

Lamps," by H. Smithson and E. R. Sharp; "English and American Lathes," by Joseph Horner; "Inspection of Railway Materials," by G. R. Bodmer; "The Modern Safety Bicycle," by H. A. Garratt; "Volumetric Chemical Analysis," by J. B. Coppock; "Elementary Practical Chemistry," by A. J. Cooper; new and revised editions of "The Atlantic Ferry," by A. J. Maginnis; "British Locomotives," by C. J. Bowen-Cooke; "Electric Light Cables," by Stuart A. Russell.

THE BRITISH ASSOCIATION.

SECTION K.

BOTANY.

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II.

THE second period of our history begins with the arrival in India in 1848 of Sir (then Dr.) Joseph Hooker. This distinguished botanist came out in the suite of Lord Dalhousie, who had been appointed Governor-General of India. The province to the exploration of which Sir Joseph directed his chief attention was that of Sikkim in the Eastern Himalaya, the higher and inner ranges of which had never previously been visited by a botanist, for Griffith's explorations had been confined to the lower and outer spurs. The results of Sir Joseph's labours in Sikkim were enormous. Towards the end of his exploration of Sikkim he was joined by Dr. Thomas Thomson, and the two friends subsequently explored the Khasia Hills (one of the richest collecting grounds in the world), and also to some extent the districts of Sylhet, Cachar and Chittagong. Dr. Thomson subsequently amalgamated the collections made by himself in the Western Himalaya with those made in Sikkim by Sir Joseph individually, and by them both conjointly in Eastern India; and a distribution of the duplicates after the fashion of the Wallichian issue, and second only to it in importance, was subsequently made from Kew. The number of species thus issued amounted to from 6000 to 7000, and the individuals were much more numerous than those of the Wallichian collection. The immediate literary results of Sir Joseph Hooker's visit to Sikkim were (1) his superbly illustrated monograph of the new and magnificent species of *Rhododendron* which he had discovered; (2) a similar splendid volume illustrated by plates founded on drawings of certain other prominent plants of the Eastern Himalaya which had been made for Mr. Cathcart, a member of the Civil Service of India, and (3) his classic "Himalayan Journals"—a book which remains until this day the richest repertory of information concerning the botany, geography and anthropology of the Eastern Himalaya. A remoter result was the appearance in 1855 of the first volume of a "Flora Indica," projected by himself and his friend Dr. Thomson. The first half of this volume is occupied by a masterly introductory essay on Indian botany, of which it is hardly possible to overrate the importance. This remarkable essay contains by far the most important contribution to the physico-geographical botany of India that has ever been made, and it abounds in sagacious observations on the limitation of species and on hybridisation, besides containing much information on the history of Indian botanical collections and collectors. The taxonomic part of the book was cast in a large mould, and the descriptions were written in Latin. Unfortunately, the condition of Dr. Thomson's health and the pressure of Sir Joseph's official duties at Kew made it impossible that the book should be continued on the magnificent scale on which it had been conceived. After a period of about twelve years Sir Joseph, however, returned to the task of preparing, with the aid of other botanists, a Flora of the Indian Empire, conceived on a smaller scale and written in the English language. His proposals for this work were accepted and officially sanctioned by the Duke of Argyll while he was Secretary of State for India. The first part of this great work was published in 1872 and the last in 1897. In the execution of this great undertaking Sir Joseph had the assistance of Mr. C. B. Clarke, who elaborated various natural orders; of Mr. J. G. Baker, who worked out *Leguminosae* and *Scitamineae*, and of Sir W. Thiselton-Dyer, Messrs. A. W. Bennett, Anderson,

¹ Continued from p. 584.

Edgeworth, Hiern, Lawson, Maxwell Masters, Stapf and Gamble. The greater proportion, however, of the book is Sir Joseph's own work, and a noble monument it forms of his devotion and genius.

Since the date of Sir Joseph Hooker's visit to India, by far the most important botanical work done in India has been that of Mr. C. B. Clarke. Rather than attempt to give any appreciation of my own of Mr. Clarke's labours (which would be more or less of an impertinence), I may be allowed to quote from the preface to the concluding volume of the "Flora of British India" Sir Joseph's estimate of them. Referring to all the collections received at Kew since the preparation of the "Flora" was begun, Sir Joseph writes: "The first in importance amongst them are Mr. C. B. Clarke's, whether for their extent, the knowledge and judgment with which the specimens were selected, ticketed, and preserved, and for the valuable observations which accompany them." Mr. Clarke has published numerous papers on Indian botanical subjects in the journals of the Linnean and other societies. He has issued as independent books monographs of Indian *Cypositae* and *Cyrtandraceae*, the former in octavo, the latter in folio, and illustrated by many plates; and he is now engaged on his *opus maximum*, viz. a monograph of the *Cyperaceae*, not only of India, but of the whole world; and to the completion and publication of this every systematic botanist is looking forward with eager anxiety.

