards definite visualisation, making modern physiology for the first time possible.

On the other hand, 1835 fell within the heroic age of scientific exploration: and Glasgow, through Sir William Hooker's son Joseph, took her full share. We may well hold the years from 1831 when the *Beagle* sailed with Darwin on board, or 1839 when Ross, with Joseph Hooker as a young medical officer, penetrated the Antarctic with the *Erebus and Terror*, to 1851 when Joseph Hooker completed his Indian journey—or better still 1852 when Wallace returned from the Amazon—as its golden period. Discovery was then in the air, with its handmaids collection and record. It opened with a tacit acceptance of the fixity of species, but it bore within the germ of evolutionary theory. Sir Joseph, in working out his circumpolar collections into the Antarctic flora, gave in 1859 expression to his belief in the mutability of species. This was the year of publication of Darwin's "Origin of Species". Sir Joseph was in fact the first of the great group who stood round him. Thus not only did 1835 fall within the nascent period of evolution, but also an alumnus of Glasgow, son of the some-time professor of botany, was himself deeply involved.

Sir William, however, belonged to a prior age. He never publicly committed himself to the later view of the mutability of species. He was essentially an old-fashioned systematist, with a particular leaning towards the mosses and ferns. He had already published his "British Jungermanniaceæ" in 1816, as well as important memoirs on mosses. But it was during the period in Glasgow that he produced with Greville the sumptuous

"Icones Filicum" (1851), and with the artist Ferdinand Bauer the preparatory work was being done there for the "Genera Filicum" (1842). Later came the "Species Filicum" (1846–64), a work which was finally condensed into the "Synopsis Filicum" (1865). These and other of his writings established Sir William's position as the leading systematic authority of his time on the Archeogoniatae. But he was also a general botanist, whose personal influence moulded the scientific establishment at Kew. Robert Brown still reigned at the British Museum. The effect of their work spread to the universities, with the result that between 1835 and 1885 descriptive and systematic botany held the field in Britain.

My second date, 1885, also marks a nascent period, but the conditions were very different from those of 1835. The intervening half century had brought in Britain, as the result of foreign travel, great accessions to its herbaria. The systematic treatment of these, particularly as published in floras of the British possessions, had occupied the time and capacities of our professional botanists to such a degree as almost to paralyse efforts in other branches of the science. Not only Kew and the British Museum, but the universities as well, were drawn into the floristic vortex. In Glasgow itself a notable result was the "Flora Indiae Orientalis", in which Prof. Walker Arnott described the rich Indian collections made by Wight. It was published in their joint names. But, meanwhile, on the Continent, and particularly in Germany where imperial demands were not so pressing, laboratories private and public were opening. The branches of minute anatomy, physiology and development of plants were advancing rapidly. In particular, Schleiden, Hofmeister, Naegeli and Pringsheim were laying afresh the foundations of morphology, broadly based upon the study of anatomy and developmental life-histories. Physiology was rejuvenated under the genius of Sachs. Tulasne and De Bary were meanwhile establishing a new cult of mycology, while Bornet and Thuret were doing the like among the algæ. Our own universities, however, concentrated their botanical teaching in the 'sixties and 'seventies upon the classes for medical students. The professors based their rather limited syllabus not on the biological side of the science so much as on the floristic and pharmaceutical. The idea of tropical forests and desert islands, of Crusoe and the Swiss Family Robinson hovered in the background. There were before 1870 no botanical laboratories in the British universities. Floristic and systematic botany, with dashes of pharmacy, morphology and economics made up the usual fare offered to the student. The individual professor might take what

special branch of study he pleased : but this rarely filtered through, as a private act of grace, to the individual pupil. In point of fact, Britain had fallen behind in all branches excepting systematic botany, in which she excelled.

