said:—"It is obvious, if malaria is due solely to the bites of anopheles mosquitoes, that the extirpation of these mosquitoes will abolish malaria. The continuous use of quinine, even for a short time, is inconvenient, unpleasant to the individual, and difficult to carry out among a community. It is therefore evident that the best way to get rid of malaria is to destroy the mosquitoes. The only questions are, Can it be done? and, if it can, At what cost? It has been successfully done at Ismailia, but in conditions which were extraordinarily favourable, such, as I fear, occur very rarely, if they occur at all, in India."

Colonel Leslie then referred to the operations against mosquitoes conducted at Mian Mir by Captain James and Lieut. Christophers. The latter reported that a distinct effect was produced upon the malaria of troops and on the endemic index of the bazaars. This was, however, only evident in the beginning of the fever season, and could not be maintained. The failure of the operations appeared to be due to the passage of adult anopheles into the area from without. All the Mian Mir experiment showed was that success in operations against mosquitoes is not so easily gained as some people say. Where drainage is perfect, as in the case of Ismailia, the inhabitants can exterminate mosquitoes with little trouble; but where drainage is non-existent or bad, as at Mian Mir, it is practically impossible, by any means at present within their reach, for the inhabitants to destroy the mosquitoes.

After dealing with the question of prophylaxis by quinine, Colonel Leslie proceeded to formulate a scheme for a permanent organisation to deal with malaria in India, viz. a committee in each province of three or more members to obtain information and supervise local inquiries, and perhaps to control the distribution of quinine. Each provincial committee would delegate one of their members to attend a meeting of a general committee in Simla, this general committee consisting of the provincial delegates, the Sanitary Commissioner, representing the Government of India, with Major James as secretary. The Government of India would appoint a scientific committee, and a certain number of workers would be under the scientific committee, and when necessary workers might be deputed to serve under the provincial committees.

Major James, I.M.S., introduced a discussion upon the distribution of malaria in India, and dwelt upon the necessity for an investigation similar to that which Captain Christophers made in the Punjab, which should be begun in every province. He concluded that there are not extensive areas in India in which anti-malaria measures are urgently required; he doubted if there were more than half a dozen considerable areas in the Madras Presidency which would come within this category.

Captain S. R. Christophers, I.M.S., read a paper on a new statistical method of mapping epidemic disease, with special reference to malaria, and confined himself to a discussion of the returns of the Punjab. He suggested that in each district a list of the more unhealthy *paraos* (rest camps) could be maintained, and operations commenced upon each in turn with a view to (1) destroy mosquitoes and larvæ and get rid of their breeding ground: (2) render the wells mosquito-proof; (3) issue quinine free to the local inhabitants, and to place it at all times within their reach free of cost. These operations should result in lessening the infectivity of such places. Captain Christophers also read a paper on malaria in the Punjab, in which he discussed quinine prophylaxis.

Major Chaytor White, I.M.S., considered that the recommendations of past malaria conferences are costly, and almost prohibitively so, if undertaken annually. More should be done in the propagation of fish which prey on mosquito larvæ.

Papers were also read by Lieut.-Colonel Thornhill, on malaria in cantonments; by Major James, on problems relating to the use of quinine; and Major Wilkinson brought forward a revised scheme for the distribution of quinine by Government.

At the termination of the conference various conclusions and recommendations were drawn up under the following main headings:—(1) scientific investigation; (2) the agency by which investigations should be made; (3) practical measures: (*a*) extirpation of mosquitoes; (*b*) quinine treatment and prophylaxis; (*c*) education; (*d*) finance.

ECONOMIC ENTOMOLOGY IN THE UNITED STATES.

MAPLE trees grown in the United States are liable to severe injury from defoliation by caterpillars. In addition to the fall web-worm (*Hyphantria cunea*, Dru.) and tussock moth caterpillar (*Hemerocampa leucostigma*, Dru.) there is a common and troublesome species known as the green-striped maple-worm (*Anisota rubicunda*, Fab.), which attacks maples of all kinds, and feeds occasionally on box-elder and oak. In a bulletin recently issued by the United States Department of Agriculture Bureau of Entomology, the latter pest is described in some detail by Messrs. Howard and Chittenden. In another publication they describe the leopard moth (*Zeuzera pyrina*, Fab.), the larvæ of which cause severe injury to many deciduous trees in northern New Jersey and eastern New York. It has been successfully combated in the public parks of New York City by injecting carbon disulphide into the larval burrows in the bark. Mr. Chittenden describes the rose-chafer (*Macrodactylus subspinosus*, Fab.), a long-legged beetle of a light yellowish-brown colour, which appears suddenly and in vast swarms in certain years, usually towards the middle of June in the northern States and about two weeks earlier in the southern, overrunning vineyards and orchards, nurseries and gardens. In about a month or six weeks from the time of their first arrival, generally after they have done a vast amount of damage, the beetles disappear as suddenly as they came. No successful means of combating them is yet known, the difficulty being that any process, to be successful, must be applied almost continuously.