During this second half of the century, Dr. Thomas Anderson, who was for ten years superintendent of the Calcutta Garden, collected much; and he had just entered on what promised to be a brilliant career of botanical authorship when his life was cut short by disease of the liver, contracted during his labours to establish the cultivation in British India of the quinine-yielding species of cinchona. Dr. Anderson was also the earliest conservator of forests in Bengal. Sulpiz Kurz, for many years curator of the Calcutta Herbarium, also collected largely in Burma, and besides many excellent papers which he contributed to the *Journal* of the Asiatic Society of Bengal, he prepared for Government an excellent manual entitled the "Forest Flora of Burma." This was published in two volumes in 1877. Other collectors in Burma were Colonel Eyre (in Pegu), Mr. Burness (at Ava), and the Rev. Mr. Parish, to whom horticulturists are indebted for the introduction to Europe of the beautiful orchids of this rich province. And in this connection must be mentioned Mr. E. H. Man, C.I.E., who, although not himself a botanist, has given for many years past the greatest possible help in the botanical exploration of the Andaman and Nicobar groups of islands, our first knowledge of which was, by the way, derived from the collections made by the naturalists of the Austrian and Danish exploring expeditions. A large book on Burma, which contains a good deal of botany, was published by an American missionary named Mason, who resided for the greater part of his working life in that country. General Sir Henry Collett, who commanded a brigade during the last Burmese war, also made most interesting collections in that country, the novelties of which were described by himself in collaboration with Mr. W. Botting Hemsley, of the Kew Herbarium, in the Linnean Society's *Journal* some years ago. Sir Henry Collett also collected much in the Khasia and Naga hills, and in the portion of the North-western Himalaya of which Simla is the capital, and on these latter collections, together with the materials in Kew Herbarium, Sir Henry is now elaborating a local flora of Simla. The preparation of a local flora for an Indian district is an entirely new departure, and the publication of Sir Henry's book, which is to be well illustrated, is looked forward to with much interest. At rather an earlier period, Dr. Aitchison was a diligent collector of the plants of the Punjab and of the North-western Frontier. Some results of his work are to be found in his "List of Punjab Plants," which was published in 1867, and in various papers which he contributed (some of them in conjunction with Mr. Hemsley) to the Linnean Society and to the Botanical Society of Edinburgh. In Dr. G. Henderson's book on Yarkand there are also descriptions of some plants of the extreme North-western Himalaya and of Western Tibet. Mr. (now Sir George) Birdwood also made some contributions to the botany of the Bombay Presidency.

Five officers of the Indian Forest Department, viz. Dr. Lindsay Stewart, Colonel Beddome, Sir D. Brandis, and Messrs. Talbot and Gamble, have within the past thirty years made important contributions to the systematic botany of India. Dr.

Stewart collected largely, and published in 1869 his "Punjab Plants," a book which gives a very imperfect impression of his acquirements as a botanist. Sir Dietrich Brandis issued in 1874 his admirably accurate "Forest Flora of the North-west Provinces of India," illustrated by seventy excellent plates. Between the years 1869 and 1873, Colonel Beddome issued his "Flora Sylvatica of the Madras Presidency," illustrated by numerous plates. He also published, between 1869 and 1874, a volume of descriptions and figures of new Indian plants, under the title "Icones Plantarum Indiæ Orientalis." Colonel Beddome is the only Indian botanist of note, except Griffith, Mr. C. B. Clarke and Mr. C. W. Hope, who has written much on Indian ferns. His two works, the "Ferns of Southern India" and the "Ferns of British India," published the former in 1863 and the latter between 1865 and 1870, practically give a systematic account, together with excellent figures, of the whole fern flora of India. Of these excellent books a condensation in a popular and abridged form has also been issued. The fourth forest officer who has published contributions to systematic botany is Mr. W. A. Talbot, whose "List of the Trees, Shrubs and Woody Climbers of the Bombay Presidency" gives evidence of much careful research. And the fifth is Mr. J. S. Gamble, who, besides amassing at his own expense probably the largest private collection of plants ever owned in India, has published a systematic account of the Indian *Bambuseae*, a tribe of grasses which, from the peculiarity of many of the species in the matter of flowering, had so long been the bane of the Indian agrostologist. Mr. Gamble, in his monograph, gives a description and a life-sized figure of every one of the Indian species. Of this monograph (which forms a volume of the "Annals of the Botanic Garden, Calcutta") Sir Joseph Hooker writes (at p. 375, vol. vii. of his "Flora of British India"): "It is indispensable to the student of the tribe by reason of its descriptions and admirable plates and analyses." Mr. Gamble has also published a Manual of Indian Timbers. A forest officer who was ever ready to help in botanical work, but who never himself published, was Mr. Gustav Mann, for many years Conservator of Forests in Assam, but now lost to India by his premature retirement. Other forest officers, who have done, and are still doing, good botanical work in their various spheres, are Messrs. Lacey, Heinig, Haines, McDonnell, Ellis, Oliver, and Upendra Nath Kanjilal. Mr. Bourdillon, conservator of forests in the Travancore State, is also an enthusiastic botanist and collector.

