Agricultural Research.

THE address delivered by Sir John Russell, as president of Section M (Agriculture), at the recent meeting of the British Association at Toronto, may be characterised as a somewhat despondent survey of present day activities in agricultural research, with particular reference to those branches of the subject allotted to the Rothamsted Station and the special problems upon which the workers there have been engaged. It may be worth while to give consideration to some of the more general aspects of applied research to which Sir John Russell's remarks inevitably direct attention.

When philosophers, as they then called themselves, first turned their attention to the problems presented by the life of the plant, they were not long in finding that the pioneer science of chemistry enabled them to throw an immediate light on what we may now regard as the crude fact, that plant life is dependent for food upon an adequate supply of certain elements, such as carbon, nitrogen, phosphorus, and potassium. It was an easy step to supply some of these elements by "artificial" means. The result was that, dating from the forties of the last century, the practice of applying "artificial" manures received an immense impetus: so much so that farming practice was almost revolutionised. It became possible not only to raise the level of food production from a given area of land, but also to maintain that level indefinitely.

The material consequences of these early discoveries were so great that they created a belief in the efficiency of scientific research as applied to husbandry which has been held to justify the expenditure by the State, as well as by other agencies, of larger sums than have hitherto been devoted to research of any other description. But during the last eighty years science has presented only one other gift of an economic importance equal to that just indicated. Mendel and his belated disciples have taught us to regard the plant as a plastic organisation which can be systematically moulded in desired directions. Sir John Russell has catalogued the remarkable results of the work of Biffen and others.

Yet it cannot be denied that the agricultural sciences have made great advances in other directions in these long years. Our knowledge of the factors concerned in the growth of animals and plants is almost inconceivably greater than it was eighty years ago. Why is it then, that, as judged by economic tests, farming practice has been so little modified that even Virgil's "Georgics" may still be read as a textbook? One reason may be suggested. The growth of a plant or animal is affected by a number of environmental causes beyond human control. A severe hailstorm, a rainy season, may render nugatory all the efforts of the most skilful and scientific husbandman. He earns his living really by virtue of the law of averages. If old tradition is right, he rings a cycle of changes in a lunar period of nineteen years. It is a fair inference, therefore, that he is not likely to be much moved by scientific evidence that a certain course of action will produce a better result *of the order of difference* that he associates with a normal seasonal variation. If, for example, the supposition is made that the yield of any crop on a particular field will vary normally by 10 per cent. from year to year, a scientific improvement, which, if adopted, increases yield by 10 per cent. in any one year, is scarcely likely to interest the husbandman. It may be, therefore, that science has failed to produce discoveries of sufficient magnitude. "Artificial" manuring, it is true, may be said to have been a discovery of the order of 100 per cent.; and the

science of plant-breeding may be said to have involved differences of the same order.

In Sir John Russell's address, consequently, one detects a feeling of disappointment. We have passed through, he says, a "pioneer period with . . . the disadvantages of certain lack of perspective, failure to follow up important issues, and some narrowness of outlook." He suggests that steps should be taken to secure the co-operation of a team of workers in every science bearing on agriculture—the members to be drawn from all parts of the British Empire. The proposal is scarcely in the region of practical politics. After all, the epoch-making discoveries of science have not come from team work—nor from what is sometimes termed "directed" research.

The Member of Parliament and the Treasury official are apt to think of research as if it functioned like a penny-in-the-slot machine—a mechanism which unfailingly gives "results" for the inserted coin. Such and such an industry should form a Research Association, accept a grant, and forthwith grind out results good for the industry concerned. The whole history of scientific effort, however, is a record of individual successes in so-called "pure" science, and, with due respect to the Director of Rothamsted, what appears to be wrong with agricultural science is that it is too agricultural. If, as he says, the "co-operation of a plant physiologist" is needed, let us take care that the worker is not tied to the study of agricultural plants, and if, in consequence, he is a worker in "pure" botany, let us see that he gets as liberal a grant as his brother working in agricultural botany. At the present juncture, research in pure botany is languishing in all our universities, and yet, on Sir John Russell's admission, the advances made by one branch of the science, that of plant-breeding, have far outdistanced any discoveries in the sciences with which he is directly concerned.

The lesson one may venture to extract from the address of the Director of Rothamsted is that it is high time that the State turned its attention to the need for fostering scientific research in pure science. Directed research, that is, research directed to secure definite economic results, is in danger of becoming outworn for lack of draughts from the *pocula sacra* which University research in pure knowledge exists to provide!

CANTAB.

The Vibrations of Air in Organ-Pipes of Unusual Shapes.

IN an interesting letter published in NATURE for August 30, Principal J. A. Aldis discusses the vibrations of air in organ-pipes of unusual shapes, and gives a number of elegant formulæ for calculating the frequencies of the tones in certain cases. The date of the investigations (1867–1868) gives them a special interest, since they were carried out some three or four years before the publication of Rayleigh's well-known paper on "The Theory of Resonance," in which, by the introduction of a quantity which he called the "conductivity" of an orifice, he was enabled to give a simplified treatment of the theory of bottle-resonators and of pipes with restricted mouths.

I was at first somewhat surprised to see that the formula given by Principal Aldis for the frequencies of the tones of bottle-pipes agreed satisfactorily with observations, apparently without any restriction as to the size of the bottle. The formula is obtained by assuming the existence of stationary plane waves in the two parts of the bottle—i.e. in the neck (or mouth part) and in the stopped part—and the continuity of the pressures and velocities at the