have been crippled; the Association has now to draw on its very limited capital. The committee took the view that, as an Imperial people, it is our duty to shoulder our responsibilities and develop the resources of the Empire—resources of knowledge as well as resources of material—in time of war as well as in time of peace. We are too apt to make war an excuse for postponing our immediate duty. Sir Thomas Wrightson, Bart., has given 50*l.*, but it does not seem too much to expect that three other subscriptions of equal amount may be placed at the disposal of the Research Committee for Archæological Investigation in Malta, in addition to the grant from the British Association. The labour conditions in Malta are at present favourable for the continuance of this kind of Imperial undertaking, and the men who are in charge have the skill and experience to employ to the best advantage the modest sum here asked for.

ARTHUR KEITH,
President, Section H (Anthropology) of the British Association.

A Successful Method of Obtaining Amœbæ for Class Purposes.

ZOOLOGICAL departments in all parts of the British Isles have experienced, during the last few years, considerable difficulty in obtaining a good supply of *Amoeba proteus* for class purposes at the proper time, the usual hunting-grounds for this organism failing, for some reason or other, to yield their former abundant supply.

The difficulty was overcome in this department during the present session by making use of amœbæ obtained from soil by a suitable culture method, the outcome of the writer's work on soil protozoa. This method has proved so successful that it has been thought desirable to give a brief account of it, especially as it has come to my knowledge that other zoological departments are desirous of trying it. A somewhat similar method of obtaining amœbæ for class purposes has been in use for some years in the University of California, and has been described by Kofoid in the Trans. Amer. Micro. Soc., vol. xxxiv., October, 1915.

For the cultivation of amœbæ from soil a liquid medium is preferable to a solid one, such as nutrient-bouillon agar, frequently used for amœba cultivation, owing to the fact that one frequently finds on a solid medium amœbæ with two or more nuclei and various other abnormalities not found in amœbæ from a liquid-culture medium.

One per cent. hay-infusion is a very useful medium, and is constantly used here. It is prepared as follows:—Ten grams of chopped hay are put into a beaker or flask with one litre of distilled water, and steamed for about three-quarters of an hour; filter, and then make the filtrate just alkaline by the addition of a sufficient quantity of caustic-soda solution (N.NaOH solution is quite suitable) to make a strip of red litmus paper turn a bluish tint when immersed in the liquid. Sterilise in the autoclave, and, when cold, pour a small quantity into three or four Petri dishes until the liquid is a few millimetres in depth, and inoculate each with soil; about half a gram is sufficient soil for each plate. Almost any kind of soil will serve—garden or field soil.

Put the dishes aside for a day or two, either in an incubator at 20°–25° C., or on the laboratory-table, away from direct sunlight, and then examine under the microscope for amœbæ. The latter are, as a rule, of the *limax* type, and are generally to be found on the surface or at the bottom of the culture.

Ciliates and flagellates will also be found in considerable numbers; in fact, the ciliates frequently predominate in the early days of the culture, and only when they become less numerous do the amœbæ increase in numbers.

For the purposes of examination clean coverslips may be dropped on to the surface of the culture-liquid, and then removed to slides and examined under the microscope; or a platinum loopful or two of the surface layers may be taken and put on a slide and then covered with a clean coverslip. When most of the amœbæ are at the bottom of the culture, as sometimes happens, they are more difficult to remove to slides, but they may be sucked up by means of a capillary pipette gently moved over the bottom of the dish and then transferred to the slide. The coverslips should be sealed with vaseline or wax to prevent evaporation.

The amœbæ vary in size from very small forms, which are not of much service for class purposes, to fairly large forms, which are quite admirable, showing great amœboid activity and revealing clearly under the higher powers of a junior-class microscope the differentiation between ectoplasm and endoplasm, the nucleus, and the streaming of the protoplasm during the progression of the amœba. Such forms may measure anything from $20\,\mu$–$60\,\mu$ in length, according to the degree of extension of the body, and even larger forms may be met with. The organism which has been obtained in practically pure mixed culture here, and has proved so useful, measures between $30\,\mu$ and $50\,\mu$ when extended. The cyst has a diameter of $16\,\mu$–$17\,\mu$.

Having obtained a good-sized form, one should allow it to multiply, and finally to encyst. The cysts may then be picked up by means of a capillary pipette and transferred to fresh culture medium, when one is almost certain to obtain a practically pure mixed culture. Further subcultures can be made by inoculating the cysts into fresh dishes of hay-infusion, and by this means the race may be kept going for months, or even years.

Even if the cultures dry up, and remain dry for a month or two, it will still be found possible to obtain a supply of organisms by scraping some of the brown deposit from the inside of the dish and placing this in fresh sterile hay infusion. After a few days amœbæ will be plentiful, having hatched out of the cysts contained in the deposit from the old culture.

Such a cyst-containing deposit or old culture containing cysts can be kept as a stock, and when active amœbæ are required all that is necessary is to seed a dish or two of hay-infusion with cysts two or three days before the organisms are wanted, and one can be certain of obtaining a good supply of active forms.