The control of the pear-thrips (*Euthrips pyri*, Daniel) has been for several years the principal problem confronting the growers of deciduous fruits in portions of central California. This insect, on account of its mode of attack and habits, has presented unusual difficulties in control. Adults emerge from the ground in late February and early March, just when most trees are breaking into bloom. Eggs are usually deposited in the blossom, fruit stems, and leaf petioles. The larvæ, after hatching out, feed for two or three weeks, then drop to the ground, where they form a tiny protecting cell, within which they remain during the rest of the year. The pupal changes take place within this cell in the ground during October, November, and December. As measures of control, Mr. Dudley Moulton recommends winter cultivation followed by March and April spraying with tobacco extract.

The life-history of the greenhouse thrips (*Heliothrips haemorrhoidalis*, Bouché) is described by Mr. H. M. Russell. The damage caused by this insect is confined to the foliage of ornamental plants. Adults and larvæ both obtain their food by puncturing the epidermis of the leaf with their sharp mouth-parts and sucking out the sap. Fumigation with nicotine or with hydrocyanic acid gas were found to be effective methods of control.

Mr. A. L. Quaintance, who is in charge of deciduous fruit insect investigations, describes a new genus of Aleyrodidæ, *Paraleyrodes* (*aleurodicus*) *perseae*, Quaintance, found on orange trees and other plants in Florida. The adult is buff or pinkish in colour, and marked with white. The wings are whitish and lie almost flat along the dorsum, but do not meet along the middle line. A large amount of flocculent white wax is secreted over the leaf surface in the depressions in which the sluggish adults rest. From the same section of the Bureau is issued a description, by Mr. Hammar, of the cigar-case bearer (*Coleophora fletcherella*, Fernald), which damages the foliage and fruit of apple and pear trees. The name is given because of the curiously shaped cases, resembling cigars, made by the larvæ. Arsenical sprays were found effective in keeping it down. Messrs. Foster and Jones publish some additional observations on the lesser apple-worm (*Enarmonia prunivora*, Walsh), which is prevalent throughout the apple-growing district east of the Rocky Mountains. Late broods do a considerable amount of damage in autumn, and some of the larvæ work in the fruit for weeks after the crop is harvested. The methods adopted for keeping down the codling moth have, so far, proved effective in checking serious injury by this pest.

The regions of Virginia surrounding the Chesapeake Bay probably produce more early potatoes than any other part of the eastern States, the annual value of the crop approaching 6,000,000 dollars. Little damage is caused by blight, but the Colorado potato-beetle (*Leptinotarsa decemlineata*, Say) is a serious pest, and only very crude methods are adopted for keeping it in check, because of the prevalence of negro labour and the scarcity of capable white help. Mr. Popenoe gives a description of the pest and of the damage it does, and describes experiments in which three applications of lead arsenate mixed with Bordeaux mixture, the first about the time the eggs begin to hatch, and the others at intervals of three weeks, sufficed to control it.

Some new breeding records of the coffee-bean weevil (*Araecerus fasciculatus*, De Geer) are published by Mr. Tucker. He found the larval and pupal stages in some dried maize stalks, and obtained evidence that the insect causes injury to the maize plant. The attacks begin in the green stalks before the corn matures, and thus cause stunted ears. This weevil has also been found in the berries of the China berry tree.

Stringent laws are in operation in most of the States with regard to the importation of nursery stock. It is commonly necessary to notify the State entomologist within twenty-four hours of the arrival of the stock, and to fumigate satisfactorily. The laws of the different States are not all alike, and Mr. Burgess has collected in a short pamphlet the requirements which must be complied with by those making inter-State shipments of nursery stock. The pamphlet will form an interesting study for those who are agitating for some State supervision in this country.

THE METHODS OF MATHEMATICS.[1]

THE position assigned to mathematics in the educational system of every civilised country seems to mark it out as an essential element of mental culture, but an examination of the arguments that have been put forward from time to time to justify this position reveals a diversity of view that is at first sight disquieting.

