of the underspin and the dynamics of the slice and the pull are as if they were not. There is no "science" in the book; but it is admirably human.

C. G. K.

A History of the Teaching of Domestic Economy.

Written for the Association of Teachers of Domestic Subjects in Great Britain by Ailsa Yoxall. Pp. 58. (London: Knapp, Drewett and Sons, Ltd., n.d.) Price 6d.

THIS little book represents the first attempt to place on record an account of the growth of the teaching of domestic economy in Great Britain. The movement appears to have been started in earnest about 1840, when some instruction in needlework began to be given in national schools for girls and infants. From this date to the present time the importance of instruction of this character has been recognised increasingly, until to-day the Association of Teachers in Domestic Subjects includes no fewer than thirteen important local branches, receives direct recognition by the Government, and elects one of its members to represent it on the Registration Council. The subject is now also given a more scientific character and includes a practical and theoretical study of every aspect of housewifery. The book deserves the attention of all who are interested in vocational education for girls.

LETTER TO THE EDITOR.

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Newton and the Spectrum.

IN NATURE of November 5, 1914, p. 263, I notice in the Astronomical Column a statement to the effect that, in connection with spectrum analysis, Wollaston (1802) was the first to employ the slit. I therefore venture to send a copy of the following passage, contributed by me to the 1913 Journal of the Leeds Astronomical Society, published last September:—

"Almost all writers, who quote Newton's classical experiment, overlook or ignore the fact that, recognising the impurity of the spectrum formed by admitting the sunlight through a round hole, Newton suggested the use of a linear aperture. Here is the passage from pp. 59–60 of the 4th edition of the *Opticks* (Book I., Prop. IV.):—

"Yet instead of the Circular Hole, 'tis better to substitute an oblong Hole shaped like a long Parallelogram with its Length parallel to the [refracting edge of the] Prism. For if this Hole be an Inch or two long, and but a tenth or a twentieth Part of an Inch broad, or narrower; the Light of the Image will be as simple as before, or simpler, and the Image will become much broader, and therefore more fit to have Experiments try'd in its Light than before."

"It is not quite clear whether Newton actually tried this narrow aperture. I think he did; and it is interesting to consider that, if he had sufficiently narrowed the slit, and observed the spectrum directly by the eye, instead of observing it upon a screen, he might have discovered the dark lines."

C. T. WHITMELL.

Invermay, Hyde Park, Leeds, November 9.

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THE PARTIAL STERILISATION OF SOILS.

THE work to be described in this article arose, as so often happens, out of an accident in the laboratory. The writer was investigating the rate of oxidation of phosphorus, and during the progress of the work was called to take charge of an agricultural laboratory. Before finally disbanding the apparatus some observations were made on soils, and it was found that fertile soils absorbed oxygen more rapidly than non-fertile soils of the same character. Since the action was very considerably reduced in sterilised soils it was concluded that the process is largely due to

Untreated soil.

Partially sterilised soils (by toluene). (by heat).

Partially sterilised soil (by toluene).

Untreated soil.

Partially sterilised soil (by carbon disulphide).

FIG. 1.—Crops grown on untreated and in partially sterilised soils.

the activity of micro-organisms, and the connection between oxygen absorption and fertility was attributed to the large part played by micro-organisms in the production of plant food.

In doing the final confirmatory set of experiments the soils were only sterilised at 100° and not at 130°, in consequence of a mistake which caused some little annoyance at the time. An experiment was, however, carried out with this partially sterilised soil, and it led to the remarkable result that oxygen absorption is more rapid in such soil than in normal untreated soil. Other methods of partial sterilisation gave the same result. In view of the close connection between

oxidation and productiveness, a set of pot experiments was put up, and these showed that the fertility of the soil was also increased after partial sterilisation. Typical results are illustrated in Fig. 1: the upper part gives experiments with rye, the lower part with tomatoes.

