Principles of Field Experimentation.

THE science of field experimentation has developed rapidly during the last decade, and its ever-widening importance justified a Rothamsted conference devoted entirely to its principles and technique.[1] As was only fitting, the first paper was contributed by Dr. R. A. Fisher, who detailed the three principles of modern field experimentation—replication, randomisation, and local control—and showed how these three are necessary in order to reduce, and to give a valid estimate of, the error which must always loom largely in this type of inquiry. Following this, Dr. J. Wishart illustrated the calculations appropriate to randomised blocks and Latin squares, which have proved the most serviceable forms of lay-out.

Later speakers enlarged on a variety of subjects. It is clear from a perusal of the papers that the need is often felt for inquiries carried out at a number of centres simultaneously, so that different conditions of soil and weather may be encountered, and hence that the conclusions may be of general applicability; if each centre adopts the same form of lay-out (though with separate randomisation of treatments) then it is possible to combine all the results in one calculation and attain considerable precision, and still not lose the individuality of the results. Details were given of the methods which experience has shown to be the best for experiments located at a distance from the research station. In these cases a sampling method has proved satisfactory, not only as a means of making developmental studies but also to provide a reliable estimate of the final yield.

Particular cases necessitate special technique. Horticultural experiments introduce difficulty through the longevity of the plants concerned, with the concomitant danger of accident, and the problem of measuring the vigour of the plant. In the case of variety trials, the National Institute of Agricultural Botany still prefers the well-known 'Beaven's half-drill strip' method. The only paper on grass experiments was contributed by Prof. Stapledon, who described the methods adopted at Aberystwyth: he laid much less stress on the statistical adequacy of the technique than on botanical analyses and the problem of how the result should be measured and converted into terms of nutritive value. The papers deal fully with all the working details, and together they provide a most valuable compendium of experience.

A number of examples of the precision and type of results which may be expected from modern field experiments is contained in the Rothamsted Report for 1930.[2] The majority of problems attacked are manurial ones, and the complex lay-outs used give very detailed information. The response of the crop to two or three plant foods, each in varying amounts, can be tested in one and the same experiment, and, if occasion arises, this can be combined with inquiry into the different forms in which any nutrient can be supplied, or the responses of different varieties of the crop plant.

The reader is soon convinced of the necessity for complex experiments, for it is evident in nearly all cases that incomplete inquiry might give misleading results. As an example, it was found that potatoes only responded appreciably to potash and to large doses of nitrogen when a sufficiency of phosphate was supplied, and that superphosphate provoked more than three times as much response in the presence of plenty of nitrogen and potash as it did in the absence of dressings of these two nutrients. Relations of this type appear again and again, making the conclusions difficult to state in a simple manner: there is always a danger in these intricate cases that the reader may 'miss the wood for the trees', but in general the report is admirably and lucidly expressed.

The height of complexity is reached in two rotation experiments which were initiated in 1930: these will yield results year by year, but for their full completion they need twenty years and thirty years, respectively. The Report also contains a brief description of the work proceeding in the laboratory, and summaries of papers recently published by the staff; it is a valuable volume to workers in agriculture and the allied sciences.

H. G. SANDERS.

[1] "The Technique of Field Experiments": being the Report of a Conference held at Rothamsted on May 7, 1931, under the chairmanship of Sir A. D. Hall; with contributions by Sir A. D. Hall, Sir John Russell, Dr. R. A. Fisher, Dr. J. Wishart, Prof. R. G. Stapledon, S. F. Armstrong, A. H. Lewis, T. N. Hoblyn, H. V. Garner, D. J. Watson, T. H. J. Carroll, and others. Pp. 64. (Harpenden: Rothamsted Experimental Station, 1931.) 1*s*. 6*d*. net.

[2] Rothamsted Experimental Station, Harpenden: Lawes Agricultural Trust Report for 1930. Pp. 172. (Harpenden: Rothamsted Experimental Station, 1931.) 2*s*. 6*d*.

The Coal Measures of Belgium.

IN several Continental countries the geology of the coal measures has for long received great attention. This is especially true of those coalfields where the rocks are highly disturbed and the interpretation of the geological structure is often a matter of great difficulty.

In Belgium a succession of brilliant workers has applied palæontological methods to the elucidation of the sequences and structures in the coalfields. Lately this work has been carried out under the direction of Prof. A. Renier, of Brussels, whose contributions to the geology of the Carboniferous of Belgium have been widely known for many years. In a recent memoir, Prof. Renier has summarised the development of these investigations, and has given a concise account of his views concerning the mode of deposition of the rocks and of their correlation, while Prof. Pierre Pruvost, of Lille, has contributed to the memoir a very valuable account of the fauna.*

* Considérations sur la stratigraphie du terrain houiller de la Belgique, par Armand Renier; La Faune continentale du terrain houiller de la Belgique, par Pierre Pruvost. *Mém. Mus. Roy. d'Hist. Nat. de Belg.*, No. 44, 1931.

Prof. Renier asserts that in the coal measures of Belgium the floor of every seam is full of the rootlets of *Stigmaria*. The plant remains of these fossil soils are of very monotonous aspect, *Stigmaria ficoides* being present at every horizon throughout the sequence. Renier emphasises that the tracing and recording of such fossil soils, even when they are, locally, not overlain by coal seams, is of great assistance in the investigation of the strata. This is in marked contrast with the general practice in many mining areas in Britain, where frequently there have been no records of any of the strata passed through excepting the coal seams.

Renier directs attention to the wide lateral extent of many coal seams, while at least one marine bed in the coal measures he recognises in areas so far apart as the Pas de Calais, Holland, and Westphalia. This wide extent of at least some beds in the Upper Carboniferous strongly supports the view that there was at times continuous deposition over wide areas. The views formerly held by some geologists regarding the deposition of the coal measures in small isolated basins, more or less co-extensive with the present coalfields, receive no support from Renier's work.