Of those who acknowledge the value of mathematics there are many who see that value almost solely in its usefulness, in the help it brings to other sciences. Not unnaturally, those who are absorbed in the work of applied science are apt to turn away from the more abstract developments of modern mathematics; even the men whose special pursuits call for constant applications of mathematical processes, as in physics and engineering, can hardly be blamed if they lay special emphasis on those elements of a mathematical training that are of immediate application to their daily work. Yet it is not this aspect of mathematics that is usually present to the professional mathematician when he seeks to uphold the position of his subject in an educational system.

Mathematics may be assigned its place for a different reason. To those who reject the argument from utility, mathematics is not the humble auxiliary of other sciences, but is itself the one genuine science; it often comes to the aid of other sciences, but does not depend for the justification of its existence on the help it may be able to bring. From the adherents of this view come the familiar arguments for the disciplinary value of a mathematical training in which deductive logic is given a prominent place.

The question naturally arises whether these two aspects of mathematics are incompatible. To the teacher, whether in school or in college, the question is of prime importance; for the whole scheme of study and the methods of instruction will be found in the long run to be determined by the general attitude that is taken up with respect to the value of the subject. At the present time there is considerable uncertainty in the minds of teachers regarding the methods of school mathematics, and many of the older men are disposed to look unfavourably on recent changes as tending to impair the disciplinary effects of a mathematical training.

It may help us to understand more clearly the points at issue if we consider for a little the trend of mathematical inquiry during the nineteenth century. It is not necessary that I should sketch even in the roughest outline the development of mathematical science in that period; it will be sufficient for my purpose to indicate one dominant feature of the mathematical methods that were introduced in the early years of that century and that revolutionised the treatment of pure mathematics before it had reached its close.

During the eighteenth century the infinitesimal calculus and the doctrine of infinite series enabled mathematicians to investigate problems, intractable by the older methods, with a facility that led to a wide extension of the field of mathematical inquiry and to an enormous accumulation of results. In this period interest was centred less in demonstrations than in results, which were often reached by methods of a strange character, and sometimes, indeed, seem so absurd in themselves that we find it hard to understand how they were ever promulgated. Induction played a most important part in the discovery of theorems, and these inductions were often made from insufficient data and too seldom verified by subsequent tests. When the novelty of the processes had worn off, the necessity for a critical examination of their legitimacy became evident, and this examination was one of the tasks of the nineteenth century. It should be noted, however, that the great critics were also great creators; the criticism of the methods of mathematics was accompanied by a wide extension of its domain.

Of those who first saw the necessity for criticism and set themselves to the task were Gauss, Cauchy, and Abel. Gauss was first in the field, but, for various reasons, his work was long neglected. It was not until the publication in 1821 of Cauchy's "Cours d'Analyse" that the attention of mathematicians was effectively directed to the question.

Geometry in the hands of the Greek mathematicians had been reduced to a system of logically consistent truth; from assumed definitions, axioms, and postulates the various theorems of geometry were derived by the methods of formal logic, and Euclid's "Elements" were for centuries the standard of mathematical rigour. Algebra, or, in modern terminology, analysis, was of much later growth, and Cauchy's reference to the rigour that is demanded in geometry simply means that the time had come when the revision of principles and methods that the Greek mathematicians had effected in geometry should be carried out for algebra or analysis. The eighteenth century was a period of great activity in the development of analysis, and it is not surprising that the pioneers of this development should have been more interested in the resources of the country they were opening up than in the roads they followed. Their methods of mathematical inquiry were not limited by the traditional canons of Greek geometry; they included induction as well as deduction, there was constant appeal to intuition, and general theorems in mathematics were often established from physical considerations. The usefulness of mathematics as an aid in the investigation of the phenomena of the material world was the predominating feature of the period. The aim of Gauss, Cauchy, Abel, and their coadjutors was, in general terms, to do for analysis what the Greeks had done for geometry, and to make mathematics an independent science by clearly defining its province, stating the postulates from which the science starts and developing the consequences by the laws of logical operation without appeal to extraneous considerations.

The work of scrutinising the methods of analysis was vigorously pursued throughout the nineteenth century, and exerted a far-reaching influence. The notion of continuity, which seems so naturally to attach to geometrical quantity, required to be formulated in such a way that it would be amenable to calculation. Current conceptions of number were too vague, and it was found necessary to analyse more carefully the notion of numerical quantity so as to frame definitions and to establish rules of operation for the continuous variable of analysis. The so-called imaginary numbers had been long in use, but their existence was of a precarious nature, and the right to use such numbers had to be justified.

As will be easily understood, many of these discussions are of a very abstract nature, but they have provided a

[1] From the inaugural address delivered on October 11 by Dr. George A. Gibson, Professor of Mathematics in the University of Glasgow.