At this stage it was found that the fact had been discovered before by practical growers. Soil that had been heated, *e.g.* by a bonfire, or treated with the antiseptic (carbon disulphide) used for destroying certain pests, gave larger crops than before. The fact had even been reported to one or two of the German experiment stations, but it had not attracted very much attention. One important discovery had been made, however: it was found that partial sterilisation caused increases in the numbers of bacteria, and this was explained by supposing that the weaker races had been

sation, whereupon the bacterial numbers began to rise. Owing to its highly complex nature soil forms very unpromising material for a direct attack; investigations have nearly always to be indirect. In the present instance the method adopted for discovering the detrimental factor was to ascertain what agencies put it out of action and what did not, and thus to draw up a list of its properties. It was found, for example, that the detrimental factor was sharply put out of action by heating to 55°C ., or by any poison, and that it never set up again so long as the soil was kept free from dust; it did, however, appear when a little untreated soil was added, but the reappearance was slow and somewhat erratic. These and other experiments all indicated that the factor was biological; but definite evidence was obtained that it was not bacterial. Suspicion therefore fell on

the protozoa, which were found to occur in all the natural soils examined but to be killed by the partial sterilisation. A very large number of experiments showed that the destruction of the soil protozoa always went hand in hand with the increase in bacterial numbers; up to the present no exception has been found. This is strong presumptive evidence, but unexpected difficulties arose when attempts were made to clinch the evidence by inoculating mass cultures of protozoa into partially sterilised soils, and up to the present these have not been overcome. We are, therefore, thrown back on indirect methods.

The first difficulty that was raised against the identification of the detrimental factor with the soil protozoa was that the protozoa were probably present in the soil as cysts, and not in the trophic state. It was argued that the soil conditions must be unfavourable for the development of animals like protozoa, which stand in constant need of air and water. The first investigations

seemed to support this view. The copious development of protozoa when untreated soil is inoculated into hay infusion, of course, proves nothing; and when attempts are made to entice anything out of the soil by thermo- or galvanotactic methods nothing happened. The test organism was *Colpoda cucullus*, a ciliate occurring abundantly in the culture and easy to pick out under the microscope, and no evidence could be obtained that it occurred in the trophic state in the soil.

However, the experiments were continued. Mr. Martin found that a film was formed when soil was vigorously shaken with concentrated picric acid solution which, on examination, was seen to contain protozoa. The significance of the observation is, of course, that the acid instantly kills the organisms in the soil, so that the state in

FIG. 2.—Lime as an agent for soil sterilisation. Pot 73, control; 76–87, successively increasing doses; between 79 and 80 lies the partial sterilisation point; 87 contains an excessive amount. (H. B. Hutchinson.)

killed, leaving the more vigorous in clear possession of the field.

Systematic investigations at Rothamsted soon showed that the increased productiveness of partially sterilised soils was due to an increased formation of ammonia, and this in turn was traced to the increased numbers of bacteria. The new flora, however, was not composed of more vigorous races as had been supposed; on the contrary, it was less vigorous than the old, and it owed its extra decomposing power to its numerical superiority. This point was established by numerous experiments because of its great importance in explaining the phenomena. The reason for the increased bacterial numbers was traced to a detrimental factor present in normal soils and keeping down the bacterial numbers; this factor was put out of action by partial sterili-

which they are found in the film is the state in which they actually occur in the soil. It was with no little interest, therefore, that the work of the protozoologists was watched, and when they discovered that the amœbæ were in the trophic state, and not all present as cysts, it was felt that a distinct advance had been made. Mr. Lewin has since devised a method of getting the protozoa alive out of the soil. Thus, satisfactory proof is furnished that an active protozoan fauna exists in normal field soils. Some of the organisms are of special zoological interest, and have therefore been studied in detail.

Even yet, however, the problem is not solved, because there is nothing to show how numerous the active protozoa are. Neither Martin's nor Lewin's method is susceptible of quantitative use, and at present the only guide is the ease with which the organisms can be picked out.

however, the main interest of the "sick" soils, *i.e.*, the soils known to be heavily stocked with the detrimental factor, is that they contain numerous active amœbæ, and never fail to give good crops of organisms by either of the methods in use.

On the other hand, the detrimental factor is reduced considerably by drying the soil, especially at high summer temperature. So also the harvest of protozoa becomes very thin in field soils during dry summer weather.

