cerebellum or the cortex) to the working of the system as a whole. Both methods have yielded information of great importance, but neither of them gives much prospect of explaining the intimate nature of the processes involved in nervous co-ordination. The third, a field relatively barren until Prof. Sherrington's work, consists in analysing the simplest activities of the nervous system by a detailed study of the reflexes.

A "simple reflex"—*i.e.* the performance of an isolated movement as the direct consequence of sensory stimulation—is generally regarded as the unit reaction of the nervous system, the behaviour of the animal being compounded out of a series of simple reflexes. But as this compounding of reflexes is the chief work of the nervous system it is naturally a difficult matter to isolate a single reaction out of the whole behaviour of the organism; indeed, in an animal which is intact we find that the response to a given stimulus may depend not only on that stimulus, but also on the total effect of all the sensory impulses which are entering the central nervous system or have entered it previously. Prof. Sherrington overcame this difficulty by isolating a part of the central nervous system, so that relatively few sensory impulses can reach it, and the reflex response to a given stimulus can be studied under approximately constant conditions. His method takes advantage of the fact that in the higher animals the great majority of sensory impulses are those which enter the brain from the special sense-organs in the head. These organs—the eye, ear, and nose—supply information about events happening at a distance, and it is on such information that the behaviour of the higher animals is largely based. For this reason the brain has come to be the most important part of the nervous system, and is in complete control of the more primitive spinal cord which receives impulses only from sense-organs in the skin and in the interior of the body.

If the brain is cut off from the spinal cord, the latter is at first completely disorganised, but in a short time it recovers from the initial shock, and carries out simple movements of the limbs in response to stimulation of the skin or of the sensory nerve-fibres. These simple reflexes will now occur with almost mechanical regularity, because the spinal cord is isolated from the great mass of continually changing impulses which would otherwise reach it from the brain. In practice the animal is anæsthetised and the brain destroyed, usually by cutting off the entire head; as the breathing will cease, some form of artificial respiration must be employed, but with this the decapitated carcase will continue to show reflex movements for many hours. Prof. Sherrington has carried out a detailed analysis of certain of these spinal reflexes, in particular the scratching movements of the hind leg in response to irritation of the shoulder area, the withdrawal of the foot on the application of a painful stimulus, and various movements which form a part of the act of walking. He has studied also the "tonic" reflexes whereby the animal maintains a continued posture by the steady contraction of certain groups of muscles.

As a result of this method of research, he has been able to show the chief differences between conduction in the simple nerve-fibre and in the more complicated pathway through the central nervous system. He has shown how reflexes are compounded together so that two antagonistic muscles (*e.g.* the flexors and extensors of a limb) can never be called into play at the same moment, and how one reflex becomes fatigued and gives place to another so that the pattern of nervous conduction is continually changing and the behaviour of the animal varies even though the environment remains unaltered. The general principles of reflex action which Prof. Sherrington has formulated have had an immediate practical application to the problems of nervous disease and experimental psychology, and it is no exaggeration to say that his researches have opened up an entirely new chapter in the physiology of the central nervous system.

Industrial Research Associations.

IV.—The British Research Association for the Woollen and Worsted Industries.

By Arnold Frobisher.

THE main object of the British Research Association for the Woollen and Worsted Industries is to promote co-operation amongst wool-using firms with the view of establishing a national scheme of research into the problems presented by the woollen and worsted industries. In the formation of the association, and in the matter of providing facilities for some work that has already been done, much assistance has been given by educational bodies, particularly by Leeds University and by the Bradford Technical College.

The scope of the work of the association includes the investigation of problems arising in all branches of the woollen and worsted industries—that is to say, the growth of wool, scouring, carbonising, carding, combing, spinning, weaving, hosiery manufacture, dyeing, bleaching, printing, finishing, and other auxiliary or related processes. As certain classes of "woollen" goods also contain substitute fibres, the investigation of these is also necessary.

One of the first duties of the council of the association has been to make a survey of the field of research which is likely to be beneficial to the industry. In this connection members of the association can be of great assistance in the framing of a thoroughly comprehensive scheme by making suggestions relating to that part of the

industry with which they are intimately acquainted.