I shall be pleased to supply any zoological department with a small quantity of cyst-containing deposit or old culture liquid containing cysts of the form cultivated here in case no success is obtained with the method described above. T. GOODEY.

Department of Zoology, The University,
Birmingham, July 16.

SCIENTIFIC PLANT BREEDING.

SO much attention has been directed to the purely scientific advance that has followed the birth of Genetics as a new branch of science that little regard has been paid to the very remarkable results already reached by the application of Mendelian methods to the problems of economic plant production. It is necessary to distinguish somewhat sharply between the facts which Mendel was the first to discover, and the hypotheses which have been put forward to explain these facts. The practical plant breeder is not primarily concerned with the theory of the subject; the Mendelian fact of grand importance to him is that unit characters do segregate, and that new combinations of these characters can be made.

It may be of interest, therefore, to consider some of the more important results obtained in regard to food-producing plants, and to indicate some of the difficulties which may impede future progress. Of food grains none is more important than wheat. The most marked achievement in wheat breeding is the production of a variety resistant, if not entirely immune, to the fungous disease known as Yellow Rust (*Puccinia glumarum*), as a result of the discovery that resistance to this disease obeys the Mendelian law of segregation. Once this was established it became a comparatively simple matter to transfer this character as an independent unit from the poor yielding Russian wheat, "Ghirka," in which it was found, to a wheat suitable to the conditions of England. The variety "Little Joss," which was "made" in this way some ten years ago, is now well established in the Eastern Counties.

The possible economic value of this achievement becomes apparent if the enormous yearly losses caused by rust—perhaps not far short of 10 per cent. of the yield annually—are considered. Another economic character that can be controlled in the same way is stiffness of straw, a matter of importance in those parts of the country, such as the Fens, where a weak-strawed wheat becomes "laid" in wet seasons. It is interesting to learn that a short, stiff-strawed variety known as "Fenman" has recently been produced which is likely to be largely adopted in the Fen country. But the possibility of greater additions to the food supply of the country is now in sight. It is well known that wheat is commonly a slow-growing plant; sown in late autumn or winter, it is harvested in August. Barley and oats, on the other hand, come to maturity more rapidly, and need not be sown until spring. There are, however, certain varieties of wheat which can be sown in spring, but, unfortunately, their yield of grain is considerably less than that given by winter wheats. The result has been that under the ordinary conditions of farming in this country the area that can be sown with wheat is limited to that not occupied by a crop during winter. Barley and oats must be grown after "roots" because the latter are not completely off the ground until early spring. If, then, it were possible to make a spring wheat combining the character of early maturity with a yield approaching that given by winter wheat, the economic gain might be enormous, for, obviously, it would be in the interest of home food production to curtail the area occupied annually by barley. If, then, we could add to the existing acreage sown annually with wheat only one-quarter of the normal acreage under barley and oats, we should add probably 20 per cent. to the home-grown cereals available for human food. The possibility of making an improved spring wheat depends upon how far early maturity and yielding capacity are found to segregate. Apparently, there are indications that the former does, but the problem in regard to the latter is complex, depending for its solution on the clearing up of the difficulties that are encountered in dealing with quantitative characters, such as yield, as distinct from qualitative characters, such as colour of grain.

The questions involved are obviously of great economic importance, for it is the quantitative characters that often determine the economic value of a plant or animal. But it is not simply a question of the universality of the Mendelian law. If, as some geneticists hold, the inheritance of quantitative characters is regulated by a complex of unit characters, the practical application of Mendelian principles becomes exceedingly difficult, for with any number of characters over three the number of possible combinations of unit characters becomes generally too large to handle. And the difficulty does not end there, for, owing to environmental fluctuation, the comparative genetic behaviour of individuals cannot be disentangled, and the plant breeder is consequently driven to resort to purely empirical methods of selection. Nevertheless, the fact that the exact nature of the laws regulating the inheritance of quantitative characters is still obscure may not seriously impede the work of the practical breeder. In fact, it has been found in practice that, provided desirable qualitative characters can be built up in the desired complex, the quantitative characters may be susceptible of improvement by selective methods of a more or less empirical nature.

But when all is said, scientific plant improvement in Great Britain has made only a small beginning, due, no doubt, in part to the general excellence of the varieties of economic plants now established in this country. The "Improvers" of agriculture and horticulture in the nineteenth century revolutionised the industry, and, as an outcome of their activities and influence, British seedsmen, largely by selective methods, effected very great improvements in economic plants. It is only comparatively recently that this country has fallen behind. Allusion may be made to the great advances achieved in Sweden as a result of the work of the Svälof plant-breeding station. Denmark also is forging ahead, but, curiously enough, progress has not been remarkable in Germany, owing, perhaps, to the extraordinary cult of Darwinism which prevails there, and the consequent belief in the effectiveness of mass selection. In America considerable progress has been made from a scientific as well as from an economic point of view—notably in producing a cotton immune to the destructive Wilt disease.