In the Madras Presidency botanical work has been carried on during this second half of the century by Noton, Perrottet, Metz, Hohenacher, Schmidt (on the Nilgiris), Bidie and Lawson. By the efforts of the latter two, a second public herbarium was established in Madras (the first having been broken up many years ago), and in this second Madras herbarium are to be found many of the collections of Wight, besides those of the other Madras botanists just named.

In the Bombay Presidency, the only public herbarium is at Poona. This is of recent origin, and owes its existence to the devotion of four men, viz. Dr. Theodore Cooke (late principal of the College of Science at Poona), Mr. Marshall Woodrow (until recently superintendent of the garden at Guneshkind and lecturer in botany in the Poona College), the late Mr. Ranade (a native gentleman), and Dr. Lisboa (a medical practitioner in the Deccan)—all four enthusiastic botanists. The amount of Government support given to the herbarium at Poona has hitherto been very inadequate. It is to be hoped that greater liberality may be extended to it now that a stranger to the Bombay Presidency has just been appointed to its charge in the person of Mr. George Gammie, hitherto employed in the cinchona department of Bengal.

Reference has already been made to the botanic gardens at Seharunpore and Calcutta. But to complete this sketch, and especially in order to give a clear idea of the apparatus at present existing in India for carrying on the study and practice of systematic botany, it is necessary again to refer to them. On the retirement of Dr. Jameson in 1872, Mr. J. F. Duthie was selected by the Secretary of State for India as superintendent of the Seharunpore garden. Mr. Duthie is still at Seharunpore. During his tenure of office he has added to the herbarium previously existing there (which consisted chiefly of the collections of Royle, Falconer and Jameson) a magnificent collection of his own. Mr. Duthie has published a valuable book on the "Field and Garden Crops of the North-western Provinces," and another on the grasses of the same area. He is now en-

gaged on the preparation of local floras of the North-west Provinces and of the Punjab.

The Calcutta Garden at the date of Sir J. D. Hooker's arrival in India in 1848 was under the charge of Dr. Falconer, who, in 1855, was succeeded by Dr. J. Thomson, and he in turn by Dr. T. Anderson in 1861. Mr. C. B. Clarke acted as superintendent during the interregnum between Dr. Anderson's lamented death in 1870 and my own appointment in 1871. The garden and herbarium at Calcutta have been most liberally supported by the Government of Bengal. By funds thus supplied the garden has been remodelled and improved; the herbarium has been housed in an excellent fire-proof building (erected in 1883), and the collections of which it consists have been greatly increased. The chief items of these later acquisitions have been the large contributions of Mr. C. B. Clarke; of Dr. D. Prain, for many years curator of the herbarium, and now superintendent of the garden and of the cinchona plantation and factory; of Mr. G. A. Gammie, formerly one of the staff of the cinchona plantation, and now lecturer on botany in the College of Science at Poona; of Mr. R. Pantling, deputy-superintendent of the cinchona plantation, who, in addition to dried specimens of the orchids of Sikkim, contributed nearly five hundred drawings, most of which have been lithographed as the illustrations to a book published in the "Annals" of the garden, as the "Orchid Flora of Sikkim"; of Mr. Kunstler, a collector in the Malay Peninsula; and last, but by no means least, of a trained band of aborigines of Sikkim named Lepchas who possess keener powers of observation of natural objects, more patience, sweeter tempers, and, I am bound in fairness to add, dirtier clothes than any race I have ever met—black, yellow, or white! In addition to their liberal grants to the garden and herbarium, the Bengal Government, twelve years ago, sanctioned the publication, at their expense, as occasion might offer, of monographs of important families or genera of Indian plants. These monographs are printed in quarto, and they are, with one exception, profusely illustrated by plates drawn and lithographed by Bengali draughtsmen. The series is known as "The Annals of the Royal Botanic Garden, Calcutta," and it has now reached its eighth volume, the ninth being in active preparation. These "Annals" have been contributed to by Dr. Prain (my successor at the Calcutta Garden), by Dr. D. Douglas Cunningham, Mr. J. S. Gamble, Mr. R. Pantling, and myself.