In addition to conducting the ordinary laboratory research work, provision has been made for entering into agreements with mills and works for carrying out any experiments on the manufacturing scale which have, or may, become necessary.

Considerable progress has been made towards the establishment by the association of a wool textile library, where literature relating to the industries is being indexed, abstracted, and arranged. In this connection it is hoped to work in close co-operation with the university and commercial libraries already in existence, so that there shall be a minimum of overlapping.

There is also being established a bureau of information, to which any member of the association can apply for assistance in the technical and other difficulties which he may encounter in his business. If the information necessary for the solution of his difficulty is available, it will be supplied to him; if this information is not available, the member will be able to rely on attempts being made to procure it.

Besides the scheme of co-operative research for the common good of members of the association, it is proposed to make provision for carrying on investigations at the request of individual members, at their own cost and for their own benefit. In such cases the work will be done under the supervision and control of the Director of Research, and fees will be charged to cover the cost of the investigation.

The association has purchased a large mansion in about four acres of ground, which is at present being converted into physical, chemical, and mechanical laboratories, with rooms specially adapted for photographic and photomicrographic work. A feature is being made of the possibility of modifying and improving testing machines and devices for fibres, yarns, fabrics, etc.

In the basement of the premises a room is being fitted up, the atmosphere of which can be automatically controlled as to temperature and humidity. The chamber is of sufficient size to enable experiments to be conducted within it under known and controllable conditions. At least two such rooms exist in the U.S.A. for use in testing paper and textiles, but, so far as is known, there are none in this country, apart from arrangements for *increasing* humidity. A small experimental plant is also being installed for the investigation of problems of scouring, milling, and finishing, and, as necessity arises, small-scale plants will be installed for other experiments.

As regards the programme of research, a number of "practical" problems have been formulated, among which may be mentioned the effect of "condition" (*i.e.* percentage of moisture), strength, finish, handle, waterproofing, efficiency and suitability of machinery, etc. For the solution of these problems a large amount of work is required on the ultimate properties, physical, mechanical, chemical, etc., of the fibre. Even for the commoner processes and reactions the information available is by no means complete or convenient. The early work of the association is bound, therefore, to include a great deal of former work by way of review and amplification. There are very many branches of the subject that have been worked at many times, but not completed. This particularly applies to the absence of micrographic and often of physical tests.

For example, some information is available on the swelling and elongation of fibres with water and reagents, on the manner in which the strength and elasticity of fibres are affected, and how they stiffen, soften, etc. The information at present available on those points is, however, neither sufficiently authoritative nor complete. Again, similar investigations will require to be extended to yarns, etc. Then there is the whole question of the effect of tension on the measuring and winding of yarn. Also, there is no accurate method of standardisation of qualities or descriptions in the trade, and the possibility of establishing accurate standards is to be investigated. Experiments have been going on for some time into the matter of the electrification of fibres during certain processes, and the better control of this factor would be of great commercial importance.

It is on the basis of such information as is indicated above that manufacturing processes ultimately depend. Whenever a problem in manufacturing arises, it is nearly always found that the investigation leads back to questions of a fundamental character.

Appointments of staff have already been made to cover the sections relating to physical, chemical, and mechanical problems. On the physics side an analysis will be undertaken of the ultimate physical conditions which distinguish wool from other fibres. This will lead up to a definition of the properties of any substitute. Many experiments will be made in the special humidity-controlled room, and tests carried out during and after the various processes through which the fibre passes before becoming finished fabric.

A wide field is opened up on questions of the effect on strength, elasticity, etc., of numerous reagents, and in this connection very many notes have been made of the action of various reagents, which require further investigation. It is intended to examine the many proposals for the preparation of wool substitutes, and to compare the actual properties of the resulting products.

Attention will also have to be paid to the elimination of waste in the various processes and to the recovery of grease, soaps, etc. This might be done more by way of demonstration than by investigation, as many processes are known but are not in regular use. Comparisons will be made of the detergent power of soaps and other detergents, and also of the soaps of various fats as between themselves.