But if a striking object-lesson of the successful application of new methods to plant production is needed we must turn to India.[1] Dating from

[1] Report on the Progress of Agriculture in India for 1916–17. (Calcutta Supt. Govt. Printing, 1918.)

the foundation of the Pusa Research Institute about the beginning of the present century, great developments in the scientific exploitation of Indian agriculture have taken place. Much credit is due to Lord Curzon, who, aided, it is now curious to recall, by the munificent bequest of an American (Mr. Phipps), founded a department which it is no exaggeration to say has added thousands, and will add millions, to the wealth of the country. India undoubtedly presented a fine field for the modern plant breeder. If we consider the immense variety of her plant products, their value either as food or in the arts and industries, and then observe that, owing to the absence of any skilled seed production industry, there is an uncounted number of identifiable races within each distinctive variety of economic plant, we can form some conception of the possibilities which even selection presents: superadding hybridisation, it is difficult to assign any limits to the field that is opening out.

It would be impossible in the ordinary limits of space to give a detailed account of what has already been achieved, but some indication may be given of proved successes in relation to the more important economic plants.

Mention may first be made of Wheat, of which upwards of 30 million acres are grown, and which was naturally one of the first crops to receive attention. Both selection and hybridisation have been brought into action, and several new varieties are now firmly established. In the United Provinces in 1917 alone "Pusa No. 12" occupied 100,000 acres, and was extensively grown in the Punjab as well. This wheat gives a cultivator an *increased yield of 25 per cent.* over the varieties formerly grown by him, as well as nearly one shilling per quarter more on the market, owing to its improved quality. Another and later production of Pusa has on occasions given a yield of nearly fifty-five bushels per acre, which for India is an unheard-of figure, and may be compared with thirty-two bushels, the British average yield of wheat. In the Punjab another new variety occupied 97,000 acres, and it is estimated that the growers of this wheat were presented with an additional income of nearly 15,000*l.* In the Central Provinces improved varieties, returning to the cultivators considerably increased profits, occupied 200,000 acres.

Remarkable progress is also being made in the production of improved varieties of Rice, the most important cereal crop in India. A variety known as "Indrasail," isolated by pure lime selection, occupied 20,000 acres in Bengal. In the Central Provinces it has been necessary to establish thirty seed farms for the production of other new varieties. Turning to non-food products, we find that extraordinary advances have been made in regard to cotton (of which 20 million acres are grown in India). In Surat an improved cotton has been produced giving a premium value of 13 per cent.; in Sind new varieties are giving a premium of 23 per cent. In the Central Provinces a new introduction is estimated to occupy no less than 800,000 acres, and to have brought the cultivators increased profits of nearly 900,000*l.* After this we may pass over such relatively inconsiderable figures as 215,000 acres under a new variety in the Punjab, but, for its human interest, mention may be made of one incident in a campaign directed to the eradication from a certain district of an inferior indigenous variety. It is a good example of the methods adopted to impress the Oriental imagination. "In the Tinnevelly district the department had to resort to drastic action for the control of seed in the case of some ninety acres of *pulichai* [the inferior cotton] . . . the seed from this cotton was publicly burnt . . . before a large gathering of ryots."

In the improvement of Jute (of which India exports annually products worth 40,000,000*l.*) some notable advances have been made. It is expected that in the present year more than 30,000 acres will be sown with a new selected variety as a result of the distribution by the department of 500,000 packets of seed. In this connection a valuable scientific discovery may be mentioned. The pernicious weed, water hyacinth, which infests the waterways of Bengal, has been found to have a high potash content, and is consequently a valuable manure for jute, the use of which not only directly stimulates yield, but also protects the plant against a Rhizoctonia disease which attacks it.

It will be readily admitted that this tale of economic progress is astonishing. No *mention* has been made of the purely scientific results achieved, and they are very considerable. The workers no doubt feel well rewarded by the satisfaction with which they must regard the additions to knowledge which they have made, but they may also feel some pride in the remarkable economic advances which their labours have brought about, especially in regard to the food-producing plants.

THE VALUE OF INSECTIVOROUS BIRDS.

THROUGHOUT the country at the present time farmers, fruit-growers, allotment-holders, and owners of gardens are faced with a plague of insects such as has not been experienced in the United Kingdom for many years past. True it is that we have had more or less local outbreaks of the winter moth, the cabbage butterfly, apple and plum aphids, wireworms, leather jackets, and numerous other pests of great severity, but not, in the present writer's opinion, to such a general extent as at the present time.

The reason for this very serious state of affairs is not difficult to discover, and although the truth may not be palatable, it is, nevertheless, true that it is largely due to neglect and to an absence of a State Department with a thoroughly practical and scientific staff. It would be futile and unprofitable to dwell upon either of these two causes. Rather let us turn to another phase of the matter not altogether foreign to the subject, viz. the value