The revival of biology, and of its branches of zoology and botany, was initiated in Britain by Huxley, Michael Foster and Thiselton-Dyer : but an important preliminary step was taken by Dean Farrar, himself at the time a public-school master. He advocated the teaching of science in schools, at the British Association meeting at Nottingham in 1866, with Huxley in the chair. Little result followed at first in the old public schools or in the universities. It was, in fact, through the national schools that the revival began. If science was to be taught there, the teachers must themselves be taught first. This led to the classes for teachers at South Kensington, organised under Huxley from 1871 onwards. The essential feature of his method was a daily preparatory lecture, followed by personal observation by each student. Thiselton-Dyer undertook the botanical side and Vines, originally a medical student in London, assisted him : by his election as a scholar of Christ's College, Vines formed the connecting link with Cambridge. Marshall Ward soon stood out among the early pupils at South Kensington, and later he also was entered as a scholar of Christ's. He and I, as fellow students at Cambridge under Vines, soon found places on the demonstrating staff to the summer classes at South Kensington.

This revival in the 'seventies spread with varying success to the English universities : but Huxley's methods caught on less readily in Scotland. The northern lag was, however, made up in Glasgow by the appointment of Bayley Balfour, fresh from foreign travel and visits to German laboratories, as professor of botany there in 1879. When I succeeded him in 1885, also having experience of foreign universities, and after three years' experience as lecturer at South Kensington, elementary practical classes of Huxley's type were already in being in London and elsewhere for the study of the 'New Botany' : my duty was to develop them in Glasgow.

All this sounds very easy now : but the revival that spread from South Kensington found opposition like any other missionary effort. "The Cause", as Marshall Ward used to call it, involved a change over from the dead to the living plant : from the herbarium, supported by study in the garden and field, to observation at the laboratory table by each student himself. Structure, function, development and life-history were to be examined, and that not only in flowering plants, but in the cryptogams as well.

In 1885 there were in the Scottish universities no faculties or degrees in science : nor were there any advanced classes under ordinance. In Glasgow, botany was studied officially only in the summer. Not only was the time then devoted to botany in Glasgow limited, but also the space available for its study. The Department in 1885 consisted of two small rooms used as voluntary laboratories, and dusty attics for the herbarium. There was no lecture room, but such as could be borrowed from another department. I paid my own assistant and laboratory attendant. There was no official staff, not indeed any department at all in the modern sense. In theory this was corrected under the Act of 1889 : nevertheless, for sixteen years after my appointment the accommodation remained the same. It was not until 1901 that the new building was opened.

Great as were these official and material defects in Glasgow in 1885, that date again fell within a nascent period in the history of botany in Britain. The first English edition of Sachs's "Textbook" had been published in 1875 : the translation of De Bary's "Anatomy" followed in 1884, and that of Sachs's "Lectures on Physiology" in 1887. Thus the student of the British revival was supplied with fresh textbooks. His observational work was also vivified by the experience of teachers who had studied personally under these great men. Beyond this, many new starts were already in the air. Tangl had demonstrated in 1880 the continuity of protoplasm from cell to cell, and Gardiner extended these results so that Sachs found himself able in 1882 to state that "every plant, however highly organised, is fundamentally a protoplasmic body forming a connected whole".

On the other hand, in 1874, Schwendener had given a new aspect to anatomy by demonstrating the mechanical principles that underlie structure : while Haberlandt further stimulated the functional study of tissues by his "Physiologische Pflanzenanatomie" of 1884. At the same time, from the Buitenzorg garden, Treub was revealing the wonders of Lycopod embryology, with their bearing upon the morphology of the Archegoniatae. At Bonn, Strasburger had already laid the foundation for cytology by his inquiry into the minute details of nuclear division. The third edition of his "Zellbildung und Zelltheilung" had appeared in 1880, while statistical hybridisation, the experimental correlative of nuclear division, had already been initiated by Mendel in 1865, though the world did not know of his results until 1900. Finally, it was in 1885 that Weismann's pronouncement on germplasm was published. Thus at our second period many new lines of advance were being opened up.