In contrast with the uniformity of the floors of the coal seams, the roofs yield extremely varied faunas and floras. These have been examined and recorded with great precision. Renier quotes approvingly the words of Crépin, who laid down two rules for palæontologists working on the coal measures so long ago as 1878. Palæontologists, he advised, should never confine their researches to material collected from the rubbish tips of collieries, but should themselves descend the mines and study the Carboniferous vegetation *in situ*; further, they ought not to leave the collecting exclusively to workmen and others ignorant of the science, but to undertake some of the labours themselves.

The neglect of this advice—not only in Belgium—led for many years to serious errors in regard to the palæontology of the coal measures. Thus, Prof. Renier shows that certain palæontologists who have studied the coal measures of Belgium since Crépin's time based their conclusions almost entirely on museum collections, and decided that the flora was uniform in character from top to bottom of the sequence; recent work, on the other hand, based on the actual examination of each horizon, has made it clear that distinct floras can be recognised and used both in the identification of seams and in the correlation of the coal measures over western Europe.

Prof. Pruvost's account of the non-marine faunas makes a fitting sequel to his monumental work on the faunas of the coal measures of the north of France. A beautiful series of plates is devoted chiefly to the fossil insects and other arthropods and to the fishes. A number of remarkable fossils is described, and this part of the memoir will be indispensable to all students of coal measure palæontology. It is much to be regretted that no illustrations of any of the Mollusca are included (except in relation to their supposed borings); the Mollusca are much more frequent than other fossil animals at most horizons, and Pruvost relies on them to a great extent in his correlation.

Pruvost is not prepared, however, to accept any of the refinements in nomenclature which have been made in recent years. To a large extent he has followed the late Dr. Wheelton Hind, who was very conservative (and sometimes, unfortunately, rather inaccurate) in his interpretation of these species. But whereas even the latter was willing to recognise some twenty-five species of non-marine lamellibranchs in the coal measures of Belgium, Pruvost admits no more than twenty. In his 'lumping' of species he places *Anthracomya librata* Wright as a synonym of *Carbonicola similis* Brown, and *Naiadites elongata* Hind as a synonym of *Anthracomya phillipsi* Will. It is probable that his discrimination of the faunas is much more precise than the nomenclature which he uses, but his method must make it difficult for other palæontologists to make full use of his labours.

A. E. TRUEMAN.

Dyestuffs and Enzymes.

MANY dyes and related compounds have a specific toxic effect on certain micro-organisms which has been utilised in the treatment of the diseases caused by them. The mode of action of the dyestuff is not known, but it is probable that it poisons some particular system in the cell, without which the latter cannot carry on its metabolic activities.

Some recent researches by J. H. Quastel on the action of dyes upon enzymes may throw light not only on the nature of the toxic effect, but also on the constitution of the enzymes employed (*Biochem. Jour.*, vol. 25, p. 629; 1931 (with A. H. M. Wheatley); and *ibid.*, vol. 25, pp. 898 and 1121; 1931). In the first paper it was found that basic, but not acid, dyes inhibited the oxygen uptake by *B. Coli* in the presence of glucose, lactate, succinate, and formate. The degrees of inhibition varied both with the dye and the substrate used, so that the effect could not be due to a general lethal action. Since it is the basic dyes which are active, it appears that the cell dehydrogenases are essentially acidic in character; but basicity is not the only factor in toxicity, since the basic Bismarck brown has little action. The inhibitory action of the dye was less marked in phosphate than in veronal buffer. Similar results were obtained with muscle enzymes, but no inhibition was observed with any dye when brain tissue was used, probably because the dye failed to reach the enzyme.

In the second paper, the behaviour of fumarase from micro-organisms or from brain or red-blood cells was studied. This enzyme converts fumarate to *l*-malate, which can be estimated polarimetrically. It was found that both acid and basic dyes were toxic, but a marked specificity was apparent; of the former, the Congo red series was the most toxic, of the latter, the triphenylmethane series. It was also observed that fumarate combines with its enzyme and prevents the combination, and hence the toxic action, of both acid and basic dyes; that proteins exert a protective action, and that the protective action of phosphates is less than in the case of the dehydrogenases.

The most recent experiments have been carried out with certain naphthylaminedisulphonic acids and fumarase, after observing that trypan red and Bayer 205, like Congo red and trypan blue, are toxic. None of the six acids tested were toxic, nor were their first *s*-carbamide derivatives. The second and especially the third *s*-carbamide derivatives were, however, very toxic, that is, the *s*-carbamides of *m*-aminobenzoylnaphthylaminedisulphonic acid and of *m'*-aminobenzoyl-*m*-aminobenzoylnaphthylamine-disulphonic acid. The importance of this observation lies in the fact that there is a definite, though not strict, parallelism between the toxic action of these carbamides on fumarase and their trypanocidal potency, as determined by Balaban and King. It is possible that this method of investigating the toxicity of dyestuffs on enzymes may prove suitable for preliminary tests in the preparation of compounds likely to be of chemotherapeutic value.

Carbonisation of Coal.

GREAT expectations have been placed upon coal carbonisation at low temperatures as a source of motor spirit. Fuel Research Technical Paper No. 34 (H.M.S.O., 6*d.* net), on the "Light Spirits from the Low Temperature Carbonisation of Coal", shows that the experience with benzole production cannot be directly transferred to low temperature products. The proportion of tar acids and unsaturated compounds is higher, necessitating greater consumption of chemicals in refining. The refined products were found by actual tests in petrol engines to be good motor fuels at least equal, when fresh, to commercial petrol. They still contained considerable quantities of unsaturated compounds which were liable to polymerise