About ten years ago, it occurred to the Supreme Government of India that it might be to the interest of science if the four botanical establishments at Calcutta, Seharunpore, Madras, and Poona were to be formed into a kind of hierarchy under the designation of the Botanical Survey of India, without removing either the officers or the four institutions to which they were attached from the financial or general control of the local administrations within which they are respectively situated, the Supreme Government making a small contribution of money for the purpose of exploring little-known districts and making itself responsible for the cost of a publication called "The Records of the Botanical Survey." The four institutions just mentioned continue, therefore, to be paid for and controlled by the Governments of Bengal, the North-west Provinces, Madras and Bombay, but their superintendents are placed on the cadre of the Botanical Survey. The published Records of this Survey now extend to twelve numbers, each of which is devoted to an account of the botany of some part of the enormous and continually expanding area to be explored.

Such, then, is the machinery by which systematic, as distinguished from economic and physiological, botany is carried on within the Indian Empire. But the work done in India itself by no means represents all the work that is being carried on in connection with the elucidation of the flora of the Empire of India. On the contrary, the bulk of the work of elaborating the materials sent from India in the shape of dried specimens has always been, and must always be, done in a large herbarium; and until lately no herbarium in Asia has been sufficiently extensive. The last word on every difficult taxonomic question must still lie in Europe. A very large number of the herbarium specimens collected in India have found their way to the various centres of botanical activity in Europe, and have been described by botanists of many nationalities. The lion's share of these specimens has naturally come to the two great national herbaria in the British Museum and at Kew, but especially to the latter. It was in the Kew Herbarium that Sir Joseph Hooker and his collaborateurs prepared the flora of

British India. And it is in the Kew Herbarium that are to be found the types of an overwhelming proportion of the new species described for the first time in that monumental work. The Kew Herbarium is therefore to the Indian botanist the most important that exists. I must apologise for diverging for a moment to remind you what a type specimen is. It is the very one on which an author has founded any species to which he has given a name. And in order to determine absolutely what is the specific form to which the author meant his name to apply, it is often necessary to examine his type. This necessity increases in urgency with the extension of our knowledge of the flora of the world.

The preservation in good condition of a type specimen is therefore, from the point of view of a systematic botanist, as important as is the preservation to the British merchant to the standard pound weight and the standard yard measure on which the operations of British commerce depend. "Types" also stand to the systematic botanist much in the same relation as the national records do to the national historian. The latter are guarded in the Record Office, I understand, with all the skill which the makers of fire-proof, damp-proof and burglar-proof depositories can suggest. If, however, the type of a species happens to be deposited at Kew, what are the probabilities of its preservation? Such a type at Kew is incorporated in what is admitted to be in every sense the largest and, for its size, the most accurately named, the most easily consulted, and therefore the most valuable herbarium in the world, the destruction of which would be a calamity commensurate in extent with that of the burning of the library at Alexandria. One might therefore reasonably expect that a people who rather resent being called a "nation of shopkeepers" would feel pride in providing for this priceless national collection a home which, although perhaps somewhat inferior to that provided for the national historical records, might at least be safe from fire. This expectation is not fulfilled. The infinitely valuable Kew Herbarium and library have no safer home than an old dwelling-house on Kew Green, to which a cheap additional wing has been built. The floor, galleries and open inner roof of this additional wing are constructed of pine coated with an inflammable varnish, and on the floor and galleries are arranged cabinets (also made of pine-wood) in which the specimens (which are mounted on paper) are lodged. The provision of a fireproof building, capable of expansion as the collections extend, is surely not beyond the means of an exchequer which last year netted over one hundred and six millions sterling of revenue. On behalf of the flora of India, I venture to express the hope that the provision of a proper home for its types may receive early and favourable consideration by the holders of the national purse-strings. But India is by no means the only portion of the Empire interested in this matter, for the types of the Australasian floras, those of a large part of the North American flora, and those of many species inhabiting countries outside British rule or influence, find their resting-place at Kew. The safe custody of the Kew Herbarium is, therefore, not merely a national, but a cosmopolitan responsibility.

In this Address I have hitherto made little reference to cryptogamic and economic botany. As regards cryptogamic botany there is little to relate. Except Griffith, no Indian botanist of the earlier of the two periods into which I have divided my sketch ever did any serious work amongst non-vascular cryptogams. During the second period two men have done gallant work under difficulties which no one who has not lived in a tropical country can thoroughly appreciate. I refer to Drs. Arthur Barclay and D. D. Cunningham. The former made some progress in the study of uredinous fungi, which was cut short by his untimely death; while the latter, in addition to his bacterial and other researches connected with the causation of human disease, conducted protracted investigations into some diseases of plants of fungal or algal origin. Some of the results of Dr. Cunningham's labours were published in the *Transactions* of the Linnean Society, and in a series entitled the "Scientific Memoirs, by Medical Officers of the Indian Army." To the "Annals of the Botanic Garden, Calcutta," Dr. Cunningham also contributed elaborate memoirs on the phenomena of nyctitropism, and on the mode of fertilisation in an Indian species of *Ficus* (*F. Roxburghii*). There is no doubt that, in the past, cryptogamic botany has not been studied in India as it ought to have been and might have been. This discredit will, I hope, be soon removed; and I trust that, by the time the twentieth century opens, a cryptogamist may have been appointed to the

staff of the Calcutta Botanic Garden. The collecting of cryptogams was not, however, altogether neglected in India in times past. For, from materials sent to England, Mitten was able to elaborate a moss flora of India, while Berkeley and Browne were enabled to prepare their account of the fungi of Ceylon. George Wallich, in whom the botanical genius of his father burnt with a clear though flickering flame, did some excellent work amongst Desmids, and was among the earliest of deep-sea dredgers.