On the biological side it is emphasised that there is much scope for improving the quality of British wools, and several conferences have been held at which all interested bodies and

classes, including the Boards of Agriculture, sheep-breeders' associations, flock-owners, university professors, and manufacturers, were represented. It was generally agreed that by the method of selective breeding and the establishment of new crosses, etc., an improvement in wool, without loss of mutton characters, is feasible. Experiments directed to this end are already in hand in several quarters, and it is hoped that with the co-operation of the Boards and breeders substantial advances will be made.

The management of shows and individual prize-givers can also do an enormous amount to further the objects in view. It is suggested that the services of a wool expert should be retained for the more important shows, and that, in all classes where such is possible, points should be given for the wool. This expert should direct attention to its merits and defects for manufacturing.

Much work might be done in the microscopic examination of fibres and in the actual carrying-out of small- and large-scale breeding experiments, with the object of improving the wool, particularly of British breeds.

The question of large-scale experiments is not being neglected, and a site has already been purchased upon which it is proposed to build an experimental factory for investigating under actual commercial conditions, on a manufacturing scale, the many problems connected with woollen carding and spinning. This factory will be equipped with the most up-to-date machinery and staffed with the most expert labour available, with the view of conducting experiments and investigating variations of present-day methods. A well-qualified man of science will be engaged in the factory to observe conditions and keep records, and any variations in method or investigations with a view to improvements will be under his supervision. Individuals will be allowed to use the machinery for private investigations at a fee to cover the working costs. Members have also been of great assistance in allowing experiments to be made in their factories. On these questions, and, in fact, on all other topics upon which it is considered expedient, publications will be prepared, and several have already been issued.

It is clear that the work of this association overlaps or dovetails with that of other bodies in many directions. Co-operation is a welcome necessity, and has been given or offered by several Government Departments, universities, technical schools, the Industrial Fatigue Research Board, the other research associations, etc., as has already been mentioned in one or two connections.

The Education Committee of the association has submitted, after some months of very careful and detailed deliberations, a series of revised syllabuses for textile courses in technical colleges, etc., and much outside support has been given to the recommendations it puts forward. These new syllabuses are the outcome of the joint discussion of existing syllabuses and standards by heads of textile departments in the universities and colleges and by the manufacturers themselves, and they have laid the foundations of a system whereby the actual needs of industry can be put plainly before those responsible for the training of the manufacturers of the future. The committee also hopes to aid the colleges in placing students in the industries both during and after their usual technical training.

It is intended not only to award prizes to inventors, research workers, and others for work of benefit to the industries or to the association, but also to establish scholarships and to subsidise research workers and educational institutions which devote themselves primarily to the objects which are before the association.

All questions relating to these matters should be addressed to the Secretary, Torridon, Headingley, Leeds.

Noted ad. Dec 9 p. 475

Obituary.

PROF. ERIC DOOLITTLE.

PROF. ERIC DOOLITTLE, director of the Flower Observatory at the University of Pennsylvania, died on September 21 at the early age of fifty years. His father, C. L. Doolittle, was professor of mathematics and astronomy at Lehigh University, and the author of a well-known treatise on practical astronomy. In 1896 the father was appointed professor of astronomy at Pennsylvania University, and the son was placed in charge of the 18-in. refractor in the Flower Observatory, which was established that year in connection with the university. The latter remained there for the rest of his life, at first in the capacity of observer and instructor, and later as professor. The refractor had been specially designed for work on double stars, and the young astronomer adopted this line of study with great energy and enthusiasm. His published work embraces some 4600 pairs, and further observations are ready for issue. In 1913 Prof. S. W. Burnham, finding himself unable to continue the work of observing double stars and discussing their orbits, paid Prof. E. Doolittle the compliment of handing over his books and manuscripts to him. The latter proved himself worthy of the trust, continuing the classification and discussion of the observations of an immense number of pairs. This work is already available in card-catalogue form, and will be published later.

Another subject in which Prof. E. Doolittle took a great interest was the computation of the secular perturbations of the planets, in which he followed a method developed by Dr. G. W. Hill. His results were published by the American Philosophical Society in 1912.

In 1917 he was called on to organise and conduct a Navigational School at Philadelphia. The