This, therefore, is the present position so far as the identification of the detrimental factor is concerned. There seems no doubt that it is living, and there is strong indirect evidence to connect it with the soil protozoa. But the direct evidence is lacking, partly because the difficulties of introducing mass cultures into partially sterilised soils have not yet been overcome, and

FIG. 3.—Effect of a typical volatile antiseptic on bacterial numbers and production of ammonia in soils. (Buddin.)

It was found from the soil investigations that the detrimental factor increased in intensity when the soil was kept moist, warm, and well supplied with organic matter. In these circumstances the bacteria might reasonably have been expected to increase enormously; as a matter of fact, they did not. Moreover, the fertility of these soils did not increase as much as was anticipated; it became less, and after a time no longer justified the cost of intense cultivation: this fact is well known among nurserymen, who speak of such soils as "sick." The treatment in the past has been to throw the soils out in despair, and to sacrifice the great manurial residues they contain. But it was obvious that the proper course was to adopt partial sterilisation methods; and laboratory and pot culture experiments alike proved the success of the method. For the moment,

partly because no satisfactory method of enumerating active protozoa in the soil has yet been devised. The zoological work is being continued: it has already more than justified itself by revealing the presence in natural soil of a trophic protozoan fauna the members of which are of considerable interest: the most important further development will be to ascertain whether the present indications are correct that the fauna is most numerous when the detrimental factor is most fully developed, and least numerous when the factor is not much in evidence.

The "sick" soils mentioned above are so important from the technical point of view that they have been further investigated. Sickness is proved to be an excessive development of the detrimental factor and also of disease organisms. The demonstration that it could be cured by

partial sterilisation aroused much interest among nurserymen and growers who forthwith arranged to have trials made in their own glasshouses. The first efforts were, of course, crude; methods that work satisfactorily in a laboratory with a few kilos of material have a way of breaking down hopelessly when it comes to handling hundreds of tons in a commercial nursery. But the second season saw a great improvement, and the third an even greater, while perhaps the most satisfactory result of all is that the growers have collected 2500*l.*, half among themselves and half from the Development Fund, wherewith to build an experiment station to attack the special problems of their industry, and they have also obtained for it an income of some 900*l.* a year for the working expenses.

stances, and finds a fundamental distinction between volatile and non-volatile organic antiseptics, illustrated in Figs. 3 and 4. Volatile compounds partially sterilise and then disappear, leaving no traces behind them: the effect on the soil depends solely on the germicidal potency of the substance. Non-volatile compounds, on the other hand, remain in the soil and react both on the organisms and the plant, but their action on the bacteria is peculiar. So long as the doses are not too strong, some of the soil bacteria flourish and multiply to an astonishing degree, apparently feeding on the antiseptic: phenol, cresol, hydroquinone, quinone, are all among the unpromising substances that produce this effect. The phenomena are quite distinct from those observed with volatile antiseptics; the rise in bacterial numbers

FIG. 4.—Effect of a typical non-volatile antiseptic on bacterial numbers and production of ammonia in soils. (Buddin.)

At present nurserymen use steam, but this would not be applicable for ordinary field work. The volatile antiseptics which work so well in the laboratory have also proved ineffective, even if the difficulties of application could be overcome. Search has therefore been made among solid and non-volatile liquid antiseptics. Lime was investigated by Dr. Hutchinson and found to answer satisfactorily; small doses are absorbed by the soil, but after a certain saturation point is reached the excess remains free and partially sterilises. All the usual phenomena turn up together, and the point indicated by the chemical tests is found to agree closely with that found by bacteriological and plant-growth tests (Fig. 2). Mr. Buddin has tried a wider range of sub-

stances, and finds a fundamental distinction between volatile and non-volatile organic antiseptics, illustrated in Figs. 3 and 4. Volatile compounds partially sterilise and then disappear, leaving no traces behind them: the effect on the soil depends solely on the germicidal potency of the substance. Non-volatile compounds, on the other hand, remain in the soil and react both on the organisms and the plant, but their action on the bacteria is peculiar. So long as the doses are not too strong, some of the soil bacteria flourish and multiply to an astonishing degree, apparently feeding on the antiseptic: phenol, cresol, hydroquinone, quinone, are all among the unpromising substances that produce this effect. The phenomena are quite distinct from those observed with volatile antiseptics; the rise in bacterial numbers

E. J. RUSSELL.