Economic botany has, on the other hand, by no means been neglected. It was chiefly on economic grounds that the establishment of a botanic garden at Calcutta was pressed upon the Court of Directors of the East India Company. And almost every one of the workers whose labours I have alluded to has incidentally devoted some attention to the economic aspect of botany. Roxburgh's "Flora Indica" contains all that was known up to his day of the uses of the plants described in it. Much of Wight's time was spent in improving the races of cotton grown in India. The botanists of the Seharunpore garden during the middle of the century were especially prominent in this branch of botanical activity. Royle wrote largely on cotton and on other fibres, on drugs, and on various vegetable products used, or likely to be of use, in the arts. These botanists introduced into the Himalayas more than fifty years ago the best European fruits. From gardens which owe their origin to Royle, Falconer and Jameson, excellent apples grown in Gharwal and Kamaon are to-day purchasable in Calcutta. Peaches, nectarines, grapes, strawberries, of European origin, are plentiful and cheap all over the North-west Himalaya, and are obtainable also in the submontane districts. Potatoes, and all the best European vegetables, were introduced long ago; and at Seharunpore there is still kept up a large vegetable garden from which seeds of most European vegetables are issued for cultivation during the cold season in the gardens of the various regiments of the Queen's troops quartered in Upper India. More or less attention has been given in the past by Government botanists in India generally to the improvement of the cultivation of flax, hemp, rhea, tobacco, henbane, dandelion, vanilla, sarsaparilla, coffee (Arabian and Liberian), cocoa, ipecacuanha, aloe, jalap, india-rubber, Japanese paper-mulberry, cardamoms, tapioca, coca, tea and cinchona. Only to three economic enterprises, however, have I time to allude in any detail. These are (1) the cultivation of tea, (2) the introduction of cinchona, and (3) the formation of the Forest Department. But before proceeding to the consideration of these I wish to give a short account of the inauguration of the office of Reporter on Economic Products. Up to the year 1883 there had been no special Government department in India for dealing with questions connected with the natural products of the Empire. Whatever had been done prior to that date (and the amount was by no means unimportant) had been the result of isolated and uncoordinated effort. In 1883 the Government of India founded a department for dealing with the economic products of the Indian Empire, and under the title of Reporter on these products they were fortunate enough to secure Dr. George Watt, a member of the Bengal Educational Service. Dr. Watt is an accomplished and able botanist. He has collected Indian plants largely, and has made numerous notes both in the field and in the bazaar. The great work which, on the initiative of Sir Edward Buck, Secretary to the Department of Revenue and Agriculture, and of Sir W. Thiselton-Dyer, of Kew, Dr. Watt began and carried to a successful termination was the compilation of his "Dictionary of Economic Products," in which valuable book is collected all that is known of almost every Indian product, whether vegetable, animal or mineral. The study of economic botany is now pursued in India as part of a highly specialised system of inquiry and experiment. Dr. Watt has a competent staff under him in Calcutta, one of whom is Mr. D. Hooper, well known for his original researches into the properties of various Indian drugs. Dr. Watt has arranged in Calcutta a magnificent museum of economic products, and there is no doubt the economic resources of the Empire are now being studied with as much energy as intelligence.

Tea cultivation is one of the enterprises in the introduction and development of which botanists took a very leading part. The advisability of introducing the industry was first pressed on the attention of the East India Company by Dr. Govan (of Seharunpore), and in this he was seconded by Sir Joseph Banks as President of the Royal Society. Royle in 1827, and Falconer

slightly later, again urged it as regards the North-west Himalaya. In 1826 David Scott demonstrated to rather unwilling eyes in Calcutta the fact that real tea grows wild in Assam. In 1835 Wallich, Griffith and McClelland were deputed by Government to visit Assam, to report on the indigenous tea. In the year 1838 the first consignment of Indian-grown tea was offered for sale in London. The consignment consisted of twelve chests containing 20 lbs. each. This first sample of 240 lbs. was favourably reported upon. Last year the exports of tea from India to all countries reached 157 millions of pounds, besides 120 millions of pounds exported from Ceylon!