Such was the developmental phase of the science of botany when I accepted the Glasgow chair in 1885. Botany was no longer a valley of dry bones: a progressive and living aspect had been given to it. But at Kew and the British Museum great systematists still upheld the old classificatory traditions: and there appeared to be some danger of British botanists separating into two camps—as systematists or as physiologists. On the Continent, however, an ameliorating influence sprang from the work of Warming, who combined

under the name of ecology the records of function and of distribution: thus presenting to systematists a living aspect of their study. Here at home Sir Joseph Hooker was the Colossus who had a foot down in both camps. It was, in fact, a forecast of ecology that he had practised in the Antarctic. But he was never a teacher, nor did Kew compete with the colleges, which had drifted off with a dangerous and almost exclusive bias towards the 'New Botany'.

(*To be continued.*)

Progress of Food Investigation

AS in previous years, the report of the Food Investigation Board for 1934* describes the researches carried out at the various research stations of the Board by the members of the food investigation staff and emphasises the ways in which laboratory results have been applied commercially. Sir Frank Smith was appointed chairman of the Board, in succession to Sir Joseph Broodbank, who resigned; Mr. E. Barnard was appointed director of food investigation and Dr. Franklin Kidd superintendent of the Low Temperature Research Station, in succession to the late Sir William Hardy. That the work of the Board is of value to all parts of the Empire has been signally recognised by the contributions made by Dominion Governments, which amount to nearly £10,000 a year, and show the wide extent to which Imperial co-operation in this field of research has already grown.

The discovery that beef can be stored in the chilled state for 60–70 days when the atmosphere contains 10 per cent of carbon dioxide has quickly led to the importation of considerable amounts of chilled beef from Australia and New Zealand; during 1934, no less than 4,400 tons were imported in gas storage from these two Dominions, and it is now practicable to secure the necessary gas-tightness in the holds. At the same time, the careful preparation of the meat and the hygiene of the slaughterhouse floor are probably of even more importance than control over the conditions of transport.

A number of problems, however, remain for solution, including the correct storage to prevent chafing, and the proper conditions as regards cooling, humidity and air circulation for the preservation to the fullest extent of the natural appearance or bloom of the meat. Loss of bloom is largely due to the oxidation of hæmoglobin

to methæmoglobin; the reaction is monomolecular with respect to the concentration of reduced hæmoglobin and roughly monomolecular with respect to the partial pressure of oxygen; the rate is maximal at a partial pressure of about 23 mm. of carbon dioxide. The results show that 10 per cent of carbon dioxide in the atmosphere has a negligible effect, but with this concentration that of oxygen must be increased to more than 60 per cent if the production of methæmoglobin is to be appreciably retarded.

Important developments have taken place during the year in the application of refrigeration to the herring industry. Experiments had shown that herring, although containing much more fat than white fish, could be brine frozen at the usual temperature of -5°F. , and would make good kippers after at least five months' storage at that temperature. 800 tons of herrings were then frozen in one of the East Coast factory ships with the view of using them for kippering, for canning and for consumption fresh during the early months of this year (1935) when home-caught herrings are not normally available.

The gas-storage of home-grown fruit has gone on apace. During 1934 the number of commercial gas-stores in Great Britain increased from 12 to 40, and the number has probably doubled in the course of the succeeding twelve months. It has been found that the winter temperatures of English warehouses are too low for the satisfactory ripening of several varieties of imported pears and plums. Conditioning for a brief period at a temperature of 70°F. , however, greatly improved the quality of South African and Australian William pears and of South African Kelsey plums. The best conditions for commercial conditioning have yet to be ascertained, but there is little doubt that conditioning will soon be considered essential for the successful marketing of certain varieties of imported pears and plums.

* Department of Scientific and Industrial Research. Report of the Food Investigation Board for the year 1934. Pp. 261+x. (London: H.M. Stationery Office, 1935.) 4s. net.