The introduction of cinchona into India originated purely with the Government botanists. As everybody knows, quinine, and to a less extent the other alkaloids present in cinchona bark, are practically the only remedies for the commonest, and in some of its forms one of the most fatal, of all Indian diseases, viz. *malarious fever*. The sources of supply of the cinchona barks in their native countries in South America were known to be gradually failing, and the price of quinine had for long been increasing. The advisability of growing cinchona in the mountains of British India was therefore pressed upon Government by Dr. Royle in 1835, and he repeated his suggestions in 1847, 1853 and 1856. Dr. Falconer, in his capacity of superintendent of the Botanic Garden, Calcutta, made a similar suggestion in 1852; and his successors at Calcutta, Dr. T. Thomson and Dr. T. Anderson, in turn advocated the proposal. In 1858 Government at last took action, and, as the result of the labours of Sir Clements Markham and Sir W. J. Hooker, of Kew, the medicinal cinchonas were finally, in the period between 1861 and 1865, successfully introduced into British India—on the Nilgiris under Mr. McIvor, and on the Sikkim-Himalaya under Dr. T. Anderson. Various experiments on the best mode of utilising the alkaloids contained in red cinchona bark resulted in the production in 1870 by Mr. Broughton, quinologist on the Nilgiri plantation, of an amorphous preparation containing all the alkaloids of that bark. This preparation was named *Amorphous Quinine*. Somewhat later (1875) a similar preparation, under the name of *Cinchona Febrifuge*, was produced at the Sikkim plantation by Mr. C. H. Wood, the quinologist there; and of these drugs about fifty-one tons have been distributed from the Sikkim plantation up to the end of last year. The preparation of pure quinine from the yellow cinchona barks, so successfully grown in the Sikkim plantation, long remained a serious problem. The manufacture of quinine had hitherto been practically a trade secret. And when the Indian Government had succeeded in providing the raw material from which a cheap quinine might be made for distribution amongst its fever-stricken subjects, the knowledge of the means of extracting this quinine was wanting. Philanthropic platitudes were freely bandied about as to the immensity of the boon which cheap quinine would be to a fever-stricken population numbering so many millions. But there was a singular absence of any practical help in the shape of proposals, or even hints, as to how quinine was to be extracted from the rapidly increasing stock of crown and yellow bark. The officers in charge of the cinchona plantations in India had therefore to do their best to solve the problem for themselves. And it was ultimately solved by Mr. C. H. Wood, at one time Government quinologist in Sikkim, who suggested, and Mr. J. A. Gammie, deputy-superintendent of the plantation there, who carried into practice, a method of extraction by the use, as solvents of the cinchona alkaloids, of a mixture of fusel-oil and petroleum. The details of this process were published in the *Calcutta Official Gazette*, for the benefit of all whom it might concern. Very soon after the introduction of this method of manufacture, the Government factories in Sikkim and the Nilgiris were able to supply the whole of the Government hospitals and dispensaries in India with all the quinine required in them (some 5000 or 6000 pounds annually), besides providing an almost equal quantity for the supply of Government officers for charitable purposes. The latest development of the quinine enterprise in India has been the organisation of a scheme for the sale at all the post-offices in the province of Bengal, and in some of those of Madras, of packets each containing five grains of pure quinine, that being a sufficient dose for an ordinary case of fever in a native of India. These packets (of which some are on the table for distribution) are sold at one pice each, the pice being a coin which is equal, at the current rate of exchange, to one farthing sterling!

In conclusion, I wish to make a few remarks on the third great

economic enterprise connected with botany in India, viz. the Forest Department. The necessity for taking some steps to preserve a continuity of supply of timber, bamboos and other products from the jungles which had for generations been exploited in the most reckless fashion, was first recognised by the Government of Bombay, who in 1807 appointed commissioners to fix the boundaries of and to guard the forests in that Presidency. This scheme was abandoned in 1822, but was resumed in a modified form during 1839-40. Seven years later a regular forest service was established in Bombay, and Dr. Gibson was its first head. Dr. Gibson in turn was succeeded by Mr. Dalzell—and both were botanists. In the Madras Presidency the first man to recognise the necessity of perpetuating the supply of teak for ship-building was Mr. Connolly, collector of Malabar, who in 1843 established a teak plantation at Nelumbur, which has been carried on, and annually added to, down to the present time. In 1847 Dr. Cleghorn (a botanist) was appointed to report on the conservation of the forests of Mysore (which contained the well-known sandal-wood), and the following year Lieutenant Michael (still with us as General Michael, a hale and hearty veteran) was appointed to organise and conserve the public forests in Coimbatore and Cochin. The crowning merit of General Michael's administration was the establishment, for the first time in India, of a system of protection against the fires which annually used to work such deadly havoc. In 1850 the British Association, at their Edinburgh meeting, appointed a committee to consider and report upon the probable effects, from an economic and physical point of view, of the destruction of tropical forests. This committee's report was submitted to the Association at the meeting at Ipswich in 1851. The weighty evidence collected in this report so impressed the Court of Directors of the East Indian Company that, within a few years, regular forest establishments were sanctioned for Madras and British Burma, the two main sources of the supply of teak.

In 1856 Mr. (now Sir Dietrich) Brandis was appointed to the care of the forests of the latter province. These forests had been the object of spasmodic efforts in conservancy for many years previously. In 1827 Dr. Wallich reported on the teak forests, and five years later a small conservancy establishment was organised, officered by natives. This, however, was kept up for only three or four years. In 1837 and 1838 Dr. Helfer reported on these forests, and an English conservator was appointed. In 1842 and 1847 codes of forest laws were drawn up, but do not appear to have been enforced to any extent. In 1853 Dr. McClelland was appointed superintendent, but he continued to hold the office for only a short time. A few years after Sir Dietrich Brandis's assumption of the charge of the Burmese forests, he was appointed Inspector-General of all the Government forests in British India; and it is to him that we owe for the most part the organisation of the Indian Forest Department as it now exists. That organisation includes two schools of forestry (in both of which botany is taught), one in connection with Coopers Hill and the other at Dehra Dun in Upper India. The latter has for many years been under the direction of a gentleman who is distinguished both as a forester and as a botanist. In the Coopers Hill School the higher grades of forest officers receive their training; at Dehra Dun those of the lower grades receive theirs. The officers of the department on the Imperial list, according to the latest official returns, now number 208, divided into the grades of conservator, deputy- and assistant-conservator, with a single inspector-general as chief. In addition to these, there are 566 provincial officers, ranking from rangers upwards to extra deputy-conservators.

Botanists took a leading part in moulding the department in its earlier years; for, as already stated, its pioneers—Gibson, Dalzell, Cleghorn, Anderson, Stewart and Brandis—were all botanists. And to most people, who give even casual attention to the matter, it appears fitting that the possession of a knowledge and liking for botany should form a strong characteristic of officers whose main duties are to be in the forest. And this belief did for some time exercise considerable influence in the selection of recruits for the department. But, except in the Dehra Dun School, it does not appear to guide the department any longer. For example, at the entrance examination to the Forest School at Coopers Hill, only three subjects are obligatory for a candidate, viz. mathematics, to which 3000 marks are allowed; German, to which 2000 are allowed; and English, for which 1000 are given. Botany is one of the nine optional

subjects, of which a candidate may take up two, and in each of which 2000 marks may be made.

Botany is taught at Coopers Hill, and (according to the Calendar of the College) it forms one of the "special auxiliary subjects" for the forest student. I do not wish to say a single word in depreciation of the botanical teaching at this college, which is probably excellent of its sort. I do not know what value, as part of their professional equipment, students are accustomed or encouraged to attach to the possession of the means of acquiring a knowledge of the trees and shrubs in the midst of which they are to pass their lives in India. But this I do know, that the ordinary forest officer educated in England now arrives in India without sufficient knowledge to enable him to recognise from their botanical characters the most well-marked Indian trees. To tell such an officer the name of the natural family to which a plant belongs conveys no information to him whatever, for he knows nothing of botanical affinities. Moreover, the forest officer after he has arrived in India is not encouraged to familiarise himself with the contents of the forests under his charge. This will be better appreciated by giving an example than by any number of remarks. Some three years ago, Mr. J. S. Gamble (a forest officer) published a monograph of the bamboos of British India. From bamboos, as you may possibly be aware, a very large amount of forest revenue is annually derived. The sales of bamboos for the year 1896-97 amounted to no less than 110 millions of stems. A great number of the species of bamboos have the curious habit of flowering gregariously at remote intervals of thirty or forty years, and the flowering is followed by death. The absence from the forests for years in succession of flowers of a number of the species, and the similarity of many of them in leaves, had hitherto made members of the group most difficult of identification. Mr. Gamble had devoted himself to their study for many years. He had carefully examined all the previously collected materials stored in the herbaria at Kew, the British Museum, Calcutta and elsewhere; and large special collections had been made for him by Mr. Gustav Mann and other officers of the Government. Moreover, he had General Munro's great paper in the *Linnean Transactions* as a basis. Mr. Gamble's work was undertaken with the full approval of Sir Joseph Hooker, who indeed accepted Mr. Gamble's account of the bamboos for his "Flora of British India." Mr. Gamble's monograph is illustrated by a life-sized drawing of each species, with analyses of the flowers on a larger scale. When completed, the book was published as one of the volumes of the "Annals of the Calcutta Botanic Garden." In consideration of the supposed great importance of the book to the forester, and in the belief that the copies would be eagerly taken by the Forest Department, an extra hundred copies were printed, and these hundred copies were put into stout canvas binding suitable for camp use. These copies, or as many of them as he cared to take, were offered to the head of the Forest Department in India at the reduced price of fifteen rupees per copy. The result was an official refusal to buy a single one, although the purchase of the whole hundred (which was not asked for) would have cost only fifteen hundred rupees—a sum which would have reduced the revenue of the year by about one twelve-thousandth part! An appeal against this ruling having been made to a still higher authority, a modified order was subsequently issued permitting such forest officers as desired to possess the book to buy copies and charge the cost in their office expenditure. I may state that the book was not a private venture. It was produced at the expense of the Government of Bengal.

It is not because I like to play the censor that I have made these remarks about the Forest Department. Having myself served in it from 1869 to 1871, I can speak from my own experience as to the value, from the utilitarian point of view, of a knowledge of the names, affinities and properties of the trees, shrubs and herbs which compose an Indian jungle, and of a knowledge of these as individual members of the vegetable kingdom rather than as masses of tissue to be studied through a microscope. The appointment which I held in India for twenty-six years after leaving the Forest Department gave me full opportunity of getting into touch with all who interest themselves in a knowledge of plants, and of discovering how few of these at the present day are forest officers. The majority of the latter, if they love their trees, are content to do so without knowing their names or relationships! There are, of course, splendid exceptions who know as well as love. The general decadence of the teaching of systematic botany in England during the past

twenty years is, perhaps, to some extent the cause of the low estimation in which the science is held by the authorities of the Indian Forest Department. Twenty-five years ago systematic and morphological botany, no doubt, had too great prominence given to them in the teaching at universities and colleges of this country, and the other branches of botanical science were too much neglected, although I do not think they were despised. Now it appears to me that systematic botany is too much neglected. I hope it is not also despised! Few of the systematists who survive in England are now to be found attached to the universities. They are mostly clustered round the two great herbaria in London; and such of them as have to look to systematic botany for the means of livelihood are not in the receipt of salaries such as one might reasonably expect in one of the richest countries in the world!

CHEMISTRY AT THE BRITISH ASSOCIATION.

DESPITE the fact that the Dover meeting was a comparatively small one, the chemists formed a thoroughly representative gathering, including amongst distinguished foreigners Prof. Lemoine, of Paris; Prof. Fittig, of Strassburg; and Prof. Ladenburg, of Breslau. The able address of the President, Dr. Horace T. Brown, on the assimilation of carbon by the higher plants, which embodied most valuable and original contributions to the knowledge of the complex changes which go on in the living cell, introduced a subject somewhat beyond the usual scope of the proceedings of the Section; and whilst the chemists present at Dover will always look back upon the address with a special appreciation, they will be equally mindful of the many interesting contributions on kindred subjects for which the personality of the President was in the main responsible. Prof. Hanriot, the President of the Chemical Section of the French Association, communicated a short account of the excretory products of plants, in which he discussed the mutations of nitrogen in the vegetable kingdom as based on his own observation of the occurrence of asparagine amongst the secretions of plant roots; when passed into the soil this product would in all probability become oxidised to nitrates, and thus become directly available for plant life. The experimental confirmation of this view is in course of study. The chemical processes involved in the saccharification of starch by malt-diastase were discussed by Dr. A. Fernbach, of the Institut Pasteur, and by Dr. G. H. Morris. The former detailed his observations on the influence of acids and of some salts on saccharification, which led him to the conclusion that the slightest trace of any free acid retards the action of diastase on gelatinised as well as on soluble starch, provided both the starch and diastase are free from salts on which the added acid may act; but if the solution contains salts, such as secondary phosphates, which are distinctly unfavourable to diastatic action, the addition of acid is favourable as long as there is no excess over the quantity necessary to transform these salts into the primary phosphates. The President regarded these results as opposed to his own observations on the subject, and considered further details of the experiments necessary to justify the conclusions. Dr. G. H. Morris, in a paper on the combined action of diastase and yeast on starch granules, showed that similarly to the symbiotic action of diastase and yeast on the so-called stable dextrin, ungelatinised intact starch granules, when submitted to the joint action of diastase and yeast, are fermented to a large extent, the maltose first formed being converted into alcohol. The addition of a small quantity of yeast to a cold water malt extract more than doubles the percentage of starch that is changed, and this increased action is not due to any greater activity of the diastase that might result from the removal of the soluble product formed (maltose) from the sphere of action. It appears necessary to have both the diastase and the yeast present together in a condition capable of exercising their respective functions for the increased action to occur. The action of acids on starch was also discussed by Dr. Morris, who showed that maltose is always obtained as a product of hydrolysis together with dextrin and dextrose; this is in opposition of H. Johnson's statement that the two latter compounds are the sole products of the action. But the most interesting contribution to this branch of chemistry was the joint discussion with Section K (botany) on symbiotic fermentation, on the occasion of the visit of the French Association. The discussion